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Developing a Model to Estimate Cost of Construction Projects based on Target Costing Approach

Asmaa Alqhisan[*a], Mohamed Abdel-Monem[a], Karim El Dash[a]

[a] Department of Civil Engineering, Faculty of Engineering at Shoubra Benha University
* Corresponding Author
E-mail: asmaasaad90@outlook.com,m.abdelmonem@feng.bu.edu.eg,karim.aldosh@feng.bu.edu.eg.

Abstract: The targeted value design methodology is the most common expression of Target Costing (TC) in the construction industry (design, construction, and delivery stages). It is recognized as an effective tool for reducing costs and managing overruns. However, the application of target value design in construction projects is highly dependent on the experience of the estimator. The main objective of this study is to identify the estimating cost, the limitations, and the key development areas of traditional Target Cost and solve the cost-focused estimating of traditional Target Cost (TC). A questionnaire-based interview survey was conducted to study the relation between target cost application and the financial failure rates in the engineering industry companies in Kuwait. Accordingly, most common factors affecting target cost have been ranked using standardized mathematical modeling of decision tree theory. A simple mathematical model has been developed using the MATLAB application. The model considering different operating expenses categories and graphically represents all operating costs. The model optimizes the results of (design, construction, and delivery stages) of cost and shows the target cost distribution and the direct cost distribution to differentiate between them.

INTRODUCTION

Considering the civilizational and managerial revolution witnessed in modern times, considerable attention has been given to the cost estimation of projects especially the engineering projects. [24] satated unlike the traditional design-estimate process, target costing (TC) views cost as an input rather than an output, making TC a limited optimization process that seeks to maximize the project value according to the predetermined total cost. [20] mentioned that TC is recommended by many researchers for its philosophical principles, its application is still limited by its constructors. [22] mentioned through the application of TC as a management tool, the desired or target cost is pre-allocated among the various parts and systems of the product according to a defined work breakdown structure. This placed financial constraints on the building's design to improve overall project cost accuracy, even before the design process began. [23] pointed out that the cost-focused nature of current TC adoption focuses on management aspects while ignoring the technical knowledge required to understand the relationship between product components that affect the product in terms of cost and performance. Therefore, this study proposes a new model to estimate the cost of engineering projects based on the target cost approach.

Literature Review

[15] have announced new solutions for improving energy efficiency. They integrate energy research with TC technology to inform design decision makers about greenhouse gas and carbon dioxide emissions throughout the building's life cycle. These energy assessment processes are based on the direct energy impact of existing TC systems (ie, the exchangeable interactions between these systems) and the outcome of construction projects in terms of cost, performance values, and energy consumption.

There is a difference between target cost method and the traditional method of cost management in the following:1) Traditional Method of Cost Management: Market price is not considered as a part of prime cost planning, Costs determine sales price, Losses and inefficiency are taken into consideration in order to reduce costs, Customers are not

involved in cost reduction, Teamwork and multiple skills are not taken into account, Prime cost and some proportion of profit stem from closed system, Suppliers of material and equipment are involved after designing the product and It does not use value engineering. 2) Target Costing: Competitive price is considered as a part of prime cost planning, It is sales price that determine costs, Design is an important factor in reducing costs, Customer data is considered as a guide for cost reduction, Teamwork and multiple skills are taken into account, It is an open system and takes into consideration the interactive function or the external effect of variables on the System, Suppliers of material and equipment are involved before designing the product and Value engineering is used as a prerequisite in this system.

[14] identified Target Value Design as a management practice that drives design to deliver customer values and develops design within project constraints. Use of Lean Tools in Target Value Design are Target Costing, Problem Solving and Reporting, Set-Based Design/Concurrent Engineering, Choosing by Advantages, The Last Planner System, Building Information Modeling (BIM). Target Value Design strives to reduce waste and rework in the Design/Estimate/Redesign cycle, requires a fundamental shift in thinking from "expected costs" to "target costs", necessarily involves cross functional teams. No one person has all the knowledge, cries out for an integrated product/ process/ cost model.

The proposed study of cost of construction projects based on target costing approach is expected to enable automated and systematic exploration of the solution space using target cost modeling to determine globally optimal designs. [3] mentioned decision trees are often used in operations research, especially in decision analysis, to help determine the strategy most likely to achieve a goal but are also a popular tool in machine learning. A decision tree is a flowchart-like structure in which each inner node represents a "trial" on an attribute (e.g., whether a coin flips or not), each branch represents the outcome of test, and each leaf node represents a class label (decided to take after calculating all the attributes).

Methodology and Approach

Target value design factors were studied to improve the target cost model. Then forty factors affecting target cost have been identified based on the previous literature review to be used in the proposed target cost model of construction projects. Then an interview survey was conducted to identify the most important factors in Kuwaiti' projects. A sample size has been checked. The survey responses' results were analyzed using SPSS. Then a decision tree model was applied using MATLAB software to predict the target cost of projects.

