كلية الهندسة بشبرا
FACULTY OF ENGINEERING AT SHOUBRA
ERJ
ISSN:1687-1340

ENGINEERING RESEARCH JOURNAL (ERJ)
Volume (52),Issue (2)
April 2023, pp:186-193
https://erjsh.journals.ekb.eg

Developing a progressive model for managing Project Contingency reserve

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Abstract: Project cost contingency has been studied in several scholarly communities interested in project management. Numerous references have discussed its methods of estimating and modelling in the preliminary planning phase of the project while concluding version zero of the project management plan. In such a phase, project potential risk is assessed quantitatively to calculate a monetary allowance to handle project risk effects in the event that they occur and become a real issue. However, for a project management environment, there are not enough familiar practices that discuss or present a comprehensive methodology to simply and robustly manage it throughout the project execution phase. Also, the responsive decisions that should be taken to deal with its status, whether it turns out to be adequately estimated or not, have not been discussed or studied enough before.This paper is aiming to present a simple and robust method to help project managers perform such a function, depending on the widely used earned value method (EVM) to measure performance throughout execution at selected points of accomplished control account.
Depending on embedding an index that expresses the project risk within the performance measurement process The concept of risk performance index (RPI) as a reflection of the relationship between pre-assessed quantitative risk during the planning phase and real-world risk that has become an issue is similar to the widely used concept of monitoring project performance by earned value, which takes into account cost performance index. The cost performance index (CPI) is a ratio of planned to actual costs, while the schedule performance index (SPI) is a ratio of two time-oriented values. This study will present a proposal for a risk performance index (RPI) to express the impact of project risk on project performance and to better manage project risk, which will be a ratio of two risks (pre-assessed during the project planning phase and actual occurring risks). The contingency budget management process was investigated. This was done via an integrated analysis of available standards provided by internationally recognized project management associations (PMI, IPMA, PMA, etc.) and the pertinent scholarly literature, in particular an analysis of literature on contingency management, which was developed based on the idea that it is a consistent and conducive methodology to deal with this topic. All past proposed models depend on original project cost estimation, expert judgment, or both for risk analysis. So the validity of these models depends on the accuracy of estimates and unbiased opinions from experts. Tremendous effort is required to collect pertinent and correct information for model inputs, and when the risk environment changes, the process must be restarted to obtain the correct information.

Keywords: Contingency Reserve, Risk Performance Index, Overall Risk, Earned Value Analysis.

1. Introduction

Recent studies have focused on applying different quantitative methods to assign contingency before a project starts resulting in a version zero of both the contingencies and contingency plan . While tendering phase the planner should assert that all risks have been recognized and that risk contingency or risk exposure limits have been set [1] . A large project can last for years and requires cost contingency measured in millions while holding the whole contingency in reserve from the project beginning without monitoring it periodically could possibly limit the number and size of projects which a company could invest in and undertake. This puts a constraint on company investment and growth [2].

2. Literature Review

Project risk is an uncertain event or set of circumstances that if it occur, will have an effect on the achievement of the project's objectives [3]. According to [4] each project includes individual risks that affect the achievement of project objectives; furthermore, it is important to consider the riskiness of the overall project, which arises from the combination of individual project risks and other sources of uncertainty. Project Risk Management processes address both levels of risk in projects, and these are defined as follows:

Individual risk is an uncertain condition that, if it occurs, has a positive or negative effect on one or more project objectives. Individual risks are evaluated in the qualitative risk analysis. But the quantitative analysis allows us to evaluate the overall project risk [5].Overall Risk is designed to answer the question of how risky is the project, it measures the riskiness of the overall project as a whole rather than individual uncertainties that might affect the progress of the project. The overall risk is not just the sum of the individual risks [6].

The most widespread challenge that always confronts project managers is ensuring that the right amount of contingency is allocated to the project, and this should obviously be a risk-based decision. An analysis of the overall risk exposure of the project should provide

information on the range of possible project outcomes, allowing the organization to decide how much contingency is appropriate at the various levels in order to give the required degree of confidence in project success [7]. When it comes to overall project risk, a contingency reserve is also applicable to the overall project.

