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Deploying Value Engineering Strategies for Ameliorating Construction Project Management Performance: A Delphi-SWARA Study Approach

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Abstract: This study was carried out to rank and prioritize the aspects that have been shown to have an impact on the improvement of construction project management (CPM) performance based on value engineering. This analysis was carried out with the Iranian construction industry's current situation in mind. The respondents and the Delphi panel were chosen from among Iranian managers and project management professionals with a focus on building projects. These professionals had more than 20 years of experience working on international projects, and in addition to their expertise in project management, they also understood the principles of earned value analysis and value engineering. Thus, the components extracted from the literature review were used as the basis for designing a structured interview based on 39 important effective components previously determined as identified factors. The questionnaires were distributed among the experts, and the returned questionnaires were analysed using the SWARA technique to rank the weight and importance of the factors. Using the SWARA method, the opinions of the expert panel members consisting of 20 engineers and a semi-structured questionnaire was used to gather expertise in project management and managers, with a focus on Iranian CPM. As shown by the results, stakeholder management, time value of money, and worth, allocated the first to the third rank to themselves with respective weights of 0.104, 0.103, and 0.087. The sub-criteria of cost objective, function objective, and value objective were in the 37th to 39th ranks with respective weights of 0.00050, 0.00033, and 0.00021.

Keywords: value engineering; project management performance; construction project; earned value; SWARA method; Delphi technique

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1. Introduction

Over time, the careful and detailed planning of building projects has become an essential requirement for the successful completion of the project. Two key indicators in managing the performance of construction project management (CPM) are making the correct judgments and resolving issues based on relevant performance reports concerning the project implementation process. Nevertheless, prior research has not thoroughly examined these two variables, in spite of their evident significance in regulating exact project performance [1]. The people and organizations that are participating in the project or that are in some way impacted by its operations and who have a claim or ownership over the project are known as project beneficiaries [2]. Identifying the stakeholders and their requirements is crucial for the effective implementation of the project at every stage of its development. Establishing commitment as well as responsibility regarding the schedule is the primary goal of project management when deciding how project management works. This will ultimately reduce project delays and associated expenses [3]. According to the PMBOK, project management includes scope, quality, cost, and time objectives. The literature on project management considers quality, cost, and time as the main indicators for successful project performance [4]. On the other hand, the project management process includes the activities of initiating, planning, executing, monitoring, controlling, and closing. The successful implementation of any project is determined by the interaction of many processes, such as quality and resource management (optimising the utilisation of project resources), time management (prolonging the construction period), and cost management (identifying reasons for increased expenses). As a result, creating a workable solution is crucial. Value engineering (VE) is one such approach that aims to save costs and enhance project performance [1].

Despite being around since the mid-20th century, VE has not always been widely used in construction projects in underdeveloped nations due to a lack of understanding and confidence in the method among practitioners [5]. VE has shown effectiveness in reducing needless expenses while preserving the required levels of quality, safety, and dependability in several projects throughout the globe [6]. The link between function and cost is generally referred to as VE. When it comes to meeting or exceeding the customer's expectations, VE is defined as a systematic procedure that looks for ways to reduce needless costs without sacrificing the goal, performance, dependability, or other crucial variables [7]. It is the professional responsibility of the designer to assess all viable design options that fulfil the essential and desired function, such as but not limited to quality, safety, durability, etc., and to compare costs to determine which option is the most advantageous. Early in the development process, applying VE helps the project begin successfully and saves money [8,9]. Reducing the overall project construction costs by 10% to 30% can be achieved by using the VE technique [10]. The value engineering's goal in construction projects is to offer implementable strategies for problem solving, cost reduction, and quality improvement (performance); all of these depend on project function consideration; nonetheless, achieving the goal in the shortest amount of time is crucial [11]. Finding the sweet spot between function, quality, and cost in construction projects is the aim of value engineering. Increasing the value of construction projects is value engineering's main goal [12]. Value engineering is a useful strategy for managing costs, time, and quality when considering the implementation challenges seen in most construction projects [13].

For project managers, finishing a construction project on schedule and within budget is crucial [14,15]. On the other hand, a project completed after the deadline will have a detrimental effect on the sponsor's interests as well as the overall expenditures [16–18]. Earned value management (EVM) is a popular, simple method for monitoring and controlling project progress [19–23]. To assess the performance of the American Department of Defence in the 1960s, EVM was created [24–26]. EVM is a simple approach for project duration and final cost estimation. EVM can increase the precision of its estimations as the project moves forward by utilizing data on the length and expenses of its operations. As a result, researchers and project management experts are quite interested in EVM [27]. During the building stage, EVM makes it possible to measure the performance of construction projects in terms of both time and cost. Consequently, EVM allows project management to accurately track the amount of money and time allocated to the project at regular intervals, typically on a monthly basis. These permits allow for a response in the event that the project diverges from the initial costs and durations of the operations [27]. Predicting the total project length and construction cost for any kind of project is an intriguing result of using EVM [28–30]. As time has passed, further extensions have been put out to increase the precision of the project duration and ultimate cost projections [31–36].

By examining disparities and offering preliminary project performance indicators, earned value analysis is a standard, common, and effective technique for assessing a project's technical performance and determining the need for potential remedial actions [37]. If projects are launched well on schedule, they will significantly affect project marketing [38].

Non-renewable resources used in construction projects are building materials and consumables. If construction delays occur, these resources may become more costly [38], resulting in a construction project that is far more expensive than anticipated due to inflation. Therefore, higher-than-expected losses on the project would result from high-er-than-expected rates of inflation and high resource consumption costs [38].

