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A DEA Approach for Analyzing Efficiency of Projects Based on Service Quality

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Abstract. One of the most important issues in project management is delivering the project at the right time and with the predetermined expenses. Cost and time deviations have often negative effect on the quality of implementation and the popularity of organization. Hence, evaluation of project in terms of service quality and concerning cost and time deviations will be more reliable. In this paper, data envelopment analysis as a mathematical approach is applied to determine efficient projects based on quality, cost, and time criteria. In the DEA model, cost and time deviations and service quality score are considered as multiple inputs and single output respectively. It is clear that efficient projects provide the highest service quality score with the lowest cost and time deviations. Findings imply that efficient projects necessarily do not have the greatest score of service quality.

Keywords: Evaluating Projects, Data Envelopment Analysis (DEA), Service Quality (SQ), Efficiency

1. Introduction

DEA is a well known technique for evaluating the efficiencies of decision making units (DMUs). Because of its simplicity and successful applications, DEA has received too attention and widespread use by business and academy researchers. Selection of best vendors, evaluation of data warehouse operations, selection of flexible manufacturing system, assessment of bank branch performance, examining bank efficiency, analyzing firm's financial statements, measuring the efficiency of higher education institutions, solving facility layout design problem and measuring the efficiency of organizational investments in information technology are some applications of DEA in various areas [1].

Cost increases and schedule delays are common problems in projects. In a study by Chang [2], the main reasons of cost and time overruns were listed. Sowlati et al. [3] proposed a model within data envelopment analysis for prioritizing information system projects. Green dollar costs, brown dollar costs, time to market and potential risks were considered as inputs, and green dollar benefits, brown dollar benefits, breadth of benefits and intangible benefits were regarded as outputs. They concluded that cost and dollar benefits were twice as important as risks and soft benefits (breadth of benefits and intangible benefits). Green dollar benefits were as important as brown dollar benefits. Yet, breadth of benefits and intangible benefits, and green dollar costs and brown dollar costs had the same importance. Asosheh et al. [4] combined two managerial methodologies, balance score card and data envelopment analysis for information technology project selection. Inputs of proposed DEA model in this study were cost, time and human resources. Yet, financial, internal business, customer, learning and uncertainty perspectives were regarded as outputs of DEA model.

The aim of this paper is to analyse efficiency of projects. The specific objectives of the paper are to: (1) calculate the service quality score of projects; and (2) assess the cost increases and schedule delay of projects. Hence, data envelopment analysis technique as a mathematical approach is applied to calculate efficiency of projects. Service quality is regarded as output, and time and cost deviations are considered as inputs of DEA model. Finally, a numerical example is presented to prove the capability of proposed model.

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2. Service Quality

A service is an activity or series of activities in a less intangible nature that normally, but not necessarily, take place in interactions amongst customer and service employees and/or physical resources or goods and/or systems of the service provider, which are delivered to customer [4]. There are also several definitions for quality. Reeves and Bednar [5] defined quality as excellence, value, conformance to specifications and meeting or exceeding customers' expectations. During the past few decades, scholars have recognized and discussed about this concept.

Service quality is a concept that has agitated considerable interest and discussed because of its difficulties in both defining and measuring it with no overall consensus [6]. A number of different "definitions" has been stated to explain service quality concept. One that is commonly used to explain service quality is the extent to which a service meets customers' needs or expectations [7]. Hence, Service quality can be defined as the difference between customer expectations of service and perceived service. If expectations are greater than performance, then perceived quality is less than satisfactory and hence customer dissatisfaction occurs [8]. The concept of service quality was established after there had been a growing interest in the quality of goods served. Garvin [9] was amongst the first scholars who examined the quality concepts to cover both goods and services. Garvin explained the perceived quality as the subjective perception of quality through indirect measures of quality comparison. Gronross [10] introduced perceived service quality as a result of comparing the real experience with the expectation of a customer before consuming the service. Based on the perceived service quality concept Parasuraman et al. [8] applied premises from other previous studies to form their model of service quality. The conceptual model of Parasuraman et al. [8] includes five generic dimensions or factors which are as follows: [11]

(1) Tangibles. Physical facilities, equipment and appearance of personnel.

(2) Reliability. Ability to perform the promised service dependably and accurately.

(3) Responsiveness. Willingness to help customers and provide prompt service.

(4) Assurance (Including competence, courtesy, credibility and security). Knowledge and courtesy of employees and their ability to inspire trust and confidence.

(5) Empathy (including access, communication, understanding the customer). Caring and individualized attention that the firm provides to its customers.

3. Data Envelopment Analysis

Efficiency measurement has been the challenge of many organizations which have interest to improve their productivity. Farrell [12] stated that measuring the efficiency of an organization is important both for economic scholars and decision makers. One of the main reasons that all attempts to solve the problem have been failed is the failure in combining the measurement of multiple inputs into any desirable outputs [13].

Twenty years later, Data Envelopment analysis was introduced by Charnes, Cooper and Rhodes (CCR) in order to change a fractional linear measure of efficiency into a linear programming (LP) format. Therefore, decision making units (DMUs) could be analyzed based on multiple inputs and outputs [14]. In DEA approach, DMUs usually use a set of resources as inputs and transform them into a set of outcomes as outputs. DEA can successfully separate DMUs into two categories which called efficient DMUs and inefficient DMUs. Efficient DMUs have equivalent efficiency score. However, they don't have necessarily the same performance [15].DEA can provide some practical information for decision makers to improve the efficiency of a DMU.