Escalated risks are managed at the program level, portfolio level, or other relevant parts of the organization, and not on the project level [8]. The surest way to deal with a high-impact risk is to avoid it completely. One familiar avoidance response is to modify the project scope [9]. Risk transference is the contractual shifting of a pure risk from one party to another. One example is the purchase of an insurance policy, by which a specified risk of loss is passed from the policyholder to the insurer [10], And finally, mitigating aims to reduce the probability of occurrence and/or impact of a threat like conducting more tests, or choosing a more stable seller and may also involve prototype development. Active acceptance strategy of project risk is appropriate for low-priority threats, it is adopted where it is not possible or cost-effective to address a threat in any other way [11]. The most common active acceptance strategy is using a contingency reserve, including amounts of time, money, to handle the threat if it occurs. Contingencies are crucial to achieving project objectives by included in development budgets to provide managers with the required ability to address risks that threaten achievement of project objectives [12]. A very popular contingency reserve example within world history according to Australia parliament house public web site is an allowance within the Commonwealth budget for Events that the government reasonably expects to eventuate, but cannot allocate to specific programs. Quantitative risk analysis is the only dependable method to assess overall project risk through evaluating the aggregated effect on project outcomes of all individual project risks and other sources of uncertainty, its outputs are used as an input to plan risk responses by nominating the optimum response in order to confront project overall risk [13]. It is systematic methodology for identifying and quantifying contributions to the overall risk of a process [14] . It is a numeric estimate of the overall effect of risk on the project objectives such as cost and schedule objectives, its results provide insight into the likelihood of project success and are used to develop contingency reserves [15]. Once calculated, the contingency reserves are added to the schedule and budget estimates within the project baseline. As more precise information about the project becomes available, the contingency reserve may be used, reduced, or eliminated.

Earned Value analysis is an important tool to measure the performance of a project [16]. The successful integration of Earned Value Management and Risk Management can provide more realistic Earned Value assessments and better estimates related to the completion of the project [17]. Earned value management and project risk management are integrative, both of which are key aspects of the project management discipline [18].

3. Methodology

Past literature which has discussed the cost contingency reserve management will be reviewed, past trials to update it has been discussed and studied thoroughly to select and benefit from the nearest and the more useful past exerted efforts and to build the paper's philosophy on it, then proposing a model to update it throughout project execution depending upon Adjusting earned value analysis to consider the risk performance index (RPI) beside the two common indexes of it (CPI) and (SPI) to conclude improved estimate at completion.

Adopting in especial way [16] idea of developing a framework that imbed (RPI) within other earned value indexes to conclude an improved (EAC), consequently such concluded value of (EAC) will not only consider the deviation of project budget and schedule from the approved baseline, but it will also consider how the occurred project risk that has become an issue is far from the quantitatively pre – assessed project overall risk.

A survey in the survey monkey platform is being performed with taking in consideration categorizing the audience with respect to their discipline, experience in the project management field, periodic length of their experience, technical specialization and the organizational classification has been targeted also to foster the following model hypothesis:

Weights of indexes, Risk performance index supposed formula, Decision-making time station, and also model decisions to be taken in accordance to improved VARIANCE AT COMPLETION (VAC), then it is planned to test its reliability by statistical analysis.

Aforementioned questionnaire is a part of a wider survey that has targeted (212) respondent represents (58) questionnaire respondent, (53) telephone call interviews, (61) face to face interviews and (40) focus group performed with 50 % of the respondents were project managers, 9 % are portfolio managers, 7 % were program managers, 22 % were head-office team members and finally 12 % were planners.