Labour resources are renewable resources that can become more expensive if constriction is delayed. This might lead to a lack of economic rationale for the project because labour resources, such as personnel and machines, are part of the project [38]. The evaluation of engineering projects must appropriately account for the time value of the money invested because these initiatives demand financial resources [39]. Meanwhile, investments can be made for a predetermined amount of time at a predetermined interest rate and provide income. It is crucial to promptly turn money into valuable assets since, as time passes, interest accumulates and demonstrates that money may generate more money [1].

A construction project's economic feasibility should be assessed using engineering and economic assessment methods, such as value engineering, concerning the estimated costs and revenues before the project management procedures are initiated. The project's execution should be planned and overseen if it receives economic approval. Because of this, any project delay can change the projected costs depending on the criteria, requiring a revaluation of the project's economic justification. Under these conditions, the project's attractiveness rate may fall below the lowest acceptable rate, indicating that it is no longer financially feasible [39].

It is crucial to identify and investigate the key factors that influence the improvement of CPM performance through the use of earned value analysis-based value engineering. This is necessary for effectively evaluating project performance. The objective of this study was to identify the crucial factors that impact the improvement of construction project performance management through the utilisation of earned value analysis-based value engineering. Thus, to pinpoint important variables and accomplish study goals, the Delphi approach was applied together with a comprehensive analysis of the research literature. Through earned value analysis-based value engineering, project stakeholders may use the research findings to enhance their CPM performance [1]. Value engineering is a complicated process that demands careful consideration of numerous factors and the utilization of various strategies or instruments to ensure success and an appropriate outcome. As a result, even though value engineering has been around for more than a few decades and has achieved significant progress, there are still a lot of unexplored study topics and room for advancement [13].

The earned value approach is applicable to all current projects; however, different projects have different characteristics, such as being extremely expensive or having a limited duration. As such, certain earned value approach indications are more crucial for particular projects than others. Earned value estimates rely heavily on project progress reports, which are frequently imprecise due to the unpredictable nature of work progress data in most projects. However, the definite character of project information has been the main emphasis of every earned value analysis model introduced so far [37,40].

Studying the time value of money, equivalence, interest rates, the minimum appealing rate of return, and the rate of return on investment is crucial in engineering economics [41,42]. When the rate of return of a project exceeds the minimum acceptable rate of return, it is deemed economically feasible [43]. Using the Delphi technique and an earned value analysis-based value engineering methodology, this study aimed to rank the significance of the elements and factors influencing the enhancement of construction project performance management. Table 1 shows the influential elements in the enhancement of construction project performance management considering the earned value-based value engineering (EVVE) technique, based on a comprehensive review and analysis of the existing literature [1].

Table 1. Important variables that affect how well construction projects are managed using earned value-based value engineering.

Group	Criteria	Description	Sources
Engineering Economics (EE)	Time value of money	One fundamental premise of engineering economics is that the present value of a currency unit is greater than its future value. The concept of time worth of money states: currency experiences a gradual decline in purchasing power as time progresses.	[42–45]
	Equivalence	The value of money is dependent on the passage of time, and it varies as time goes on. When the economic value of different amounts of money at different times is equal, it means that the time value of money and the interest rate are balanced.	
	Interest	Cost refers to the monetary or rental payment made for the use of money or capital. The interest rate is determined by two variables: the principal amount of the loan and the duration for which the principal is utilised.	
	Interest rate	The term refers to the quantity of money that investors require in return for providing their investment funds.	
	Minimum attractive rate of return	The annual rate at which an investor is willing to invest in a project, contingent upon receiving the specified rate.	
	Attractive rate	The minimum anticipated rate is the yearly rate that demonstrates the equilibrium between expenses and earnings during a designated duration (the project's operational lifespan).	
	Rate of investment return	A crucial metric for assessing the effectiveness of an investment is the ratio of profit to the total expenditure and capital invested in a business.	
Project Management Performance (PMP)	Project stakeholder management	Stakeholder management is a methodical approach that involves the organisation, supervision, and improvement of relationships with individuals or groups that have a vested interest in a project or organisation. This process typically involves identifying the parties involved, evaluating their needs and desires, and subsequently developing and implementing a variety of activities to engage with them.	[46–53]
	Project resource management	Maximizing utilization and ensuring the best possible use of the project's elements.	
	Project scope management	To ensure the effective completion of the project, project scope management requires the application of particular procedures to include just the necessary work and avoid any unnecessary labour. The main goal of scope management is to define and control the limits and goals of the project.	
	Project planning	Project scheduling is a chronological representation of anticipated start and end dates for activities or events within a project or programme.	
	Project scheduling management	Efficient time allocation guarantees timely completion of projects. The process involves creating a comprehensive inventory of tasks, assessing their time requirements, strategizing, and closely tracking the advancement of the project. Time management encompasses the necessary actions to complete a project within the designated timeframe.	
	Project cost management	Project cost management involves methods to guarantee the project team completes work and tasks within budget. Project managers must clearly describe their projects, have realistic budgets, and estimate time and cost.	

