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Identification and Evaluation of the Influencing Factors in Target Value Design Process through an Industry Survey

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Abstract: Target value design is a new practice in the construction industry promoting concurrent engineering and collaborative design. This paper shows the results of literature survey to identify the influencing factors in the target value design. The paper also presents the results of a questionnaire survey to explore the industry practitioners' perception of the relative importance of the influencing factors. Project stakeholders participating in the survey consider the integration of different project stakeholders in the design phase as critical. The project definition is also regarded as essential in implementing the target value design. However, the market conditions and project attributes are considered as least significant in the target value design process.
Keywords: Target costing; Target value design; Influencing factors; Survey; Integration; Project definition.

1. Introduction

The construction industry globally has been viewed as highly inefficient. Most construction projects suffer from low productivity compared to production systems in other sectors. Industry experts have proposed innovation in various areas of industry's traditional practices in cost reduction [1]. A central concern of any organization is how to reduce project costs while improving productivity. However, cost reduction must be accomplished without impacting the ability of the organization to achieve its long-term goals. The real issue is how to manage the cost and reduce unnecessary cost [2].

Decisions made in a design phase influence project cost more than those in a production phase. In this regard, there are many cost reduction efforts in a design phase. Chief among them is the use of target costing (TC) techniques to ensure that the product is initially designed to have a sufficient profit [3]. In Japan, about 15% of the construction projects have adopted target costing for their cost planning and management. In the construction industry, target costing research has been carried out within the framework of lean construction as target value design (TVD) method [4]. Many research reports show that projects can achieve an average cost reduction of 15% if target value design is being applied systematically to the projects [5].

In the construction industry, target value design considers that the final cost is a design parameter driving product and process design while it is regarded as an outcome of the design process in the traditional design process [6]. In target value design, associated stakeholders including specialty contractors are involved in early design to develop target cost and determine design variables from the beginning of design phase. A target value design team could estimate costs for design alternatives while ensuring not to exceed the target cost. The team should be able to use different skills to maintain the target cost without impacting on the quality and the function of the project [7].

The review of the literature on target value design reveals that no formal study on the influencing factors is available to guide the process of target value design. In this regard, the goal of this study is to investigate the influencing factors in a target value design process.

2. Literature review

2.1 Target Costing (TC)

Target costing (TC) was initially developed in Japan after the first oil crisis in 1972. Since then the process of target costing has been improved and adapted [8]. Target costing aims to reduce the overall cost of products over the entire life-cycle making sure that product quality and reliability are guaranteed. Therefore, target costing controls the product attributes and respective production processes. Target costing can be efficiently implemented by controlling the design process through defining and analyzing different production-based on engineering-driven

alternatives. This analysis is denoted as Value Engineering (VE) and considered as a crucial part of the target costing process [9].

A study from Langfield-Smith asserted that target costing is prevalent in the manufacturing industry, not in other sectors [10]. Langfield-Smith [10] reviewed the diffusion of strategic target costing techniques over the past twenty-five years. The study [10] suggested that it would be useful to understand how target costing techniques are diffused into organizational processes.

Kato et al. [11] found that many corporations estimated costs in the product design phase. Since the initial successful application of target costing to a building project [6], the interest of using target costing methods in design phase has grown in the construction industry. Target costing has been renamed as target value design (TVD) when target costing was applied to the construction industry.

2.2 Target Value Design (TVD)

Traditional design and cost estimating process in the construction industry are sequential. A designer initially designs a facility and estimates it later. The sequential process results in non-value adding activities through negative iterations [4]. All too often, the project scope has to be altered to meet the project's budget. These iterations keep designers from delivering value to a customer while meeting the owner's requirements. Furthermore, the negative iterations create significant delay and waste.

In contrast, the application of target costing, which refers to 'design to target cost,' to design process enables a project team to develop the design outcomes that meet the project's budget (i.e., 'allowable cost'). Therefore, target value design helps a team avoid going over budget while delivering the features of a building that provides value to the owner. Since its inception, target value design has allowed multiple institutional projects to be completed on or below budget while adding value delivery to the customer [6, 12, 13]. As for their cost performance, a number of projects where target value design was explicitly applied have reported two persistent outcomes [14]: (1) The projects were completed below market cost, and (2) the estimated costs tend to decline as designs are developed.