A percent equals 96% of respondents agreed the hypothesis that embedding risk performance index (RPI) can lead to an improved estimate at completion (EAC), 84 % of respondents agreed the hypothesis that such aforementioned index can be calculated as a ratio between pre-assessed contingency and due actual contingency, 68% of respondents agreed that the actual contingency reserve equals actual cost minus row estimate of project activity, and finally 59% of respondents has agreed with the hypothesis of keep the weights of indexes constants equal to the arithmetic mean of each index within the four quarters of the project concluding that weight of cost performance index (WCPI=0.43) , weight of schedule performance index (WSPI=0.32) and the weight of risk performance index (WRPI=0.25) constantly throughout the entire project path Finally discussing the factors affecting decision making potential strategies to deal with negative and positive values of variance at completion.

4. Model development

This research proposes a model for project cost contingency management to enable monitoring its status progressively. The model aims to enhance the use of newly available earned value information as the project progresses by adopting idea by embedding a performance indicator expresses project risk influence - risk performance index (RPI) in addition to other familiar indexes CPI and SPI [16].

Such a model can be described as a justified earned value analysis process that includes considering risk influence formalized into a form of (risk performance index) as a ratio between two contingencies, such a modification introduces a clearer insight to risk monitoring activities and project cost contingency reserve status provides opportunities to monitor contingencies at project chosen milestones, definitely every accomplishment of control account as it is considered a management control point where project performance can be measured [19] and to positively or negatively take corrective or preventive action like re-allocate appropriate contingencies at different next project phases if needed, introduced the following formula for improving estimate at completion (EAC) considering risk influence.

In order to help project manager use the proposed model, the model is intended to be introduced by an easy, simple and common software like excel, the proposed spreadsheet is demonstrating the phases of processing the project data like actual cost (AC) within planned value (PV) and earned value (EV) of the monitored work package to produce project information like cost variance (CV) , schedule variance (SV) , schedule performance index (SPI) , cost performance index (CPI) in addition to integrating the newly added risk performance index (RPI) . By variance analysis and earned value analysis an improved value of estimate at completion is concluded (EAC improved), such a value is different from the common value presented by recognized references of project management as it takes in consideration the impact of project risk that concluded from embedding (RPI) within (EAC) formula presented by [20].

Traditional equation:-

"EAC = AC + [(BAC – EV) / (CPI * SPI)] " [19] **(1)**

Proposed equation:-

"EAC improved = AC + [(BAC – EV) / (WCPI + WSPI + WRPI)] " [20] **(2)**

And by extension, in order to prepare project reports includes monetary status of the project after accomplishing every work package, variance analysis is performed to get the potential deviation of the total project budget at completion (BAC), such a deviation is formulated as variance at completion (VAC) .

"VAC = BAC – EAC" [19] **(3)**

"VAC = BAC – EAC improved " [20] **(4)**

The following figure shows a presentation to the proposed model, the higher row of the table shows the stages of processing the project data to conclude the project information which will be included in project reports .It is also shown that in the right of the table the decision making stage that is built upon the aforementioned project reports.The unique and emerged issue in such a model is embedding project risk performance index (RPI) in a separate column to be included in calculating estimate at completion value . The figure shows that project performance is measured by earned value analysis at every accomplishment point of work packages according to concepts of (PMBOK 6) and the familiar best practice, it is also shown as the time station decision making about contingency reserve status at every end point of major project control account highlighted in gray color .

model for monitoring contingency reserve through earned value formula taking risk performance index in consideration