Table 1. *Cont.*

Group	Criteria	Description	Sources
Project Management Performance (PMP)	Project management processes	From an administrative perspective, project management is responsible for planning, controlling, and executing projects. It specifically targets the initial phases of project management.	[46–53]
	Project management standards	Project management standards consist of a set of rules and principles that aid in the advancement and enhancement of a project.	
	Project management software	Teams and administrators consider project management software to be an essential and effective tool. Its purpose is to streamline the management of projects, teams, and individual tasks by facilitating their integration and centralization.	
Value Engineering Approach (VEA)	Worth	Assessing the cost of a function in relation to its value is the most effective method for research teams to identify opportunities for enhancing value.	[13,54–56]
	Value	Miles-defined product value as the ratio of its function to its cost. Function refers to the specific purpose or task that an object was designed to perform, whereas cost pertains to the amount of money required to acquire and maintain the item over its lifespan.	
	Use value	Positive attributes determine the utility value, which is the primary kind of value. These aspects ascertain the product's functionalities, utilisation, and objective. The primary objective of value engineering is to maximise the utility of a product. Consumers would not purchase the goods unless it had a practical value.	
	Esteem value	The use value of a product refers to its practical usefulness; however, customers may also discover additional intrinsic value that beyond this. Esteem value, although often associated with positive brand awareness, can also have negative implications and be associated with brand dissonance.	
	Exchange value	The final and tiniest component of value is the exchangeability of a product. In addition, a value engineer must possess knowledge of product distribution, physical characteristics, and other attributes that contribute to the ease of purchasing or selling a product. The difficulty of purchasing or acquiring the good might significantly diminish its value.	
	Cost value	Given a favourable producing use value, it is now necessary to contemplate the time required to produce that good.	
	Main function	It is a necessary action to meet the consumer's requirements. The primary justification for the product's existence is its fundamental functionality. The following query is a useful one for identifying the fundamental function: "will the product's purpose still be achieved if we remove this function?"	
	Secondary function	Features that are not among the primary functions but are utilised to attract consumers to the product/service. These functions extend beyond fundamental responsibilities and provide them with assistance. A product or service's secondary functions include reliability, convenience, and aesthetic appeal.	
	Unnecessary function	The elimination or reduction of unnecessary expenses that do not affect the scope, function, quality, attractiveness, or any other crucial features of projects.	
	Methodical function	Functionality that preserves the quality and integrity of the work while reducing costs.	

Table 1. *Cont.*

Group	Criteria	Description	Sources
Value Engineering Approach (VEA)	Value index	Function cost-to-value ratio. This ratio quantifies the potential for improvement in value. The most effective approach to assist research teams in identifying value enhancements is by evaluating the expense of a function in relation to its worth.	[13,54–56]
	Cost objective	Optimising cost while upholding quality.	
	Purpose of operation	Enhance product or service elements while maintaining cost efficiency.	
	Value goal	Enhance cost effectiveness and optimize quality simultaneously	
Earned Value Management (EVM)	Planed value	The planned value of a project refers to the budgeted cost during the project.	[31,40,56,57]
	Actual cost	The actual cost is the amount spent on a task up to a specific date or milestone. Labour, materials, and overhead are included in the project cost.	
	Predicted cost variance	The result of the ratio of cost variance to the planed scheduled to perform activities in a given period of time.	
	Cost performance index	Cost performance index represents the performance of the project cost and the efficiency of the project team regarding the use of financial resources.	
	Schedule variance (%)	Deviation of planned time scheduled for a project is the difference in time between the scheduled start and the actual schedule.	
	Schedule performance index	Project performance index is represents the performance of the project time and cost and the efficiency of the project team regarding the use of financial resources.	
	Schedule complete (%)	It describes the project progress and development from its planning to completion.	
	Project actual progress (%)	The actual progress of a project is documented and tracked from its initiation to its end, including numerous phases, milestones, tasks, and results.	
	Earned value	The concept of earned value is based on the understanding that every output in a project has a predetermined cost, which represents the real cost required to achieve that goal. Referred to as "earned value", this indicator represents the real cost of the effort and measures the value it has achieved.	

2. Research Methodology

The present research sought to assess and prioritize the aspects that influence the enhancement of performance management in construction projects using the EVVE approach. The study employs a hybrid methodology, including both qualitative and quantitative approaches, and utilises an exploratory paradigm-related approach. Because of the subject's originality and wide scope, the development phases should be determined based on the consensus of experts. Accordingly, a combination of qualitative and quantitative methods was applied, depending on the kind of data and its circumstances. Twenty engineers, project management professionals, and administrators with a focus on CPM made up the Delphi panel for the study population data examination. These professionals not only understood project management, but they also had over 20 years of experience and were knowledgeable about the principles of earned value analysis and value engineering. Stepwise weight assessment ratio analysis, one of the multi-criteria decision-making techniques, was utilized to rank and assign weights to the discovered relevant elements. Prioritizing the criteria that were found was carried out using the SWARA approach following purposive sampling, which was utilized in the study to pick the respondents to the survey that had been carried out by other researchers for comparable research issues. SWARA is a multi-criteria decision-making method that contributes significantly to the decision-making method. This technique was introduced by Kersuliene et al., who believed it could assess experts' opinions about the importance of criteria throughout their weight calculation process.

2.1. Delphi Technique

By removing unimportant variables, the Delphi method retains the primary factors and variables that have the greatest effects. The Delphi technique also helped to confirm the categorization of the identified factors, where the participants of the Delphi rounds were asked about the appropriateness of categorization of the factors. The factors had been categorized based on the research literature and the authors' knowledge. Although there are explicit guidelines for selecting experts to respond to the Delphi questionnaire, the quality of the experts is more significant than their quantity [58,59]. Therefore, experts and professionals with adequate knowledge and expertise on a related subject, enough free time to participate, and strong communication abilities are qualified for the Delphi survey [60]. Less than fifty experts, and frequently between ten and twenty, participate in the survey [61]. The quantity of experts is impacted by multiple factors, such as the objective of conducting the Delphi study, the quality of decision making, homogeneity, the degree of difficulty, external credibility, the competence of the internal research team, accessible resources, the length of data collection, and the scope of the problem under investigation (ibid). Hence, the components extracted from the literature review were employed as the basis for designing a structured interview, which has already been used for a similar study [1].

