The Factors Affecting on Earned Value Management

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Abstract. Earned price management (EVM) is an associate degree business customary for observance the performance of in progress comes. The performance baseline is about up within the coming up with part to live any time and value deviations throughout project execution. EVM solely focuses on the project schedule (SPI) and value (CPI), and doesn't address alternative vital aspects of quality, Risk, safety and social factors. Therefore, this paper will explain the statistical study aims to know the most important factors that affect in implementation of EVM in a construction project in Iraq and it will be consisting of two main tools which are the assessment of the questionnaire and checklist to obtain real weights affecting the Iraqi construction projects. There is a need for understanding all affecting factors on estimate at completion in EVM. This will develop the equation of EVM. It will be necessary to study affecting factors to achieve major factors of EVM. Based on previous studies and interviews, 207 influential factors were identified. After the first questionnaire, the number was reduced to 73. Based on the interviews with experts, weights were determined and the most influential factors were 37 and were adopted as a checklist.

Keywords: Earned value, cost factors, time factors, quality factors, risk factors, safety factors, and social factors.

1. Introduction

The construction industry is mixed with uncertainty risk in several comes. The important part of the project is to complete among the calculable times, value with expected quality is that the predominant goals of the project management. However, essentially a variety of attributes varied \( \text{of varied \{of assorted\}} \) varieties and a range of constraints involve from time to time that need to be managed with success by overcoming various obstacles. Completion of the development project involves many factors and attributes of varied varieties contribute to their extent of impact on the project. These factors were known by consultations with consultants and active engineers excluding reviewing literature. In this section, the most important indices affecting the EVM are shown in Fig. 1 will be discussed in detail and these factors are cost, time, quality, risk, safety, and social aspect and will explain each factor briefly during this chapter and the impact of each factor on EVM Thus improving the estimate at completion [1, 2].

2. Factors Affecting EVM

2.1. Cost factor

Cost management is bothered by the method of designing and dominant the budget of a project or business. It includes activities like coming up with, estimating, budgeting, financing, funding, managing, and dominant prices so the project will be completed inside the approved budget [3]. Price management covers the total life cycle of a project from the initial coming up with part towards activity the particular
price performance and project completion. Several value estimating strategies is applied to predict what proportion it'll value to perform the project activities. The selection for the estimation methodology depends on the amount of data on the market. Analogous estimating mistreatment the particular value of previous, similar comes will function a basis for estimating this project [4]. Remaining uncertainties in estimates which will probably end in extra value is lined by reserving value (e.g. mistreatment step-up and contingencies).

They are several factors touching on the value of comes, however, the analysis can specialize in the foremost powerful factors within the estimate at completion in EVM, together with the policy and needs of the leader and company policy, quality assurance of processed materials, and Economic facet. Economical management of finances is that the key think about dominant the overrun of the project. A disciplined approach got to be adopted within the management of the budget and value of activities to ascertain the project cost. Most of the price studies reviewed suitably specialize in the differential cost of EVMS compliance and coverage. The “normal” prices of operating an internal control system aren't thought-about relevant as a result of they might be incurred within the absence of associate demand for an earned worth management system [5].

![Figure 1. The affecting factors on EVM modified by the authors [1].](image)

2.2. Schedule factor
Schedule management needs the active involvement of all project participants to stay up on concerning the standing of the project and any delays which will impact schedule performance. A Schedule Management arrange ought to contain all of the subsequent major elements:

- Baseline Schedule Development and Approval.
- Schedule Analysis and Coordination.
- Schedule Changes and Revisions.
- Schedule Delay Mitigation designing [6].

In the observation of the development business designing and programming could be a vital task to be performed by the old planners. However, the programing is usually applied either supported time or value and consequently termed to be value bound schedule and time-bound schedule betting on the kind of project [7]. Most of the time, the resources and their accessibility play an important role, and therefore value bound programming is most generally used and once circumstances secure for the completion of the project at intervals the time, then all activities are back worked to fulfill the completion time. Consequently, the resources are allotted, leveled, and optimized for the most effective utilization of
resources further as project time length. However, in observe the programming could be an advanced task involving variable attributes and also the assessment of their impact on the project [8].

2.3. Risk factor

Project risk management is important to the success of the project because it deals with uncertainty in two situations: the first is the threat (negative impact) the second is the opportunities (positive impact). This issue includes a group of various sub-factors betting on their importance, that depends on the character of the project, as well as the standard of the land in terms of suitableness and talent to resist construction, the presence of groundwater, the shortage of infrastructure resulting in the location and monetary aspects like delays of advances by the leader and wages of staff for businesses, high material prices… etc.