no.	work break down structure (WBS)			collected project performance data and recall planned value for work package			Project information extracted from earned value								project report			decision making		
							improved earned value management considering risk impact considering that CPI and SPI influence the remaining work								Variance at comletion(VAC)			Contingency status		
	control account	planning package	work package	Pv	Ev	Ac (including contingency)	work backage cost estimate(with out considering contingency) (ROW PLANNED VALUE (RPV)	CV	SV	CPI	SPI	due contingency الاحتياطي المستحق بالفعل	original contingency	RPI	improved EAC	BAC- improve EAC			+	-	zero
							RPV	EV-AC	EV-PV	EV/AC	EV/PV	AC - cost estimate for work backage= AC -PPV	known	due contingency / original contingency	AC+ ((BAC-BCWP)/ WCPI +WSPI+WRPI)	+	-	ZERO			
1	civil work	reaching founadation leve	survey																efficient estimate , redirect the excessive value to another coninge nt effort or conside r as a project	ineffecien t estimate (need to draw from managem ent reserve or wait tii next control point	optimum estimate of cost,time and contingencie s
			soil investigation																		
			concrete foundation																		
			fill aronnd foundation																		
		reinforced concrete elements	skeleton																		
			slab on grid																		
			protection layer above insulatio n																		
		various work	thermal insulation surface																		
			moisture insulation surface																		
			moisture insulation bathroom																		
			surface tiles																		
	A control account is a management control point where project performance can be measured (PMBOK 5 - WBS DEFINITION)														+	-	ZERO			
	TOTAL SUMMATION for earned value terms of civil works														value of variance			decision		
2	internal	electrical	rough - in electrical																		
			install the terminal																		
			HVAC equipment																		
			lightning																		
		plumping	rough - in plumping																		
			set plumping fixtures																		
			test and clean																		
	A control account is a management control point where project performance can be measured																			
	TOTAL SUMMATION for earned value terms of civil works														value of variance			decision		

Fig 1: proposed model for updating contingency reserve

4.1 Concluding risk performance index (RPI) :

The strategy adopted in this paper is different from that adopted by the predecessor trials. The difference lies in the following the same way of calculating both (CPI) and (SPI) to calculate (RPI) , using such a concept enables project team to deal with project risk not only as a pre-assessed value but also as a measurable parameter that could be measured in any project milestone . As overall project risk can be expressed in a monetary value as the term of contingency reserve, and since the project contingency reserve can be calculate in any project milestone. Then (RPI) can be calculated by a methodology similar to the way that is used to calculate (CPI) and (SPI).

Pre-authorized contingency reserve that has been already added to row work package estimates is a clear expression of the whole project risk that has been quantitatively assessed by the planner. Analysis of the project overall risk exposure should provide information on the range of possible project outcomes, allowing the organization to decide how much contingency is appropriate at the various levels to give the required degree of confidence in project success [7]. Consequently, a ratio between pre-planned contingency and actual due contingency can be considered a ratio between pre quantitatively assessed risk and real occurred risk that has become an issue. Such a conclusion can lead to a risk performance index in a similar way of calculating (SPI) and (CPI).

$$RPI = \frac{\text{Due contingency reserve relates to issue happened}}{\text{Pre-assigned contingency}} \quad (5)$$

4.2 Decision-Making Time Stations

Adopting the introduced hypothesis from [20]. Index values for each quarter of project completion are used to forecast a better EAC. Suggestion that the relative importance of KPIs changes significantly based on lifecycle stages. Incorporating this insight, stations from 0 to 100% to CPI, SPI, and RPI during the four quarters of physical progress of the project, i.e., 0–25%, 26–50%, 51– 75%, and 76–100% can be nominated a decision points about dealing with variance at completion status (VAC).

4.3 Flow diagram for decision-making direction due to variance at completion (VAC) status:

The following figure shows a flow diagram for decision making process within the proposed model, improved estimate at completion and updating cost contingency reserve during project execution depending on the risk performance index concept According to running the aforementioned model, monitoring (VAC) values.