Formal, content, and structural validity were the criteria used to evaluate and validate the last components (Table 1). Using the respondents' opinions and the SmartPLS software, the questionnaire's construct and face validity were verified accordingly. The null hypothesis was validated with a 95 percent confidence level when the Kolmogorov–Smirnov test was employed to assess the normality of the research data. The test resulted in a significance level of >0.05 for the whole study questionnaire. The data distribution in the research variable was therefore normal, and every item and dimension employed contributed rather strongly to the increase in CPM performance using a value engineering technique based on earned value analysis. The significant level of the determined dimensions and indicators was less than the 0.05 ($p < 0.05$) threshold, according to Friedman's test, which was utilized to verify their significance.

2.2. SWARA Technique

Following the classification of the 39 discovered relevant elements using the Delphi survey, the stepwise weight assessment ratio analysis (SWARA) was employed to determine the priority of these factors. During this step, purposive sampling was utilised to select individuals.

Keršuliene et al. [60] have devised a novel approach of decision making called SWARA. This method is used to determine the weight of criterion [62]. The SWARA approach is employed by experts to initially prioritise the criteria based on their relevance. This is performed by assigning a score of one to the most significant criterion, and then ranking the other criteria based on average values and their relative importance [63]. The SWARA approach comprises the subsequent stages:

Stage 1: Ordering the criteria: The criteria should be ranked according to their importance. At this stage, experts rank the defined criteria based on their importance. For example, the first and the last ranks belong to the values with the highest and lowest importance, respectively, and the other values are placed in the middle range of the two based on how important they are.

Stage 2: Calculating the comparative value of every criterion (Si): The relative value given to every criterion in relation to the preceding criteria is determined in this step and represented by Si.

Stage 3: Estimation of the coefficient (ki): Equation (1) is used to determine the Ki coefficient, which is a proportion of the relative importance of every criterion:

$$Ki = Si + 1, \quad (1)$$

Stage 4: Determination of the recalculated weight of every criterion: Equation (2) is utilized to determine the initial weight of the criteria. The weight of the first criterion, which has the highest significance, is determined to be 1.

$$Wj = (xj - 1)/Kj, \quad (2)$$

Stage 5: Calculation of the normal final weight: Equation (3) is used to determine the final weight of the indicators, or the normalized weight, in the last step of the SWARA process. Normalization is carried out by the simple linear technique.

$$qj = wj/Sumwj, \quad (3)$$

As previously stated, the primary feature of the SWARA technique is the ability to assess the opinions of assessment teams or experts about the significance of indicators throughout the weight determination method [20,23].

3. Results and Discussions

This study used the Delphi technique and an earned value analysis-based value engineering methodology to identify important aspects that affect the improvement of CPM performance. This phase involves using the SWARA approach, a multi-criteria decision-making technique, to rank the aspects that the Delphi method discovered.

Stage 1: Criteria should be ranked according to their importance. At this stage, experts rank the defined criteria based on their importance. For example, the first and the last ranks belong to the values with the highest and lowest importance, respectively, and other values are placed in the middle range of the two according to their importance (Table 2). As highlighted by the experts' opinions, engineering economics, earned value management, project management performance, and the value engineering approach had the first, fourth, second, and third ranks, respectively (Table 3). The relative importance of each criterion compared with the previous ones is also indicated (Table 2).

Table 2. Sj coefficient.

Criteria	Sj
EE	0.000
PMP	0.144
VEA	0.116
EVM	0.156

Table 3. Relative importance of each criterion (Sj).

Criteria	Relative Importance
EE	1
PMP	2
VEA	3
EVM	4

Stage 3: Calculation of the coefficient Kj: The Kj coefficient, which is a function of the relative importance value of each criterion (Table 4), is calculated using Equation (4):

$$Kj = Sj + 1, \quad (4)$$

Table 4. Kj coefficient.

Criteria	Kj
EE	1.000
PMP	1.144
VEA	1.116
EVM	1.156

Stage 4: Calculation of the initial weight of each criterion: Equation (5) is used to determine the initial weight of the criterion (Table 5). It should be noted that the first criterion, which is the most significant, is equal to 1:

$$Wj = (xj - 1)/Kj, \quad (5)$$

Table 5. Initial weight of each criterion.

Criteria	Initial Weight
EE	1.000
PMP	0.874
VEA	0.783
EVM	0.678

Stage 5: Calculation of the final normal weight: The following formula is used in the final step of the SWARA technique to obtain the indicators' final weight, which is also known as the normalized weight: A simple linear approach is used to perform normalization.

$$qj = wj/Sumwj, \quad (6)$$

Following each step of the SWARA technique, the last weights of the criteria were determined (Table 6). The engineering economics, earned value management, value engineering strategy, and project management performance final weights were, in order, 0.3, 0.262, 0.235, and 0.081.

Table 6. Final normal weight.

Criteria	Final Normal Weight
EE	0.300
PMP	0.262
VEA	0.235
EVM	0.081

Table 7 presents the ranking of the project management performance sub-criteria. Based on the experts' opinions, stakeholder management, project resource management, and project management software were allocated the first, second, and ninth ranks, respectively.

Table 7. Ranking of the project management performance sub-criteria.

Criteria	Mean Ranking
Project resource management	2
Stakeholder management	1
Project management processes	7
Project scope management	3
Project timing management	5
Project management standards	8
Project scheduling	4
Project management software	9
Project cost management	6

Table 8 shows the weight calculation of the project management performance sub-criteria. As indicated, stakeholder management, project resource management, and project scope management had respective weights of 0.398, 0.238, and 0.144, respectively. Project management standards and project management software were in the eighth and ninth ranks with respective weights of 0.013 and 0.007.