Survey Variables of the Model

Target cost method aims at developing an existing product or presenting a new project with high quality and less cost. This method studies all probable factors that reduce costs. Cost-effective ideas are then translated into the form of product design with all the functions the client needs. This can only be achieved by the support of engineering, design, research, development, production and marketing departments within the company or project. The variables of estimating cost factors are for the four main factors design, construction, and delivery stages. The survey is conducted via interviews to study existence of a relation between target cost application and the financial failure rates in the engineering industry companies for Kuwaiti construction projects. A questionnaire was designed with fifty questions. forty questions to measure individual variables divided into ten hypotheses and four questions for each part of the hypotheses (individual variables). After each hypothesis, a space was provided for the respondent to comment, and ten questions was assigned to measure the sub variable (competitive advantage). The structure type of questions is Closed-ended with ordered choices. The choices are ordinal response (Strongly Agree, Agree, Neutral, Disagree, Strongly Disagree) as shown in table1. The population of the conducted survey is one hundred and fifty respondents (who are in nine companies in Kuwait). The respondent chooses the most appropriate response from the choices provided.

Table 1 The Weight Degree of Respondents of Survey

Answer level	Answer degree	Answer weight
Strongly disagree	1	20%
Disagree	2	40%
Neutral	3	60%
Agree	4	80%
Strongly agree	5	100%

From the total number of respondents, fifty-two responses were responded for analysis as shown in Table2. distribution the study sample individuals according to the scientific qualification, job title, major and the practical experience

Table 2 The Respondents Classification

1- The scientific qualification.	Number	Percentage
High university degree.	3	5.9%
Bachelor.	47	92%
Diploma.	1	2%
General secondary.	—	—
2- Job title.	**Number**	**Percentage**
General manager.	1	2%
Unit manager.	18	35%
Department manager.	29	57%
Branch manager.	3	5.9%
3- Major. department	**Number**	**Percentage**
Accountancy.	16	31.4%
Banking and financial sciences.	4	7.8%
Business administration.	12	23.5%
Economy.	3	5.9%
Others.	16	31.4%
4- The practical experience.	**Number**	**Percentage**
Less than 5 years.	2	39%
From 5 to less than 10 years.	4	7.8%
From 10 to less than 15 years.	18	35.3%
From 15 to less than 20 years.	24	47%
More than 20 years.	3	5.8%

Table (3) Questionnaire's Response Analysis

Paragraph num.	Activity	Arithmetic mean	standard deviation	Ranking
1	product design	4.4	0.8	1
2	product research and development	3.7	0.9	3
3	product design engineering	4.1	0.7	2
4	design right products	3.7	0.8	4
5	Inbound	4.2	0.7	1
6	Handing over	4.2	0.6	2
7	Shipping	4	0.9	4
8	Storing	4.2	0.6	3
9	Productive processes	4.3	0.7	2
10	Processes design	4.2	0.8	3
11	Processes engineering	4.1	0.6	4
12	Actual production	4.4	0.7	1
13	Outbound	4	0.9	4
14	Shipping and storing	4.1	0.6	2
15	Clients' reports	4.1	0.6	3
16	Processes information	4.2	0.6	1
17	Sales and marketing	4.2	0.8	2
18	Demand's prediction	3.9	1	4

19	Estimation market need	4	0.9	3
20	Sales	4.3	0.6	1
21	After sales service	4.2	0.8	3
22	Handing over and guidance	4.3	0.8	2
23	Technical check	4.4	0.7	1
24	Spare parts	4.1	0.8	4
25	Infrastructure	4.3	0.7	1
26	Accountancy and finance	4.1	0.7	2
27	General management	3.9	0.6	3
28	Solve the disputes	3.7	0.6	4
29	Human resources	4.5	0.6	1
30	Compensations	4.2	0.8	4
31	Education and health services	4.4	0.6	2
32	Employment and training	4.3	0.7	3
33	Technical development	4.4	0.8	1
34	Research's agreements	4.4	0.6	3
35	Research's evaluation and permission	4.2	0.8	4
36	Customers' programming	4.4	0.7	2
37	Purchases management	4.4	0.7	3
Paragraph num.	Activity	Arithmetic mean	standard deviation	Ranking
38	Classification	4.4	0.5	2
39	Consultations	4.6	0.6	1
40	Communications	4.3	0.6	4

Data analysis

The questionnaire was analyzed using SPSS. Arithmetic mean: It's one of central tendency measures and the most common one used in describing and measuring the level of the study sample responses and arranging the importance of the items and the degree of approval or rejection of the questionnaire paragraphs which match with the type of study. Standard deviation: It's used for measuring the dispersion and to know the extent of the dispersion of the values from their arithmetic mean and to ensure the accuracy of the analysis which matches with the type of study. The suitable statistical methods have been chosen after consultation some special professors and they were used in choosing the study's hypothesis as shown in Table (3):

Survey results:

There are two kinds of effects on cost management and value chain factors cost:

- First, internal factors which the company can control and can make the right decision.
- Second, external factors where the company can't make the decision and the external factors became semi-binding and are imposed on companies with an authoritarian rule.