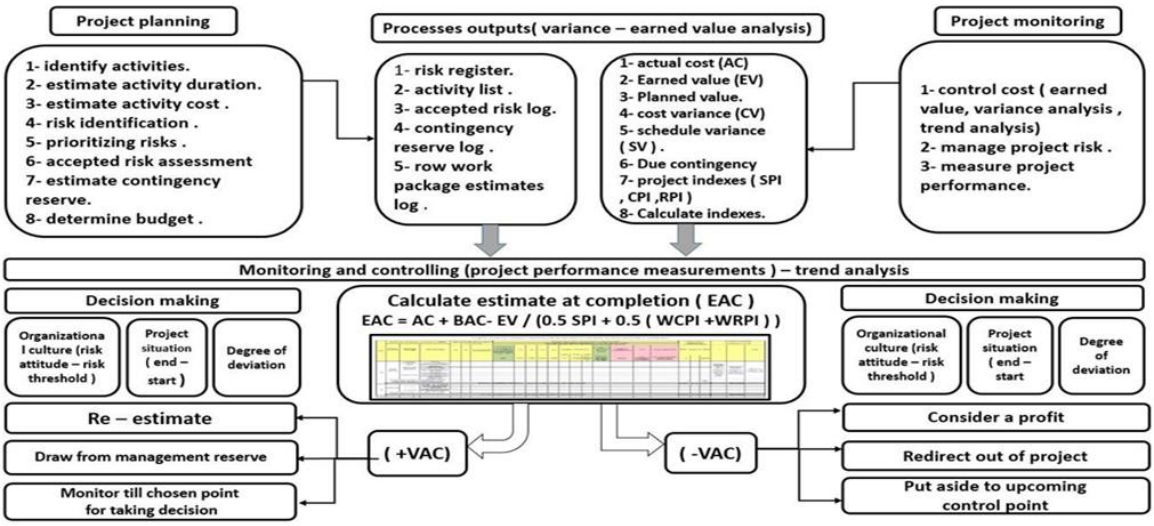

Fig 2: proposed Contingency reserve management model flow diagram managing

Variance at completion value is vital to decision making process, its status show how accurate the estimate is, how efficient the project performance is and how adequate the estimate of the contingency reserve is.

The figure above demonstrate three strategies to deal with positive value of (+ VAC) which means that there is a problem that project seems to be above budget and three strategies to deal with negative value of (- VAC) which means that project is under budget . The pre – mentioned survey has also explored such an area, in both cases it is likely to still monitoring in 25 % accomplishment of the project. In 50 % accomplishment in (+VAC) value leads to drawing from management reserve while (-VAC) value leads to putting a side till the upcoming control point. In 75 % accomplishment,(+VAC) leads to still drawing from management reserve or re –estimate the residual part of the project within formal control board , while (-VAC) leads to considering such an excessive values as a profit or redirecting it to be allocated to another project budget .

4.4 Weight of Indexes

Considering convergence in weights values of assigned weights of performance indexes introduced by [20], the following table shows the considered weight of each index within four project quarters as a completion points and decision making stations.

Table 1: Weights of Performance Indexes with in Four Project Quarters [20].

Weight of performance index Project phase (by quarter)	Weight of cost Performance index (WCPI)	Weight of schedule performance index (WSPI)	Weight of risk Performance index (WRPI)
0 – 25 % completion	0.4209	0.3011	0.2780
26 – 50 % completion	0.4200	0.3209	0.2951
51 – 75 % completion	0.4355	0.3171	0.2471
76 – 100 % completion	0.4365	0.3207	0.2607

4.5 Contingency Reserve-Related Processes in Sequence

As project management is integrative, the process of managing contingency will interfere with several managerial processes and will extend through iterative project phases, the following table shows the managerial processes those are usually intersects with contingency reserve management to take such a relationship into consideration while estimating its magnitude and managing it throughout the project, the following processes are directly affect and affected by contingency reserve.

Table 2: Contingency Reserve Related Process according to PMBOK 6TH edition

No	Process	Output
1	Identification of activities	Activity attribute – activity list
2	Estimate activity duration	Planned value (PV)
3	Estimate activity cost	Actual cost (AC)
4	Risk identification	Risk register
5	Qualitative risk assessment	(list of low-priority risks – accepted risks log Passive acceptance strategy:- contingency reserve)
6	Quantitative risk assessment	List of authorized cost contingencies allocated to work packages.
7	Budget determination	List of row estimates of the work package.
8	Control project cost	CV,SV ,CPI , SPI, RPI, improved EAC, VAC
9	Monitor project risk	Modify cost contingency, and point of redirect.

5. Model stages

5.1 Obtaining work performance data

Raw observations and measurements are collected while directing the project work process in execution resulting in actual cost incurred in the activity (AC) [21] to be compared against pre-planned values (PV) for the judged activities divided into halves expressing raw estimate in addition to pre-assigned contingency reserve log will be taken in consideration, also budget at completion will be useful in every following steps.