2.3 Benefits and barriers

The use of target value design in the construction industry imposes many advantages that project stakeholders can benefit. Target value design is a management system focusing on cost reduction [11]. It also promotes the team spirit and collaborative attitude among competitors (owners and contractors) in construction projects. To efficiently implement target value design, companies should be able to overcome silo-minds and internal boundaries that each stakeholder set. Target value design is also a managerial practice which helps increase the speed of knowledge transfer and propel organizational changes by creating a culture of continuous improvement as well as enhancing employee awareness and empowerment.

Although the adoption of target value design promotes numerous benefits in the industry, there are still barriers and challenges. The main problem for target value design is that the construction industry is a limited competitive market. In other words, an exclusive market is not willing to use target costing that leverages market competitiveness [15]. According to Costa and Formoso [16], the construction industry has barriers that prevent the industry from adopting target value design as follows:

(1) construction is a project-oriented industry, and each project is unique in terms of project team and design;
(2) there are no clear guidelines in how project teams execute the process of target value design;
(3) every construction project is run by a different management team.

3. Literature survey on factors influencing the successful implementation of TVD

The study aims to analyze the target value design influencing factors through in-depth literature review. A comprehensive review of literature in the field was conducted with a view to identifying the factors affecting on the target value design process. The literature review found that there are thirty-two factors in five categories that impact on the target value design process.

3.1 Category 1. Market competition

Market condition is characterized by politics, law, economics, sociology, and technology [17]. Contractors have to maintain a long-term coordinated interaction with the local market and their competitors. The category of market competition includes five factors: the competitiveness of the construction market (V1) [17], social demand of the project type (V2) [18], the availability of reference project cost data (V3) [6], the availability of a reliable cost data (V4), and the availability of A/E and contractors capable of target value design process (V5).

These factors help determine the attributes of information on the competitors in the market analysis. These factors constitute a set of external determinants for contractors to consider in determining target costs on target pricing practices [17].

3.2 Category 2. Customer's attributes

This category of factors addresses the involvement of project owners in the target value design process. There are seven factors that represent the attributes of a customer influencing on the target value design process: plan on the customers of future projects (V6), experiences of similar target value design projects (V7), robustness of project requirements (V8), ability to define project requirements clearly in early design stage (V9), reasonable project requirement (V10) [24] , and timely responsiveness to requests from project stakeholders (V11).

3.3 Category 3. Means

This category of factors represents the project management tools that project stakeholders use to manage the target value design process. This category has six factors: BIM and simulations' tools (V12), process management tools such as the Last Planner System (V13), value engineering (V14), the use of decision-making tool such as Choose-by-Advantage (V15), risk management process (V16), and contractual arrangement for profit and risk sharing (V17).

3.4 Category 4. Project characteristics

This category of factors represents the characteristics of the project that is influencing the target costing process. The attributes of projects determine the level of uncertainty and the role of stakeholders which eventually play essential roles in the practices of a target value design project [18, 19]. There are five factors in this category: project complexity (V18), project size (V19), the level of uncertainty and degrees of risk (V20), project delivery method (V21), and project contract method (V22).

Table 1. Factors and their Variables Influencing on TVD Process

Category 1. Market Competition	
V1	Competitiveness of the construction market
V2	Social demand of the project types
V3	Availability of benchmark data for target price
V4	Availability of reliable project cost data.
V5	Availability of qualified A/E and contractors
Category 2. Attributes of Customer	
V6	Prospect of future projects
V7	Experiences of similar TVD projects
V8	Robustness of project requirements
V9	Ability of define project requirements in early design
V10	Reasonable project requirement
V11	Timely Response to requests from A/E or contractors
Category 3. Means	
V12	Technology tools such as BIM and simulations
V13	Process management tools such as LPS (Last Planner)
V14	Value engineering (VE)
V15	Decision making tools such as CBA (Choose-by-Advantages)
V16	Risk management process
V17	Contractual arrangement for profit/risk sharing
Category 4. Project Characteristics	
V18	Project complexity
V19	Project size
V20	The level of uncertainty
V21	Project delivery method (DB, GCCM, DBB, and IPD)
V22	Project contract method (Lumpsum, GMP, and Unit Price)
Category 5. Process and Culture	
V23	Degree of innovation
V24	Degree of early involvement of project stakeholders
V25	Level of stakeholders' commitments
V26	Cultural alignment of team organization
V27	Mutual respect
V28	Trust
V29	Stakeholder's relation and degree of cooperation
V30	Timely communication among stakeholders
V31	Develop parametric estimate
V32	Allowing time for feedback before commitment