EVM is an element of Project Time Management and Project price Management information areas, whereas Project Risk Management could be a different information space with no apparent relation with the previous ones, though the basics of EVM square measure influenced by risk management [9]. This analysis seeks to clarify the mechanisms of this relation, to boost this relationship, a variety of things moving the EVM were enclosed as index (RSI) in the equation of estimate at completion. PRM and EVM have similar objectives, i.e., providing info regarding the factors moving the project performance. However, no framework exists for the interconnection of the results obtained from every technique. Because the same issues square measure self-addressed by each tool, there's a great deal of interest in combining their results. If the PMB of a project consists of well-equated risk factors, uncertainties will be expected and a more robust EAC will be forecasted [10].

2.4. Quality factor

Quality management in construction comes could be an important issue because it is meant to make sure that the development project has been completed among the desired specifications and planned with the constrains (time and cost) [11]. Quality could be a very important consider EVM. The target of Quality earned price (QEVM) is to live the projectability to deliver the standard necessities outlined by the project’s neutral, throughout the project execution. Therefore, the standard is taken into account in the third part of earned price Management [12]. It focuses on providing pictures of the project potency to deliver the project quality necessities supported the used time and spent value (actual costs) [13].

Project management aims to deliver comes on time, with the united scope consistent with mere needs, inside the planned budget. This scope, schedule, and value constraints are known as triple constraint or project triangle. The project triangle implicitly covers the standard and assumes that scope suggests that scope with quality. It’s not therefore applicable to bundle scope with quality in contrast to the opposite forms of comes. Even the task is completed, and scope target is achieved, it would need several iterations on the task to repair the bugs, improve the options and then on. They’re tightly connected however not precisely along, from the close relationship between quality and EVM, we found several factors that have a high impact on the calculations of the estimate at completion in EVM. These factors include analyzing the costs of quality and its applications. Planning, controlling, and improving strategies based on quality work, conforming materials to specifications, conforming work to quality specifications… etc.

2.5. Safety Factors

Safety management is a crucial management perform and desires to be controlled expeditiously on a project. Earned worth technique (EVM) is one in every of the popular strategies employed in the dominant construction project. Safety statistics ought to be reported within the same manner as price, schedule, and quality. The authors found the need to consider the impact of safety factors in the calculations of the estimate at completion in EVM. The most important factors are personal safety (the provision of safety equipment), lack of training when using new machinery, providing emergency exits in buildings, the development of an escape map indicating the exits, and the development of signs by the Civil Defense…etc. Several researchers have emphasized the importance of safety. According to [14], safety must be an integral part of the company's procedures. It is noted that many construction companies follow the ‘Zero accident’ or ‘Zero incidence’ policy [15].
2.6 Social Factor
The social aspect has recently become one of the influential aspects of projects as it must pay attention to the culture of society, customs, and traditions, and this interest is evident in international companies in their activity outside their countries. In contraction projects, the user and occupier are going to be either public or personal generally. The society contains users further as project participants. The support of the society is extremely crucial within the project completion. Society as an entire could object, protest, and hinder the development method in obtaining clearances and moving the lands, materials, and machinery. Within the case of the general public comes the land acquisition and their cooperation is extremely a lot of needed [1].

3. Methodology

3.1 Data Collection
It will be collecting the data by two stages as following:

3.2 Open Questionnaire and Interviews
In such cases of the research type questionnaire survey is an effective method to seek a large sample size for quantitative data analysis. The researcher based on previous studies and interviews with experts to discuss the main affecting factors. who develop and add factors to the factors that the researcher already has, 207 influential factors were identified. Table 1 will describe the characteristics of the experts.

| Scientific Qualification | No. | Specializations       | Experience         |
|--------------------------|-----|-----------------------|--------------------|
| Ph.D.                    | 6   | Civil engineers       |                    |
| MSc                      | 5   | Civil engineers       | More than 20 years |
| BSc                      | 7   | Civil engineers       |                    |

3.3 Closed Questionnaire
After the completion of the questionnaire form, it has been distributed to the sample. Research sample consists of A group of engineers, project managers, and heads of departments in government departments that perform or finance the implementation of projects or who have a scientific and practical experience in this field. the questionnaire divided into two parts, the first part is about personal information and the second part to identify the influence of the affecting factors by using a Likert scale. Based on analysis results of Questionnaire, and according to relative important index (RII) value, the experience cousins the value of (0.7) will be the threshold, therefore, any factor has RII over (0.7) will be concerned and any factor has RII less than (0.7) will be neglected. Finally, the researcher developed 73 factors that had been identified as the most affecting factors. Then the second round of interviews had been connected to filtration and prioritize the factor resulted in a shorter list consist of 37 factors.