5.2 Perform Variance analysis.

In Monitor and Control Project Work, the variance analysis reviews the variances from an integrated perspective considering cost, time, technical, and resource variances about each other to get an overall view of variance on the project to initiate corrective or preventive action.

Variance analysis, as used in EVM, is the explanation (cause, impact, and corrective actions) for the cost

" (CV = EV – AC), and schedule (SV = EV – PV) " [19] (6)

5.3 Calculate Due contingency (DUE CONT).

Expresses the real reserved amount of budget that should be allocated to the work package Estimate to confront emerged risks, real due contingency express the contingency that should be already allocated to the raw estimate of the work package, which could be calculated by the following Equation.

Real due contingency = actual cost - work package raw estimate. (7)

The SPI is calculated by Equation: " SPI = EV/PV ". [19] (8)

By the same token, a CPI value of less than 1.0 indicates a cost overrun for work completed. A CPI value greater than 1.0 indicates a cost underrun of performance to date. The CPI is equal to the ratio of the EV to the AC.

"CPI = EV/AC ". [19] (9)

5.4 Calculate Risk performance index (RPI)

To get a measure of the contingency reserve efficiency, and enable the project team to monitor project risk performance, and contingency reserve status, the paper will consider that RPI is equal to the ratio of the due contingency reserve (DUE CONT). To the pre-authorized contingency (AUTH CONT).

RPI = AUTH CONT. / DUE CONT. (10)

5.5 Calculate improved Estimate at completion (EAC)

Forecasting improved (EAC) will follow the familiar formula with embedding weighed risk performance index with considering the following weights of indexes are taken into consideration adopting those values introduced by [20]

5.6 Calculate Variance at completion (VAC):-

"(VAC = BAC – EAC) " variances in the pre–detected points for every work package.

6. Case study.

To verify the proposed model, the developed formula is applied to data obtained from the completed construction projects of erecting an administration building in the (Canal sugar beet new factory in West Menya, Egypt) project established by a Chinese company (Sinoma International Engineering Co., Ltd.), worth EGP 12.5 billion from a consortium of 10 banks, planned to be the largest beet sugar country in the world, established by a joint venture between the UAE and the Al Ghurair Group. As stated in the methodology, different weightings are assigned to CPI, SPI, and RPI, and the results obtained from the developed model have been compared with those concluded from applying the standard PMI formula.

A quantity of 20 Work Activities was monitored for the planned original contingency and the actual due contingency of the project all over the project execution period. The same was done for the variance at completion standard and the actual variance at completion using the RPI. Finally the same was done for the EAC standard and the improved EAC using the RPI.

6.1 Model validation within the case study

It was Noted from the following graphical representation comparing the estimate at completion normal (EAC) with improved (EAC) and values of variance at completion (VAC) normal with improved (VAC) concluded from two cases that in Fig (3.1) at 25% of project completion resulted an increased value in the EAC and VAC and as shown in Fig (3.2) at 50% of the project completion the EAC and VAC was increased. While at 75% of the project completion as shown in Fig (3.3) the EAC and VAC decreased same as in Fig (3.4) where it finally resulted a decrease by 3438801.9 LE of the total completion value at the project end. As the budget of the project is 19,788,293.2 dollars, at the final stage a work equal 14,025,944.9 dollars has been completed coasted actually 10,360,555.5 meaning that total variance at completion equals 3,665,389.35 dollars , such a value is very close to the one coming from the modified formula and so far from the result coming from the normal formula The data which was obtained from the normal familiar earned value method that considers only cost performance index and schedule performance index with the data which was concluded from the method embedding risk performance index (RPI) .

The magnitudes of variation at completion (VAC) and estimate at completion (EAC) will be used to compare the two methods. The difference between two concepts will present the impact of considering the project risk performance index within earned value analysis while measuring project performance. A Q-Q curve (Quantile-Quantile plots) was drawn to plot two quintiles against each other, representing the EAC as in Fig. 3.5 and the VAC in Fig. 3.6, where data was seen to lie around the reference line, showing that the data are coming from a common normal distribution and the results obtained resemble the assumed calculated data received from the project's gathered data and the associated curves.