3.5 Category 5. Process and culture

Literature suggests that the process and organizational culture influence the successful implementation of target value design [14, 20]. The category of process and culture has 14 factors: the degree of innovation (V23), the early involvement of project parties (V24), the level of stakeholders' commitments to target value design (V25), cultural alignment of team organization (V26), mutual respect (V27), trust (V28), stakeholder's relation and degree of cooperation (V29), timely communication among stakeholders (V30), accurate and conceptual estimate (V31), and allowing time for feedback before commitment (V32).

The full list and its source of each factor in five categories influencing the successful implementation of the target value design process are shown in Tables 1 and 2.

Table 2. The source of each Factor

	Cooper and Slagmulder 1997	Azari and Kim 2016	Lai et al. 2008	Drew and Skitmore 1992	Ballard and Reiser 2004	Tommelein et al 2011
Category 1. Market Competition						
V1	x					
V2				x		
V3					x	
V4	x					
V5					x	
Category 2. Attributes of Customer						
V6		x				
V7		x				
V8		x				
V9					x	
V10			x			
V11		x				
Category 3. Means						
V12					x	
V13					x	
V14						x
V15						x
V16						x
V17					x	
Category 4. Project Characteristics						
V18				x		
V19				x		
V20						x
V21		x				
V22						x
Category 5. Process and Culture						
V23		x				
V24		x				
V25	x					
V26		x				
V27						x
V28		x				
V29		x				
V30		x				
V31						x
V32			x			

4. Identifying Critical Factors through Survey

4.1 Questionnaire design and data collection

Survey research, particularly a questionnaire survey, collects data from a sample through a cross-sectional or longitudinal study with the objective of generalizing the results of the analysis to a larger population [21]. This type of research provides a quantitative portrayal of the trends or opinions of a community through studying a sample of that population [22].

To identify critical influencing factors on the successful implementation of target value design, we used the survey as a data collection method. The questionnaires for the survey were developed based on the factors identified through literature review. Those factors have potential impacts on the target value design process as well as the outcome of target value design. The questionnaires were piloted with two senior professionals to review the list for the accuracy.

The 32 factors were addressed in a questionnaire format for the survey. The questionnaire requests that a respondent judge the importance level of each variable on a predefined five-point Likert scale (5 = extremely important, 4 = important, 3 = neutral, 2 = unimportant, 1 = extremely unimportant). The survey request was distributed to 78 professionals who have experienced target value design process through an online survey tool. 26 responses were collected over a two-month period. The response rate is 33.33%.

Table 3 presents the role breakdown of each of the 26 respondents. Contractors made up the majority of the respondents, followed by designers and owners' representatives.

Table 3. Distribution of Questionnaire Response by Respondent Role

Respondent Role	# of Participants	Percentage
General Contractor	11	42%
MEP Contractor	2	8%
Owner's Rep	6	23%
Architect/Engineers	7	27%
Total	26	100%

4.2 Descriptive statistics

The questionnaire collected information on the level of influence of each factor on the target value design process. Descriptive statistics for the variables in the questionnaire survey (including sample size, mean, standard deviation, minimum, and maximum) are presented in Table 4.

4.3 Reliability of the influencing factors

The validity of survey data involves the consistency and repeatability of results using the same observations [21]. Although there are various measures of reliability assessment, internal consistency using Cronbach's Alpha is the most widely accepted measure [22].

Cronbach's coefficient alpha was employed to assess internal consistency of the scales under the headings of the influencing factors. In other words, the reliability of any given measurement refers to the extent to which it is a consistent measure of a concept, and Cronbach's alpha is one way of measuring the strength of that consistency [22, 23].

Table 5 shows the overall Cronbach's coefficient alpha on the data while Table 6 shows the Cronbach's alpha if each factor is deleted. Tables 5 and 6 provide evidence that all the factors had high internal consistency and considered reliable.

4.4 Rankings of the influencing factors

This section focuses on the ranking of the influencing factors. The ranking of the influencing factors was carried out based on their mean values. Table 7 shows the ranking of the influencing factors with the category information; Table 8 shows the ranking of the categories.