3.4 Distribution of the Questionnaire
The questionnaire offers an exact formulation of the items, suitability of the area to be measured, and getting the arbitrators validity. The form has been distributed to the target sample that consists of one hundred respondents. The distribution method is in 2 ways:

- The form is directly distributed to the participants, wherever the research worker offers straightforward information regarding the study and its objectives. This technique is taken into account as a perfect within the follow-up of form and to induce results that adjust to reality. The direct meeting technique includes sixty-six respondents; they kind half of 1 mile from the entire variety of the participants.
- The form is indirectly distributed to the participants through the web, wherever it's distributed ten forms. The research worker conjointly offered straightforward clarification regarding the study
and its objectives. the total form forms that square measure collected during this method square
measure solely vi forms, and solely five of them don’t come back.

Thus, the study gets sixty-six complete and proper forms from the entire variety that is one hundred.
The two-part written form was the most instrument of knowledge assortment. half one wanted general
data regarding the non-public characteristics of respondents, like qualification profile, category of their
organizations, and years of expertise, amongst others. partially 2, the respondents were requested to rank
these factors and criteria for achievement. The on top of literature review in previous chapters provides
the theoretical basis for developing the analytical framework for this study according to its vital in
keeping with a five-point Likert scale (1–5) where:

1) There is no effect
2) A failing grade
3) Median degree
4) High degree
5) Very high degree

The analysis of the factors and its importance done by using (SPSS statically program), using the
resulting information in building the mathematical model and software to improve the EVM
implementation Extract the weights of success factors and criteria for success deduced from
questionnaire survey which is built on a proposed system to check and improve EVM implantation.
Table 2 shows the number of questionnaires.

| Description                      | Total number | Percent, % |
|----------------------------------|--------------|------------|
| The total number of questionnaires distributed | 100          | 100        |
| Collected questionnaire          | 66           | 66         |
| Questionnaire without response   | 34           | 34         |

3.5. The Second Part (The Influences of The Main Axes)
The second part of the questionnaire consists of six axes: cost, time, quality, risk, safety and social from
this part the researcher has been identifying the effect of all factors on the projects in Iraq.

3.6. The Third Part (Study Axes)
The third part (Study axes) of the questionnaire consists of six axes, the first (The cost axis) consists of
29 factors, and the second (The time axis) consists of 22 factors, and the third (The quality axis) is made
up of two-part first case there is a system of quality follow and consists of 23 factors and second case
there is no quality system consists of 11 factors, and the fourth (The risk axis) consists of 38, and fifth
(The safety axis) consists of 40 factors, and sixth (The social axis) consists of 13 factors. Questionnaires
were distributed to some governmental institutions specialized in the creation and project management
and The National Investment Commission, Services Department of the martyr's Foundation, The
Ministry of Education, The Ministry of higher education and The Ministry of water resources in Iraq,
the Ministry of Construction and Housing, the University of Baghdad University of Technology, and
the University of ALrafdain), and after that was the explanation thorough and take advantage from the
sample in the development of the form and answer all their questions were selected 100 Engineer
(identified by the Supreme departments), of all ages and disciplinary, managerial positions, of both
gender, then received 76 forms and there were 10 forms are not clear and a section of questions
unanswered about or answered unrealistic so it has been deleted from the accounts and we relied on 66
any form by the response to the amount of 70%. The researcher has been analyzed the data, and identify
the honesty and reliability of the sample. Then show how extract Weights and importance of the factors
and calculated (mean, standard deviation the Relative important index Alpha Z Distribution).
3.7. Statistical Analysis of the Questionnaire Data

Data collected from surveys were analyzed using various statistical techniques including descriptive statistics, Z test, reliability analysis. SPSS for Windows version 25 and MS Excel were the basic software tools used to analyze raw data. Before presenting the results of statistical analyzes in the following chapters, the minimum criteria and justification for applying these tests are discussed in the following sections. Reliability and validity take into account because the most significant methodology conditions for analysis tools style. Therefore, it should be provided the dependableness and validity of the form before any applied math analyses for knowledge.

4. Validity and Reliability

4.1. Validity

It is one of the necessary conditions for building the tests, standards and honesty demonstrates the extent to measure the paragraphs of the phenomenon to be measured, and that the best way to measure honesty is the virtual honesty, which is to present the paragraphs of the scale on a group of experts to rule on its validity, was achieved sincerity ostensibly scale of through the presentation of paragraphs to a group of specialists in the field of construction project management as all the paragraphs and the factors and criteria listed in the questionnaire belong to the field.