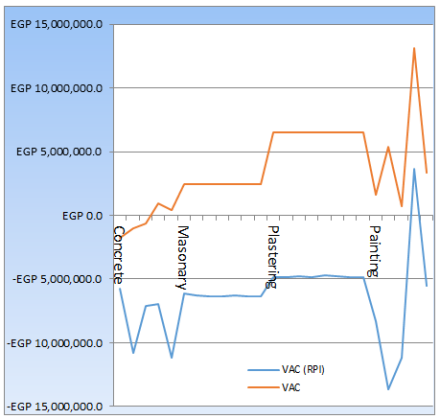

Fig 3.1:VAC Planned Vs VAC (RPI) at 25% completion

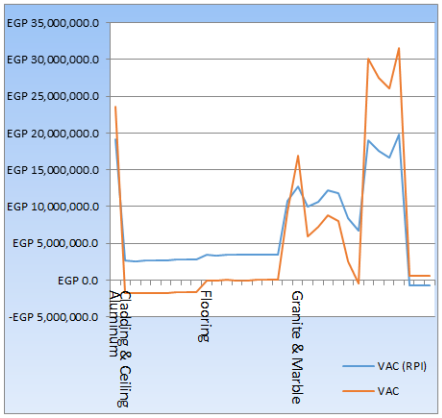

Fig 3.2:VAC Planned Vs VAC (RPI) at 50% completion

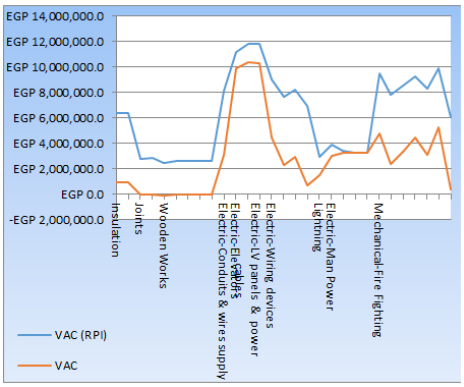

Fig 3.3:VAC Planned Vs VAC (RPI) at 75% of project completion

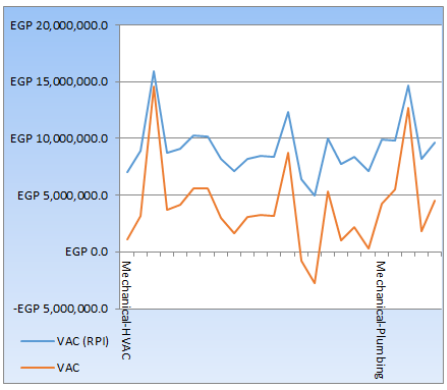

Fig 3.4 :VAC Planned Vs VAC (RPI) at 100% of project completion

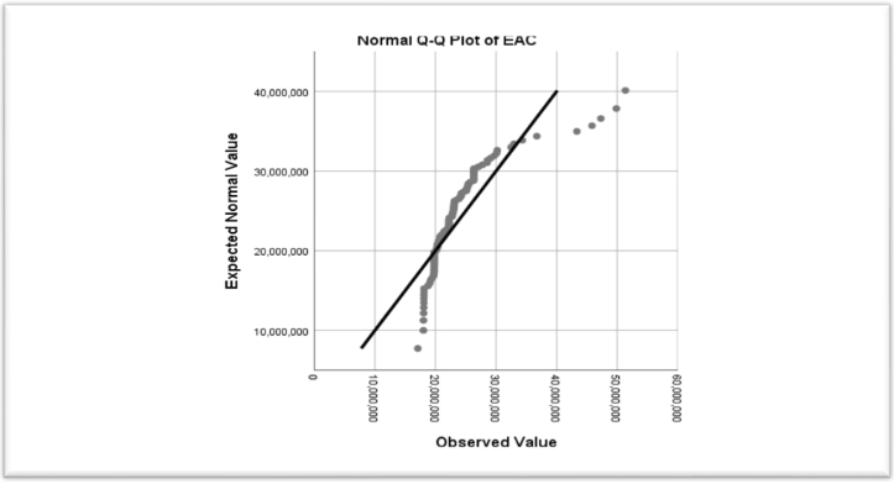

Fig 3.5: Normal Q-Q curve for EAC

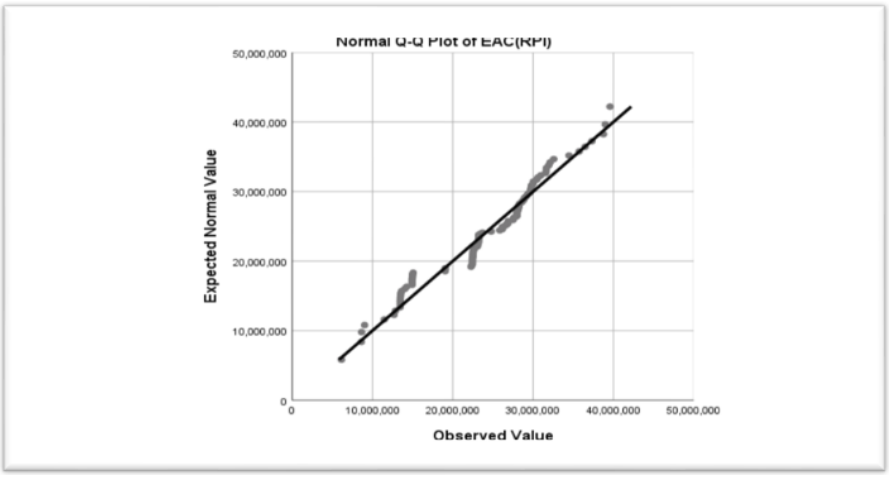

Fig 3.6 : Normal Q-Q curve for EAC

Table 3: Normal and improved values of (VAC) and (EAC) at 25%, 50%, 75% and 100% of project (case study)

Parameter	25 %	50 %	75 %	100 %
(EAC) normal	26316670.27	20345458.95	11255460.68	12608441.25
(EAC) Improved	26,535,288.0	24,476,705.3	22,262,709.9	23,227,095.1
(VAC) normal	6528377.073	5571657.485	-8532832.516	-7179851.954
(VAC) improved	6,746,994.8	4,688,412.1	2,474,416.7	3,438,801.9

7. Conclusion

It was concluded that embedding the risk performance index within the project performance index as a ratio between two risks (potential vs. occurred) leads to more expressive results and values of the estimate at completion (EAC). Such a variance can work as an early trigger to deal with the potential effect of overall risk. Total variance at completion equals 3,665,389.35 USD, coming from subtracting total actual cost from total activity planned value. The aforementioned value is very close to that calculated finally by subtracting planned budget from the final improved estimate at completion, which equals 3,438,801.9 USD. Such a result can show how the proposed model is realistic, as the difference was found to be negligible.

The shown above graphs presents the normal attitude of project risk which starts severely in early phase of the projects, and then coming to lower severity as more project activities are accomplished, The difference shown above leads to a fact that considering risk performance index within project performance measurement can result in conclusions that works perfectly at very early stage of the project working as overall risk trigger to the rest of the project life time.

It is worth mentioning that reaching such sensitive data as a raw estimate of a work package or a pre-assessed contingency reserve is not accessible to all those who are involved in the project management process.

Consequently, adopting such concepts requires more transparency and disclosure of project data that have not been stipulated to be easily accessible before. This required

transparency, which needs a revolutionary change of organizational vision and culture, especially in the Middle East, where the vast majority of organizations are very conservative in such fields.

Finally, more and more applications using such a proposed method in different types of projects with various planned times of accomplishment, specialization, and magnitude of budget will result in more data to assure the importance of using the embedding risk performance index method.

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