Table 8. Weight calculation of the project management performance sub-criteria.

Criteria	Sj	kj = Sj + 1	Wj = (xj − 1)/Kj	qj = wj/Sumwj
Stakeholder management	0.000	1.000	1.000	0.398
Project resource management	0.675	1.675	0.597	0.238
Project scope management	0.655	1.655	0.361	0.144
Project scheduling	0.570	1.570	0.230	0.091
Project timing management	0.647	1.647	0.139	0.056
Project cost management	0.650	1.650	0.085	0.034
Project management processes	0.645	1.645	0.051	0.020
Project management standards	0.635	1.635	0.031	0.013
Project management software	0.705	1.705	0.018	0.007

Table 9 presents the ranking of the value engineering approach sub-criteria. As shown, worth and value were at the first and second ranks, respectively, while function objective and value objectives allocated the 13th and 14th ranks to themselves.

Table 9. Ranking of the value engineering approach sub-criteria.

Criteria	Mean Ranking
Use value	3
Worth	1
Cost value	6
Secondary function	8
Exchange value	5
Credit function	4
Value	2
Value index	11

Table 9. *Cont.*

Criteria	Mean Ranking
Methodical function	10
Function objective	13
Unnecessary function	9
Value objective	14
Cost objective	12
Main function	7

Table 10 shows the weight calculation of the value engineering approach sub-criteria. As indicated, worth, value, function objective, and value objective had weights of 0.369, 0.229, 0.014, and 0.0009, respectively.

Table 10. Weight calculation of the value engineering approach sub-criteria.

Criteria	Sj	kj = Sj + 1	Wj = (xj − 1)/Kj	qj = wj/Sumwj
Worth	0.000	1.000	1.000	0.369
Value	0.610	1.610	0.621	0.229
Use value	0.510	1.510	0.411	0.152
Credit value	0.565	1.565	0.263	0.097
Exchange value	0.640	1.640	0.160	0.059
Cost value	0.600	1.600	0.100	0.037
Main function	0.670	1.670	0.060	0.022
Secondary function	0.560	1.560	0.038	0.014
Unnecessary function	0.580	1.580	0.024	0.009
Methodical function	0.595	1.595	0.015	0.006
Value index	0.615	1.615	0.009	0.003
Cost objective	0.640	1.640	0.006	0.0021
Function objective	0.525	1.525	0.004	0.0014
Value objective	0.585	1.585	0.002	0.0009

Table 11 presents the ranking of the engineering economics sub-criteria. As shown, the time value of money and equivalence had the first and second ranks, respectively. Attractive rate and rate of investment return allocated the sixth and seventh ranks to themselves.

Table 11. Ranking of the engineering economics sub-criteria.

Criteria	Mean Ranking
Minimum attractive rate of return	5
Time value of money	1
Interest	3
Interest rate	4
Attractive rate	6
Equivalence	2
Rate of investment return	7

Table 12 shows the weight calculation of the engineering economics sub-criteria. As indicated, the time value of money, equivalence, attractive rate, and rate of investment return had final weights of 0.344, 0.234, 0.046, and 0.031, respectively.

Table 12. Weight calculation of the engineering economics sub-criteria.

Criteria	Sj	kj = Sj + 1	Wj = (xj − 1)/Kj	qj = wj/Sumwj
Time value of money	0.000	1.000	1.000	0.344
Equivalence	0.470	1.470	0.680	0.234
Interest	0.440	1.440	0.472	0.162
Interest rate	0.505	1.505	0.314	0.108
Minimum attractive rate of return	0.445	1.445	0.217	0.075
Attractive rate	0.630	1.630	0.133	0.046
Rate of investment return	0.470	1.470	0.091	0.031

Table 13 presents the ranking of the earned value management sub-criteria. As shown, the planned value and actual cost were in the first and second ranks, respectively. Project actual progress and earned value were in the eighth and ninth ranks, respectively.

Table 13. Ranking of earned value management sub-criteria.

Criteria	Mean Ranking
Project schedule progress	7
Schedule performance index	6
Planned value	1
Cost performance index	4
Schedule variance	5
Project actual progress	8
Actual cost	2
Earned value	9
Predicted cost variance	3

Table 14 shows the weight calculation of the earned management sub-criteria. As indicated, the planned value, actual cost, project actual progress, and earned value had final weights of 0.310, 0.226, 0.028, and 0.022, respectively.

Table 14. Weight calculation of the earned value management sub-criteria.

Criteria	Sj	kj = Sj + 1	Wj = (xj − 1)/Kj	qj = wj/Sumwj
Planned value	0.000	1.000	1.000	0.310
Actual cost	0.370	1.370	0.730	0.226
Predicted cost variance	0.555	1.555	0.469	0.146
Cost performance index	0.430	1.430	0.328	0.102
Schedule variance	0.390	1.390	0.236	0.073
Schedule performance index	0.340	1.340	0.176	0.055
Project schedule progress	0.405	1.405	0.125	0.039
Project actual progress	0.390	1.390	0.090	0.028
Earned value	0.285	1.285	0.070	0.022

Table 15 present the total weight and overall ranking of the sub-criteria, respectively. As highlighted, stakeholder management (0.104), time value of money (0.103), and worth (0.087) allocated the first to the third ranks to themselves. The cost objective, function objective, and value objective allocated the last three ranks to themselves with respective weights of 0.00050, 0.00033, and 0.00021.

Table 15. Total weight of sub-criteria.