As shown in Table 7, all the mean values except two factors (V2 and V19) are more than 3.0, which suggest that most influencing factors identified through literature are regarded as essential in implementing the target value design process by all groups. Due to lack of responses or the sample size, the analysis by each stakeholder group has not been done.

From Table 8, an apparent finding is that the categories of customer attributes and process and culture were usually regarded critical among five categories. On the other hand, the categories of market condition and project characteristics are considered less critical in implementing the target value design process. The reasons why market competition and project characteristics are ranked low in this survey may include two issues. The first issue is that customer's demands are reflected in customers' attributes. The second issue is that most target value design process

begins in schematic design phase rather than in business planning. Therefore, most procurement processes of selecting major stakeholders are completed before the target value design process launches.

Table 4. Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
V1	26	2	5	3.5769	0.70274
V2	26	1	3	2.5385	0.58177
V3	26	2	4	3.2308	0.51441
V4	26	2	4	3.1154	0.43146
V5	26	3	4	3.4615	0.50839
V6	26	3	4	3.5769	0.50383
V7	26	3	4	3.6923	0.47068
V8	26	4	5	4.4231	0.50383
V9	26	3	5	4.0769	0.56022
V10	26	3	4	3.5	0.5099
V11	26	4	5	4.3462	0.48516
V12	26	3	4	3.7692	0.42967
V13	26	3	4	3.3077	0.47068
V14	26	3	4	3.6923	0.47068
V15	26	3	4	3.4231	0.50383
V16	26	2	4	3	0.4
V17	26	3	4	3.3846	0.49614
V18	26	3	4	3.3077	0.47068
V19	26	1	3	2.0769	0.48358
V20	26	3	4	3.3462	0.48516
V21	26	3	4	3.5769	0.50383
V22	26	3	5	3.6923	0.61769
V23	26	3	5	3.8077	0.49147
V24	26	3	5	4.2692	0.66679
V25	26	3	4	3.8846	0.32581
V26	26	3	5	3.9615	0.66216
V27	26	3	5	3.7308	0.60383
V28	26	3	5	3.9231	0.56022
V29	26	4	5	4.6538	0.48516
V30	26	3	4	3.5769	0.50383
V31	26	3	5	4.1154	0.5159
V32	26	3	4	3.4231	0.50383

Table 5. Cronbach's Alpha on all factors

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	No. of Items
0.707	0.699	32

Table 6. Cronbach's Alpha if each factor is deleted

	V1	V2	V3	V4	V5	V6	V7	V8	V9	V10	V11	V12
Cronbach's Alpha if each factor is deleted	0.72	0.7	0.7	0.71	0.73	0.68	0.73	0.7	0.69	0.69	0.71	0.68
	V13	V14	V15	V16	V17	V18	V19	V20	V21	V22	V23	V24
Cronbach's Alpha if each factor is deleted	0.7	0.69	0.7	0.71	0.7	0.69	0.7	0.71	0.71	0.7	0.7	0.67
	V25	V26	V27	V28	V29	V30	V31	V32				
Cronbach's Alpha if each factor is deleted	0.7	0.67	0.68	0.72	0.71	0.7	0.68	0.71				

Table 7. The ranking, the Influencing Factors

Ranking		Factor	Category	Mean
1	V29	Stakeholder's relation and degree of cooperation	Process and Culture	4.654
2	V8	Robustness of project requirements	Customer Attributes	4.423
3	V11	Timely response (owner)	Customer Attributes	4.346
4	V24	Degree of early involvement of project stakeholders	Process and Culture	4.269
5	V31	Developing parametric estimate	Process and Culture	4.115
6	V9	Ability to define project requirements in early design	Customer Attributes	4.077
7	V26	Cultural alignment of team organization	Process and Culture	3.962
8	V28	Trust	Process and Culture	3.923
9	V25	Level of stakeholders' commitments	Process and Culture	3.885
10	V23	Degree of innovation	Process and Culture	3.808
11	V12	Technology tools such as BIM and simulations	Means	3.769
12	V27	Mutual respect	Process and Culture	3.731
13	V7	Experiences of similar TVD projects	Process and Culture	3.692
14	V14	Value engineering (VE)	Means	3.692
15	V22	Project contract method (L/S, Unit Price, GMP)	Project Characteristics	3.692
16	V1	Competitiveness of the construction market	Market Conditions	3.577
17	V6	Prospect of future projects	Market Conditions	3.577
18	V21	Project delivery method (DB, GCCM, DBB, and IPD)	Project Characteristics	3.577
19	V30	Timely communication among stakeholders	Process and Culture	3.577
20	V10	Reasonable project requirement	Customer Attributes	3.500
21	V5	Availability of qualified A/E and contractors	Market Conditions	3.462
22	V15	Decision making tools such as CBA (Choose-by-Advantages)	Means	3.423
23	V32	Allowing time for feedback before commitment	Process and Culture	3.423
24	V17	Contractual arrangement for profit/risk sharing	Means	3.385
25	V20	The level of uncertainty	Project Characteristics	3.346
26	V13	Process management tools such as LPS (Last Planner)	Means	3.308
27	V18	Project complexity	Project Characteristics	3.308
28	V3	Availability of benchmark data for target price	Market Conditions	3.231
29	V4	Availability of reliable project cost data	Market Conditions	3.115
30	V16	Risk management process	Means	3.000
31	V2	Social demand of the project types	Market Conditions	2.539
32	V19	Project size	Project Characteristics	2.077