4.2. Reliability

It is a measure of consistency in the results as giving the same results after its application twice in two different times on individuals themselves, stability was measured as flowing: Coefficient (alpha) for Internal Consistency: The Alpha coefficient provides us with a good grade in most situations and adopt this method on the consistency of the individual performance of a paragraph to another and extract stability according to this method was the use of all forms search of (66) form. Table 3 shows the values of reliability and validity according to Cronbach's alpha for each factor in the questionnaire.

| No. | Factor      | No. of Item | Reliability* | Validity |
|-----|-------------|-------------|--------------|----------|
| 1   | Cost        | 43          | 0.929        | 0.963    |
| 2   | Time        | 22          | 0.891        | 0.943    |
| 3   | not found system | 25    | 0.969        | 0.978    |
|     | Found system | 12          | 0.925        | 0.962    |
| 4   | Risk        | 38          | 0.926        | 0.962    |
| 5   | Safety      | 52          | 0.969        | 0.984    |
| 6   | Social      | 13          | 0.851        | 0.922    |

*(Cronbach's Alpha)

4.3. Likert Scale

A psychology response scale chiefly employed in questionnaires to induce participant’s preferences or degrees of necessary the issue on the EVM application. The respondent's square measure asked to point their assessment to the impartation level for every issue by exploitation Associate in Nursing ordinal scale [16]. Likert Scale was Associate in Nursing ascend order to make sure the participant review all choice to elite their rate in additional accurse. The design of form is predicated on it the solution of every question that is one in all 5 choices. So, the Likert Scale Quintet is employed. it's typically coming into values (weights) as within the Table 4 [17].

Table 4. Likert scale Quintet weights.

| Opinion | | There is no effect | A failing grade | median degree | high degree | very high degree |
|---------|---|-------------------|-----------------|---------------|-------------|-----------------|
| Weight  | 1 | 2                 | 3               | 4             | 5           |                 |
4.4. Z Test

This statistical examination is useful in ascertaining the sample that participated in the questionnaire, it has a degree of dependability to be used to predict the results of the research in general. The value of (Z calculated) for each category was found using the following equations:

\[
\bar{x} = \frac{\sum_{i=1}^{k} x_i \cdot f_i}{k \cdot f_i}
\]

where:
\(\bar{x}\): Arithmetic Mean
\(x_i\): Degree of the criterion’s importance
\(f_i\): The Frequency

Calculate the standard deviation for respondents for each criterion based on the following equation:

\[
S = \left[ \frac{1}{k \cdot f_i} \sum_{i=1}^{k} (x_i - \bar{x})^2 \cdot f_i / (\sum_{i=1}^{k} f_i) \right]^{1/2}
\]

where:
\(S\): Standard deviation
\(X\): Arithmetic Mean
\(Xi\): Degree of the criterion importance
\(f_i\): The Frequency

\[
Z = \frac{\bar{x}}{S/\sqrt{n}}
\]

where:
\(X\): Arithmetic Mean
\(S\): Standard deviation
\(n\): Size of the sample

If Z calculated > Z tabular, then accept the results of the questionnaire
If Z calculated < Z tabular, then reject the results of the questionnaire.

4.5. The Relative Importance Index (RII)

The relative importance index could be a statistical procedure to see the ranking of various factors. A formula is employed to rank the foremost cogent factors on EVM supported frequency of incidence as known by the specialists. The ratio index formula is shown below:

\[
RII = \frac{\sum W/A \cdot N}{A}
\]

where \(W\) = weight given to each factor by the respondents; \(A\) = highest weight, i.e., 3 in this case; and \(N\) = total range of respondents [18]. The issue with the very best rank indicates that it’s the most frequency of incidence on the EVM whereas the issue with all-time low rank indicates that it’s the smallest amount frequency of incidence on the EVM. By victimization SPSS program (version 25), the mean of all factors are calculated, and RII are calculated by the equation No.4. The researcher adopted RII value (0.7) as a limit between that influential and non-influential factor on EVM and it achieved the expert’s consensus.