Criteria	Weight of the Main Criteria	Sub-Criteria	Weight of Sub-Criteria	Final Weight	Overall Rank
EE	0.300	Time value of money	0.344	0.10312	2
		Equivalence	0.234	0.07015	4
		Interest	0.162	0.04872	8
		Interest rate	0.108	0.03237	12
		Minimum attractive rate of return	0.075	0.02240	16
		Attractive rate	0.046	0.01374	21
		Rate of investment return	0.031	0.00935	23
PMP	0.262	Stakeholder management	0.398	0.10431	1
		Project resource management	0.238	0.06228	6
		Project scope management	0.144	0.03763	10
		Project scheduling management	0.091	0.02397	14
		Project timing management	0.056	0.01455	19
		Project cost management	0.034	0.00882	24
		Project management processes	0.020	0.00536	28
		Project management standards	0.013	0.00328	32
		Project management software	0.007	0.00192	34
VEA	0.235	Worth	0.369	0.08658	3
		Value	0.229	0.05378	7
		Use value	0.152	0.03561	11
		Value of credit	0.097	0.02276	15
		Exchange value	0.059	0.01388	20
		Cost value	0.037	0.00867	25
		Main function	0.022	0.00519	29
		Secondary function	0.014	0.00333	31
		Unnecessary function	0.009	0.00211	33
		Methodical function	0.006	0.00132	35
		Value index	0.003	0.00082	36
		Cost objective	0.002	0.00050	37
		Function objective	0.0014	0.00033	38
		Value objective	0.0009	0.00021	39

Table 15. *Cont.*

Criteria	Weight of the Main Criteria	Sub-Criteria	Weight of Sub-Criteria	Final Weight	Overall Rank
EVM	0.2031709	Planned value	0.310	0.06298	5
		Actual cost	0.226	0.04597	9
		Predicted cost variance	0.146	0.02956	13
		Cost performance index	0.102	0.02067	17
		Schedule variance	0.073	0.01487	18
		Schedule performance index	0.055	0.01110	22
		Project schedule progress	0.039	0.00790	26
		Project actual progress	0.028	0.00568	27
		Earned value	0.022	0.00442	30

The Delphi-SWARA approach was employed to assess value engineering aspects that enhance the CPM performance. The complexity of many MADM techniques hinders their application. It is often better to use simpler assessment techniques than more complex ones. The SWARA technique is the most common method for ranking factors. The SWARA technique is transparent, simple to use, and quick in comparison with other hybrid MADM techniques, such as the ANP, AHP, and TOPSIS in PMC [64]. This method has been used by many other related studies, such as Sarvari et al. [65]. This analysis focused on the gained value in four sectors, as well as common areas, which are relevant to the subject of this research. The quality, cost, time, and scope of the project are the four primary indicators of project management. These indicators are also highlighted in the research results as the main factors determining management performance in the project. However, it is likely that throughout project implementation, you may encounter problems that vary in form and level of expectations. These challenges will arise due to the contributions of different stakeholders and the impact and role they have in the project. While these efforts may occasionally seem trivial, the subsequent influence they have will be considerable. The value engineering technique facilitates the creation of synergy and harnesses the benefits derived from the perspectives and input of project stakeholders. Beneficiaries are significant stakeholders of a project, and it is crucial to precisely identify their influence or authority over various aspects of the project. Most projects tend to be costly, intricate, iterative, distinctive, and accessible to the public. The timing for implementing the value engineering approach varies depending on the nature of the project. It can be applied at any phase of the project's development or creation cycle. However, the effectiveness of this strategy lies in the strategic utilization of innovative techniques at appropriate moments. The optimal time to initiate value engineering efforts is before, to plan implementation, and after design preparation. The process of executing a fruitful value engineering research has three stages: pre-study, study execution, and post-study introduction. To achieve the desired outcomes of the study, it is necessary to collect comprehensive data and information, take practical actions, and apply value engineering. Additionally, a methodology is needed to ensure the successful implementation of the proposed modifications, which would have substantial impacts. During the team's investigation, if new information arises, it may need revisiting prior phases. However, the value engineering team is strictly prohibited from eliminating any stage or step. To attain the desired outcome, it is necessary to consistently monitor and regulate the costs and time involved in carrying out the activities. Additionally, it is crucial to identify the reasons for any deviations from the anticipated values and to oversee the management's performance in order to enhance the project's progress. Hence, the implementation of the acquired value management technique in four key areas, including basic data, index deviations, and estimates, is crucial for achieving success in project performance review. Thus, in order to maximize chances, the primary performance indicators in the field of project management can be ranked using the value engineering technique. Subsequently, utilising the aforementioned prioritization derived from the evaluation of the obtained value, it is imperative to furnish indicators for the amalgamation, assessment, and juxtaposition of the advancement of the project's cost, time, and scope.

This study lays the foundation for future research that will focus on conceptual-mathematical modelling, integrating the value engineering approach into earned value engineering in construction projects, and designing and presenting new value indicators through a brand-new procedure called "proposal of change with EVVE strategy to make necessary decisions and take corrective measures, in line with the maximum and appropriate use of the project resources and the proper project functioning to enhance productivity". It is notable that since this research depends on the standard guide of the body of knowledge of project management to assess performance in all sectors, the results will not change extensively in other case studies and nations. It is also worth noting that the body of knowledge of project management is not a regulation but an international standard, which differs in their mandatory and optional implementation, as the former is mandatory, and the latter is optional. In addition, global standards are the common language for communication around the world, facilitating the advancement of project objectives. In addition to evaluating, measuring, and controlling CPM performance, this study also examined the success of these projects. Though there is a notable distinction between the 6th and 7th editions of the PMBOK in terms of value consideration, it is significant that the sections and even knowledge fields examined in the present research were based on the 7th edition of the PMBOK standard and may need to be modified in accordance with the next edition. To put it another way, the 7th edition looks for the reason behind the project; therefore, identifying the value the project is meant to provide is essential before thinking about the project management procedures. PMBOK 7 emphasizes that during the project implementation, the goal should not be to finish the project by any means, but the considered value should be created regardless of the time and cost.