Their effect may be positive or negative for the target cost method and target cost is linked to achieving the competitive advantage and the companies can prove their presence and achieve a position which makes them continue in the market in the future,

Based on the survey of design activity cost, it effects of (product research and development, product design engineering and design right products) (Q1-Q4). There is a strong effect for design activity cost on achieving the competitive advantage. It means that there is an effect of product design cost on the competitive advantage and market share. The amount of that effect was previously determined through various decline analysis.

Based on the survey of inbound activity cost, it effects of (handing over, shipping and storing) (Q5-Q8). There isn't a statistical semantic effect for inbound activity cost on achieving the competitive advantage for the companies. There is an effect of inbound activity cost on achieving the competitive advantage for the Kuwaiti general engineering industries joint-stock companies.

Based on the survey of production processes activity cost, it effects of (Productive processes, Processes design, Processes engineering and Actual production) (Q9-Q12). There isn't a statistical semantic effect for production processes activity cost on achieving the competitive advantage for the companies. There is an effect of production processes activity cost on achieving the competitive advantage for the Kuwaiti general engineering industries joint-stock companies.

Based on the survey of outbound activity cost, it effects of (Shipping, storing, clients' reports and processes information) (Q13-Q16). There isn't a statistical semantic effect for outbound activity cost on achieving the competitive advantage for the companies. There is an effect of outbound activity cost on achieving the competitive advantage for the Kuwaiti general engineering industries joint-stock companies.

Based on the survey of sales and marketing activity cost, it effects of (demand's prediction and the prediction of sales and market need) (Q17-Q20). There isn't a statistical semantic effect for sales and marketing activity cost on achieving the competitive advantage for the Kuwaiti general engineering industries joint-stock companies. There is an effect of sales and marketing activity cost on achieving the competitive advantage for the Kuwaiti general engineering industries joint-stock companies.

Based on the survey of after sales service activity cost, it effects of (handing over and guidance, technical check, maintenance, and spare parts) (Q21-Q24). There isn't a statistical semantic effect for after sales service activity cost on achieving the competitive advantage for the companies. There is an effect of after sales service activity cost on achieving the competitive advantage for the Kuwaiti general engineering industries joint-stock companies.

Based on the survey of infrastructure activity cost, it effects of (finance, accountancy, general management, legal issues and solving the disputes) (Q25-Q28). There isn't a statistical semantic effect of infrastructure activity cost on achieving the competitive advantage for the companies. There is an effect of infrastructure activity cost on achieving the competitive advantage for the Kuwaiti general engineering industries joint-stock companies.

Based on the survey of human resources activity cost, it effects of (compensations, educational and health services, employment, and training) (Q29-Q32). There isn't a statistical semantic effect of human resources activity cost on achieving the competitive advantage for the Kuwaiti general engineering industries joint-stock companies. There is an effect of human resources activity cost on achieving the competitive

Based on the survey of technical development activity cost, it effects of (research's agreements, research's evaluation and permission and customers' programming) (Q33-Q36). There isn't a statistical semantic effect of technical development activity cost on achieving the competitive advantage for the companies. There is an effect of technical development activity cost on achieving the competitive advantage for the Kuwaiti general engineering industries joint-stock companies.

Based on the survey of purchases management activity cost, it effects of (classification, consultations, and communications) (Q36-Q40). There isn't a statistical semantic effect of purchases management activity cost on achieving the competitive advantage for the companies. There is an effect of purchases management activity cost on achieving the competitive advantage for the Kuwaiti general engineering industries joint-stock companies.

Model Formulation

[19] have defined target costing as "a disciplined process for determining and achieving a full-stream cost at which a proposed product with specified functionality, performance, and quality must be produced in order to generate the desired profitability at the product's anticipated selling price over a specified period of time in the future."

[21] defined target costing is an approach to determine a product's life-cycle cost which should be sufficient to develop specified functionality and quality, while ensuring its desired profit. Targets should not be fixed until the design is 40–60% complete.

Target cost = Target price – target profit…….…… **eq 1**

Based on the survey, the model will calculate four types of cost. These costs are design cost, inbound cost, production cost and outbound cost.