4. DEA Model for Measuring Efficiency of Projects

Data envelopment analysis is a mathematical programming methodology. It has been employed successfully for assessing the relative performance of a set of firms, usually called decision-making units (DMU), which use the same inputs to produce the same outputs. Assume that there are n DMUs, and the DMUs under consideration convert I inputs to J outputs. In particular, let the m_{th} DMU produce outputs y_{jm} using x_{im} inputs. The objective of the DEA exercise is to identify the DMUs that produce the greatest amount

of outputs by consuming the least amount of inputs. A DMU is deemed to be efficient if the ratio of weighted sum of outputs to the weighted sum of inputs is the highest. The DMU defined in this study with input and output criteria are as follows: (Figure 1)

Figure 1- DEA model based on service quality

Cost deviation is the increase in expenses of project which were estimated initially. Yet, time deviation refers to the delay in performing project. On the other hands, these two concepts are positive deviations which are more than estimated time and cost of the project. The DEA model used in this study takes the form of multiple inputs and single output. Multiple inputs and the single output DEA modeling form measures the efficiency of DMUs by how well they minimize inputs criteria to produce the single output criterion. In the following the BCC model will be used in order to identify the most efficient project. BCC model is as follows [16]:

$$MaxZ_o = \sum_{r=1}^{s} u_r y_{ro} + w$$

$$St.$$

$$\sum_{r=1}^{s} u_r y_{rj} - \sum_{i=1}^{m} v_r x_{ij} + w \le 0 \qquad , j = 1,2,...n$$

$$\sum_{i=1}^{m} v_i x_{io} = 1$$

$$u_r, v_i \ge \varepsilon$$

Where dual model is as follows:

$$Min\,\theta - \varepsilon [\sum_{i=1}^{m} S_i^- + \sum_{r=1}^{s} S_r^+]$$

$$St.$$

$$\sum_{j=1}^{n} \lambda_j y_{rj} - S_r^+ = y_{ro} \qquad , r = 1,2,...,s$$

$$\sum_{j=1}^{n} \lambda_j x_{ij} + S_i^- = \theta\, x_{io} \qquad , i = 1,2,...,m$$

$$\sum_{j=1}^{n} \lambda_j = 1$$

$$\lambda_j \ge 0 \qquad , j = 1,2,...,n$$

$$S_r^+, S_i^- \ge 0 \qquad , r = 1,2,...,s \qquad , i = 1,2,...,m$$

5. Numerical Example

In this section, a numerical example is presented to examine the possibility of implementing the proposed approach. As it is demonstrated in Table 1, 13 DMUs with two inputs and one output are considered in numerical example. All the data should be normalized before solution process. In the first step,

BCC model of input oriented should be solved for all DMUs. So, efficient and inefficient DMUs can be determined (Table 2).

Table1- Input and outputs of DEA model

DMUs	Input 1	Input 2	Output	DMUs	Input 1	Input 2	Output
	Time Deviation	Cost Deviation	Service Quality		Time Deviation	Cost Deviation	Service Quality
1	187	3870	91	8	192	990	94
2	53	1210	78	9	230	4310	71
3	131	1980	89	10	178	3450	63
4	78	1830	83	11	93	4560	69
5	214	2370	90	12	103	2560	82
6	86	5780	48	13	225	2140	42
7	91	4390	56				

Table2- Output and inputs of DEA model in normalized form

DMUs	Input 1	Input 2	Output	DMUs	Input 1	Input 2	Output
	Time Deviation	Cost Deviation	Service Quality		Time Deviation	Cost Deviation	Service Quality
1	0.100	0.098	0.095	8	0.103	0.025	0.098
2	0.028	0.031	0.082	9	0.124	0.109	0.074
3	0.070	0.050	0.093	10	0.096	0.087	0.066
4	0.042	0.046	0.087	11	0.050	0.116	0.072
5	0.115	0.060	0.094	12	0.055	0.065	0.086
6	0.046	0.147	0.050	13	0.121	0.054	0.044
7	0.049	0.111	0.059				

6. Results

In order to follow this model, linear programming solution is performed for all projects in numerical example. Results of DEA model are represented in table 3. It is clear that projects 2, 3, 4, 8 are efficient with the rating of 1.000. The remaining projects are identified inefficient. These score may help managers of projects to evaluate efficiency of projects comparatively. The efficiency of projects means that the higher outputs are achieved with lower inputs. Projects 2 and 8 with cost deviation equal to 1210 and 990 are identified efficient. Time deviation of project 2 equal to 53 is lower than others however its service quality score is not so high. Inversely, project 8 has the highest service quality score and inappropriate time deviation.

Table 3- Units' efficiency

DMUs	Efficiency	DMUs	Efficiency
1	0.83101	8	1.00000
2	1.00000	9	0.27682
3	1.00000	10	0.34672
4	1.00000	11	0.56989
5	0.68101	12	0.70874
6	0.61627	13	0.51835
7	0.58241		

7. Conclusions

In this paper, a model through DEA approach was developed in order to evaluate the efficiency of projects. The paper also described how one firm can implement this method and use DEA modelling for measuring projects' efficiency based on their cost and time deviations, and service quality. Regarding to

results of this study projects which provide lower cost and time deviations and higher service quality score are efficient. Thus, managers of projects can consider multi criteria in evaluation of projects in terms of important criteria. This approach allows safety managers to effectively evaluate service quality of each project concerning service quality score of the best project. Results of DEA model can be used in order to calculate and determine benchmark values to compare with inefficient projects. Another advantage of this model is the simplicity of calculating factors of DEA model. Comparing to traditional subjective service quality evaluation method, the proposed DEA approach provides an objective statement of how the best projects can be identified. Further researches can be done with more indispensable factors. Sensitivity analysis can be applied for measuring the influence of factors. Yet, it is possible to rank efficient DMUs.

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