The improvement of successful management performance in construction studies happens when the process is implemented practically. The implementation of the mentioned process for a coherent work requires the identification of effective components and a detailed examination of the relationship between them in the four areas of PMP, EVM, VEM and EE in order to ensure that the relationship between the factors and the areas specified above during the life cycle of the project has been well seen. Process-oriented implementation can improve management performance, and it requires paying attention to many limitations in hidden parts in the fields of PMP, EVM, VEM, and EE, and using various available techniques and tools.

Identifying and establishing mutual communication between the influential components and different stages of the project yard cycle and considering the demands and prioritized expectations of each of the stakeholders. Improving project management in order to achieve specific performance goals in construction projects with a value engineering approach based on earned value analysis is only possible with appropriate strategy and planning. It can be said that process-oriented implementation along with the analysis and measurement of technical performance combined with theoretical topics appropriate to the scope of construction projects will increase the efficiency and eliminate the reproducibility of the study. In order to improve the performance of project management and its process-oriented implementation, in a practical way, the integration of the components in the four areas and creating coherence between them will improve or even maintain the quality level, reduce time, reduce costs and eliminate unnecessary costs. This also results in increasing the efficiency of the theoretical framework and inputs as the main data and output of the process during the project yard cycle.

Therefore, by transforming the process-oriented theoretical framework or the theory of management performance in construction projects with the value engineering approach based on the analysis of the acquired value in practice, while creating scalability and creating compatibility between quality, cost, time, or the triangle of the project and the scope of the project, i.e., the limitations, the improvement in management performance in construction projects will increase. The four areas are the key elements or the main indicators of project management and performance in projects i.e., 39 effective components in the four sections, which also increase the improvement of management performance in construction projects.

Applying value engineering strategies to improve the performance of construction project management with the Delphi-SWARA study approach to create better processes is a systemic approach, proposing better systems. However, this is not an easy task, and it is possible to conduct studies, review and make sufficient connections in future studies while finding relevant key elements, continuous feedback, and closing and expanding the topic. Collecting and indexing these data and key elements can effectively increase the chances of successful implementation of continuous process orientation to maintain the benefits of implemented processes to improve management performance in construction projects. Figure 1 shows that in the different stages of the whole life cycle of the construction project, the factors affecting the performance of project management are dynamic. Figure 1 shows that although the groups and indicators examined are important in all stages of the project life cycle, but they are more important in some stages.

Figure 1. The importance of the groups and indicators in the stages of the project life cycle. Theoretical framework to improve construction project management performance through value engineering approach.

The diffusion of innovation refers to the process of transmitting novel ideas through certain communication channels [55]. The Rogers framework is a practical framework that provides guidance to policymakers on how to adopt the identified contributing strategies if they choose to utilize the value engineering method to enhance CPM. Several research have utilised Roger's diffusion of innovation attributes to investigate the application of technology, policies, and other related factors. This section establishes a theoretical framework by using Rogers' [66] diffusion of innovation theory and the critical resilience techniques derived from the existing literature. Shibeika and Harty [67] utilised Rogers' diffusion of innovation theory to analyse the spread of digital innovation in the construction industry in the United Kingdom. Gledson and Greenwood [68] employed Rogers' innovation theory to examine the implementation of 4D BIM in the building sector of the United Kingdom. Ampratwum et al. [69] employed Rogers' innovation diffusion idea to construct a framework for the implementation of green certification of buildings in Ghana. In addition, Osei-Kyei et al. [70] utilised Rogers' diffusion of innovation theory to investigate the implementation of public–private partnerships in enhancing urban community resilience. The list of contributing strategies in CPM performance is considered under the concept of value engineering. This means the community must first accept the value engineering approach as a medium to improve CPM performance. Some studies have acknowledged the importance of using the value engineering approach to improve CPM performance. But how can this implementation of the value engineering approach improve CPM performance? By using Rogers' diffusion of innovation attributes, these contributing strategies for using the value engineering approach to improve CPM performance can be used to demonstrate their viability. In this theory, the factors influencing the adoption of the value engineering approach for improving CPM performance are explored and infiltrated into the conceptual framework presented in Figure 2. These influencing factors include relative advantage, compatibility, complexity, trialability, and observability. As mentioned previously, the five factors are borrowed from Rogers' [66] diffusion of innovation theory, and they are considered as the perceived characteristics of an innovation that affect its adoption. Even though the value engineering approach is not a new concept, its usage in improving CPM performance may be described as a new concept.