4.6. Design and Development of the Assessment Checklist

After conducted statically analysis and review the results, a checklist has been developing, it consists of six-axis and 37 factors. The authors made another interview that reduced factors to 37 factors as shown in Table 5.
### Table 5. Axes and factors of statical characters.

| Category | No. | Factors                                                                                   | Mean | RII  |
|----------|-----|--------------------------------------------------------------------------------------------|------|------|
| Cost     | 1   | Policy and requirements of the client                                                      | 3.55 | 0.709|
|          | 2   | Policy and experience of the company                                                      | 3.89 | 0.779|
|          | 3   | Price changes (marital, labor, equipment)                                                  | 3.67 | 0.733|
|          | 4   | Errors in estimated quantities.                                                            | 3.52 | 0.703|
|          | 5   | Funding and factors affecting it: provide financial liquidity to contractor                 | 3.98 | 0.797|
|          | 6   | Funding and factors affecting it: The Company has access to banking facilities              | 3.64 | 0.727|
|          | 7   | Funding: grants or loans                                                                   | 3.61 | 0.721|
|          | 8   | Funding: governments financing                                                             | 3.56 | 0.712|
|          | 9   | Funding: private financing (private banks)                                                 | 3.52 | 0.705|
|          | 1   | Rise production capacity through: Increasing labor force                                    | 3.77 | 0.755|
|          | 2   | Rise production capacity through: Increase machines and equipment                          | 3.79 | 0.758|
|          | 3   | Rise production capacity through: Increase the number of working hours                     | 3.64 | 0.727|
|          | 4   | Rise production capacity through: Raising the skill of the workforce                       | 3.79 | 0.758|
|          | 5   | Quick completion of work                                                                   | 3.91 | 0.782|
|          | 6   | Effect of the management method on the delay of completion of the project                   | 3.56 | 0.712|
|          | 7   | The effect of the (economic situation) factor on the delayed completion of the project     | 3.61 | 0.721|
|          | 8   | Availability of money liquidity and exchange rate                                          | 3.71 | 0.742|
|          | 1   | Reduce the cost of acquisition and the raw materials.                                      | 3.56 | 0.712|
|          | 2   | Contribute to strengthening the competitiveness of the institution                         | 3.52 | 0.700|
|          | 3   | Matching materials to specifications                                                       | 3.65 | 0.730|
|          | 4   | matching work to quality specifications                                                    | 3.58 | 0.715|
|          | 5   | Does the organization conduct internal audits periodically to determine the conformity of the quality management system to ISO 9001 - 2015? | 3.58 | 0.712|
|          | 6   | Does the employer take the necessary procedures to remove the causes of nonconformity and prevent its recurrence? | 3.61 | 0.712|
|          | 1   | The quality of the land is not appropriate in terms of its ability to withstand construction or because of its other characteristics. | 3.83 | 0.767|
|          | 2   | Lack of infrastructure connected to the place of execution such as roads or inadequate place of implementation. | 3.89 | 0.779|
|          | 3   | Delay payments to local companies from the employer                                         | 3.73 | 0.745|
|          | 4   | Financing cut off unexpectedly by local companies                                          | 3.73 | 0.745|
|          | 5   | The high prices of materials necessary to carry out civil works in construction sites due to economic conditions | 3.82 | 0.764|
|          | 6   | Difficulty accessing project sites due to security situation                               | 3.65 | 0.730|
|          | 1   | Provide adequate personal safety equipment (gloves, glasses, helmets, etc.) on-site         | 3.68 | 0.736|
|          | 2   | Does the use of new machines affect the provision of appropriate training?                 | 3.52 | 0.703|
|          | 3   | Do accidents occur due to lack of safety standards in construction companies                | 3.50 | 0.700|
|          | 4   | The safety officer, if any, or the implementing contractor shall be responsible for the laying down of guiding plates by the approved design of the Civil Defense, indicating to the site's employees or non-employees the risk of the site according to the nature of the executed works. | 3.52 | 0.703|
|          | 5   | Are buildings adjacent to the drilling work supported if there is a potential for impact on these works? | 3.79 | 0.758|
|          | 1   | Project size                                                                               | 3.68 | 0.736|
|          | 2   | Reliance on local labor                                                                   | 3.65 | 0.730|
|          | 3   | The impact of social customs and traditions on the region                                  | 3.65 | 0.730|

5. Conclusions
The conclusions from the current study can be summarized by the following points:

- Definition of the factors of the participants in the following techniques: open interviews with experts and the questionnaire respondents.
- The researcher conducted an open interview with the experts to assist in the construction of the questionnaire.
- The questionnaire consists of 207 factors; these factors have a significant impact improve EVM to the results of interviews with experts.
- Perform a set of statistical operations on the questionnaire results to find reliability and type of data distribution. Compute the mean and Z Distribution and RII to see the trend of answers and the statistical significance respectively.
- Once the applied mathematics analyses are finished, the investigator mentions the explanations that have a big impact on rising EVM, that area unit seventy-three factors.

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