The theory used in model is decision tree. The purpose of using decision trees is to create a training model that can be used to predict the class or value of a target variable by learning simple decision rules derived from previous (training) data. The equation of decision tree is shown in equation two.

$$E(S) = \sum_{i=1}^{C} -P_i \log_2 P_i \quad \text{.....eq 2}$$

Model Development

In this study the decision tree theory has been used to estimate the costs of engineering projects based on the target costing approach. The model developed has been applied into MATLAB software as shown in Figure 1.

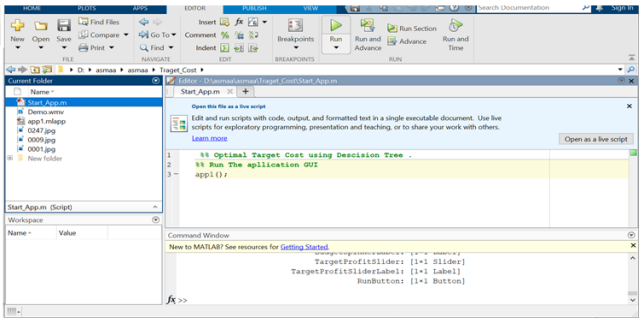

Fig. 1 MATLAB programming interface

The model used as shown in Figure 2 includes cost for each category, budget cost, total cost, and target cost. The model also generates a graph for each cost type (total cost, target cost).

Fig. 2 Model Phase

Four categories are implemented in the model, as shown in Figure 3. The categories are design, inbound, production process, and outbound activity cost.

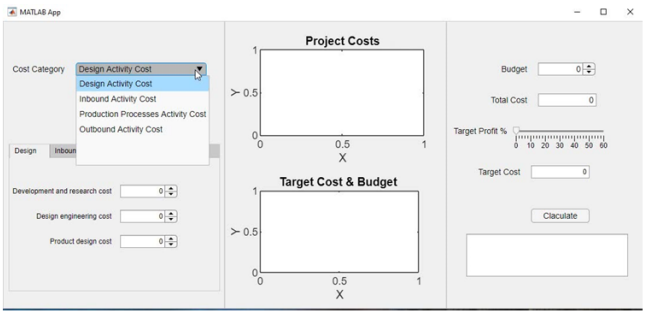

Fig. 3 Cost Categories in Model

The costs used in the model are estimate cost, budget cost and target cost percentage. The estimate cost which is used in this model are for design cost, inbound cost, production cost and outbound cost. When the cost is fulfilled by the user, the model will calculate all costs and show the distribution of cost for all cost factors as shown in Figure 4. So, the user can take decisions of the project.

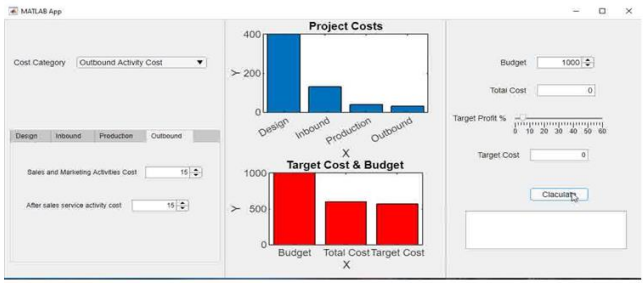

Fig. 4 Output Result

Results and Conclusion

This study examined the definition and importance of target cost for engineering projects. The primary objective of this study is to identify cost estimates, limitations, and key development areas for traditional cost of target (TC) and to resolve cost-oriented estimates of traditional cost of target (TC). The target cost method aims to develop an existing product or present a new project with high quality and low cost. This method looks at all possible cost-saving factors. A low-cost idea translates into a product design with all the features a customer needs. This can only be achieved with the support of design, engineering, research, development, production and marketing departments within the company or project. Field studies were conducted in several engineering projects in Kuwait to achieve the general objectives of the study. Data for this study were collected based on research questionnaires and interviews. The data were then tested using a suite of statistical methods appropriate to the data type to study hypotheses. These descriptive statistical techniques include repetitions, arithmetic mean, and so on. It came to explain the data analysis and results and showed some tests of stability the used measure tool in that study, also description the whole study and the sample's characteristics and the methods of testing its hypothesis and analysis its results by using the suitable descriptive and deductive statistics methods by using the statistics program (SPSS), also it talked about the sources of data and information and it explained the questionnaire as a tool of developing the gathered to serve the study's goals data and in that chapter Likert scale was explained as a method of determining the degree of his agreement or disagreement with specific options and also it showed that there is a simple relation between target cost application and the ability to expect the proportions of financial failure for the Kuwaiti general engineering industries joint-stock companies. There are four categories for factors cost, and thirty activity cost. Using decision tree theory for estimating costs of engineering projects based on target costing approach. Using MATLAB application, the model was developed. The model presents the categories of activity cost, graphing all activity costs. The model also calculates the costs of project.

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