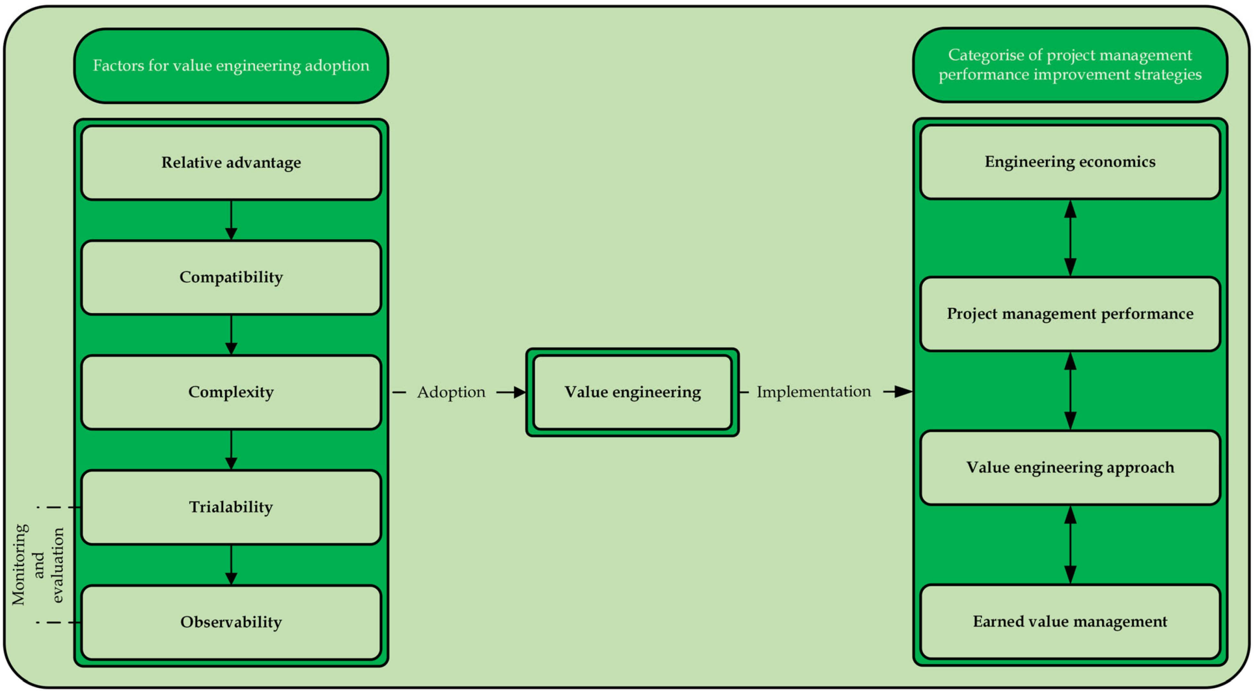

Figure 2. The conceptual framework for using a value engineering approach in improving CPM performance.

4. Conclusions

The present research was conducted to prioritize and rank the influencing CPM performance factors through the EVVE strategy with the Delphi method using a multi-criteria decision-making method. Therefore, the components extracted from the research literature were used as the basis to design a structured interview. Questionnaires were distributed among the experts to collect their opinions, after which the SWARA method was used to analyse expert opinions, identify the weight and importance of the influential factors, and rank them. With corresponding mean weights of 0.300, 0.262, 0.235, and 0.2031709 for the primary criterion, engineering economics, project management performance, value engineering method, and earned value management ranked first through fourth, according to the research findings.

The research results included prioritization and ranking of the influencing CPM performance factors through the EVVE strategy, leading to the identification of 39 final influential factors. According to Table 15, stakeholder management, time value of money, worth, equivalence, planned value, project resource management, value, interest, actual cost, project scope management, use value, interest rate, predicted cost variance, project scheduling, credit value, minimum attractive rate of return, cost performance index, schedule variance, project timing management, exchange value, attractive rate, schedule performance index, rate of investment return, project cost management, cost value, project schedule progress, project actual progress, project management processes, main function, earned value, secondary function, project management standards, unnecessary function, project management software, methodical function, value index, cost objective, function objective, and value objective have the respective ranks of one to 39 based on SWARA ranking. In theoretical terms, effective factors on the CPM performance improvement through the EVVE strategy is a new and emerging concept, especially since the research literature review shows that few studies have investigated these factors.

There are few limitations to this study. By always concerning the method adopted, i.e., the Delphi technique, it has inner reliability and validity limits. In particular, the reliability problem of the Delphi study (i.e., two or more different groups of experts can lead to different results even if facing the same questions/phenomena) was considered; and the criteria for qualitative studies—i.e., truthfulness, applicability, consistency and confirmability—were followed to ensure that credible interpretations of the findings are produced [71]. As Keeney et al. [72] stated, following these criteria cannot totally limit the involvement of different panels that may lead to obtaining the same results. Despite that, results emerging from the Delphi study can be considered reliable, in as much as the best (in terms of knowledge and expertise) possible panellists are involved. However, it is true that this study involved a small number of Iranian experts, even though their expertise was in line with the study's aims and that this number is similar to works in the same field adopting the Delphi method [73]. Future studies should increase the validity of the results through interviewing a larger group of experts or expanding their scope to that of other developing countries. Additionally, comparing the results of similar studies conducted in developed countries to that of developing countries could lead to interesting results. Furthermore, the socio-demographic characteristics of the experts participating in the initial phase of identifying factors can play a role through their opinions regarding the existence and/or importance of certain risk factors. Therefore, an interesting future prospect will be to carry out future quantitative studies based on the Upper Echelons Theory literature [74], regarding the effects of socio-demographic characteristics and/or other psychological variables on the definition and evaluation of the criteria at the individual and group levels. Regarding the limitations of the present study, it is crucial to note that the researchers were compelled to depend on experts who were pertinent to the research objectives and technique, leading to restraints in the sample size. This constraint is frequently observed in research [75], as evidenced by several studies in which the size of the sample and the factors related to sampling have a substantial influence on the capacity to apply and trust the findings. Hence, future research should prioritise the use of more thorough sample size planning to guarantee efficient and dependable results. Finally, customizing implementation strategies to fit CPM situations can improve the relevance and impact of study findings.

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