Table 8. Category Ranking

Category	Mean Value	Stand. Dev.	Ranking
1. Market Competition	3.185	0.405	4
2. Customer Attributes	3.935	0.411	1
3. Means	3.436	0.263	3
4. Project Characteristics	3.179	0.642	5
5. Process and Culture	3.900	0.365	2

From Table 7, factor 29 of "Stakeholder's relation and the degree of cooperation among stakeholders" was ranked the highest among all factors. This means that most survey participants who carried out the target value design process consider this factor as the most critical factor for the successful target value design process. In addition to factor 29, factors 24 (Degree of early involvement of project stakeholders, ranked 4th), 26 (Cultural alignment of team organization, ranked 7th), and 28 (Trust, ranked 8th) are the components required for project integration. The result is in line with the research outcomes on integrated project delivery process [20]. Azari and Kim [20] carried out their survey on integrated design process in which the cooperation and mutual trust are critical to the success of integrated design process.

It is also notable that the respondents have highly ranked factors 8 (Robustness of project requirements, ranked 2nd), 11 (Owner's timely response, ranked 3rd), and 9 (Ability to define project requirements in early design, ranked 6th). These factors are related to the owner's project definition, which is in line with the findings in the literature on design-build. Schaufelberger et al. [25] claim that the project definition by a project owner is one of the most critical success factors in design-build projects, which also promote concurrent engineering where the process design is carried out concurrently with the product design.

However, factors 19 (Project size, ranked 32th), 2 (Social demands of the project type, ranked 31st), and other factors in the category of market conditions or project characteristics are considered not significant compared to other factors. Most respondents rated them low. This reflects the view that market conditions or project attributes do not make a substantial impact on the target value design process.

5. Conclusions

Target value design is a new practice in the construction industry promoting concurrent engineering and collaborative design. The method is new and contradicts against the traditional way of design development in which each stakeholder (e.g., designers and contractors) work in a sequential and fragmented way as opposed to collaborative and integrated approach. As a result, many owners and service providers (i.e., designers and contractors) are concerned over the process and possible challenges.

Few studies appear to have undertaken the task of investigating the influencing factors in the target value design process. This paper shows the results of literature survey to identify the influencing factors in the target value design. The paper also presents the results of a questionnaire survey to explore the industry practitioners' perception of the relative importance of the influencing factors.

A total of 32 influencing factors were identified and synthesized in the survey, which was shown to be reliable based on Cronbach's coefficient alpha values. Data were collected from various stakeholders who went through the target value design process in their past projects. Since the target value design is not prevalent in the construction market, the number of respondents participating in the survey was only 26, which restricts the scope of statistical analysis.

Findings from the analysis suggest that most influencing factors identified in the literature survey are regarded as important in carrying out the target value design. Project stakeholders participating in the survey consider the integration of different project stakeholders in the design phase as critical. The project definition is also regarded as critical in implementing the target value design. The results suggest that the customer's demands are clearly defined and fully communicated with a team of target value design including designers and contractors from the beginning of the target value design process. However, the market conditions and project attributes are considered as least significant in the target value design process.

Overall, the results reflect that the organizational integration, as well as project owners' early project definition, are most important while market conditions and project characteristics are not considered critical. These findings should be useful to construction practitioners and project owners when they undertake the target value design in their projects.

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