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DIFFICULTIES OF IMPLEMENTING EARNED VALUE MANAGEMENT IN CONSTRUCTION SECTOR IN EGYPT

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ABSTRACT

Earned value management (EVM) is a project performance evaluation technique that has beenoriginated in industrial engineering.During the constructionphase, EVM implementation is facing some problems that may diminish the effectiveness of using earned value as a control technique for the project. The objective of this research is to identify and analyze thesedifficulties. Earned value analysis (EVA) is implemented on two different construction projects showing the effect of these difficulties on EVA results.A structured questionnaire and interviews were done for this objective.Their analysis illustrated that the technical problems mainly affect project's time control, while the project's cost control is affected mainly by the financial problems.There are some problems facing the actual cost recording that may impede the implementation of EV as a control technique

Keywords: Earned Value, Construction, Time and Cost Control.

1. INTRODUCTION

Construction projectsare subjected to a number of factors which interfere with their smooth completion. Therefore, it is important to monitor the progress of work in real time, and systematically analyze any variation in work schedules and project costs compared to the value previously planned, in order to take preventive measures to minimize the negative impact of confounding factors.The Earned Value method (EVM) is one of the most popular methods to monitor and control the progress of work. Its primary purpose is to measure the progress of the project, predict its total cost and completion date. Indirectly, EVM may be used to control risk in the context of exceeding project costs and failure to meet the deadline of completion of the investment.The EVMisan analysisbased on several measurements utilizing appropriate indicators. Measurements are taken at regular intervals, e.g. at the end of the month, in order to track the trends and variations of these indicators.

Traditional EVM monitoring of project performances is based on the budgeted cost of work performed (BCWP), budgeted cost of work scheduled (BCWS) and actual cost of work performed (ACWP). The cost variance (CV), schedule variance (SV), or cost performance index (CPI) and schedule performance index (SPI) are then calculated to measure the project performance. CPI and SPI are usually expressed in a periodic or cumulative way. Although he EVM approach is considered to be the most objective method available in the measurement of project performance, the method is limited and does not directly account for variation in individual performance values.Unfortunately, the subjective way of assessing work progress is one of factors that may lead to deliberate falsification of data in order to present the desired image

Moreover, the timing of check performance may give false indication due the time lapse between the work performance check and the start of corrective actions where some minor problems may be easily handled by proper direct actions.Changes in baseline due to certain discipline in the construction must be taken into consideration by updating the schedule. This is the case of implementation of innovative projects subject to

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changes and unforeseen events. The scope of the budget and the schedule are then changed and this, in turn, affects the project completion estimates and leads to difficulty in analyzing EVM indicators

In case of changes in the work order, in particular, high percentage ranges of contract value, the schedule and BCWS curve should be modified respectively, and only on that basis the actual progress of works should be evaluated.For an effective implementation of EVM, the actual cost data for the project is to be accurate and should include all possible costs, such as project services and financing costs which are currently on high interest rates. Actually, these interest rates and other financing costsare large sums that can inappropriately be hidden within the project.Another main problem affecting EVM implementation is the limited experience in project management which results in using traditional methods in controlling cost and schedule without proper analyzing.

2. PROBLEM STATEMENT

Since the implementation of EVM is a relatively new methodology in the Egyptian's construction projects, it is still undergoing further refinement. Recent new concepts are reviewed and analyzed. This paper aims to identify the gaps and anomalies that may diminish the effectiveness of EVM and discourage its acceptance as a project performance management tool. The current understanding and adoption of EVM by project management practitioners is examined, in relation to alternate techniques.These gaps are detected from literature and throughout a survey and structured interviews with experts in construction field.

3. LITERATURE REVIEW

Earned value management (EVM)is the most commonly used multi-dimensional project control method, as it integrates time and cost (Rozenes*et al.*, 2006). PMBOK defines control as "comparing actual performance with planned performance, analyzing variances, assessing trends to effect process improvements, evaluating possible alternatives, and recommending appropriate corrective action as needed." (PMI, 2004, p. 355) .Another research for the reliability assessment of EVM (Mahdi *et. al*., 2016), found that the Most effective   EVMs that assess in the sample cluster are time schedule. Cost and quality also havean effect which is not as significant as the time schedule but it still considerable. Keeping under budget and ahead of time schedule are the measures for project success. The comparison between planned time schedule and actual cost compared with expected budget is considered a basic baseline references to evaluate their project progress. The executed work compared with planned work is considered a work performance indicator, also cost spent compared with cost remaining can be taken into consideration as a work performance indicator. The major barriers that face the studying are finance and time as the major barriers; also labors can be taken into consideration.De Marco *et* Timur, (2013) stated that indicators are essential management tools in monitoring and evaluating project activities, as theyallow the achievement of goals to be monitored as well as advances and improvements in quality tobe identified.

To monitor project is to compare the current with the planned situation,determining if the costs and the schedule are progressing according to plan, in order to takecorrective action when needed. any project with considerable cost overrun and schedule delay typically gets in trouble at its beginning as indicated by Alvarado (2004). In addition, project managers do not realize this problem until late in the project when their ability to recover the project to achieve its planned objectives diminishes.

Conceptual problems and implementation difficulties of Earned value management was explored by Luis (Luis Felipe Cândido*et al.,*2014),through a case study on a construction project that applied EVM as a planning and control tool, they analyzed four major problems that the EVM approach fails to support lean construction applications, Among them are the disregard for the mobilization of resources phase and the lack of consideration of construction indirect costs ,they concluded that EVM is just an extension of the traditional approach of measuring physical and financial advances over time. This narrow approach is insufficient to provide a comprehensive managerial tool, as became clear through the analyses of the building project under consideration

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According to Fleming and Koppelman(2010)EVM techniques are difficult to be applied to dynamic construction projects and do not add much value to project execution, especially when:

      i. There is absence of adequate project planning and documentation,

      ii. The construction schedule is compounded by considering the resource constraints such as resource availability limits and multiple calendars,

      iii. Activity and project delays encountered during project executions,

      iv. There is no EVM analyst or specialist within the project team.

Some problems that may impede the implementation of EVM as specified by Kim *et al.,*(2003) such as:

      - High cost, complicated and burdensome paper work

      - Poor understanding of EVM

      - Distrust and conflict between project managers, project consulting and government

      -Pressures to report only good news

Lack of EVM as a contractual requirement diminished the directive use of EVM, since the parties of a contract cannot have a common understanding of performance in terms of earned value metrics. Discussions in any official correspondence across project role-players/parties cannot be in terms of EV metrics. This confine EVM to one party in a project, and so only that one party's decisions can be based on EV metrics. In this case, the earned value's input into such decisions was implicit, at best. This was also attributable to a limited understanding of EVM, and in particular of the future tense performance metrics such as To-Complete performance index(TCPI).(Nkiwane*et al.,* 2016).

Earned value management is ignored and even discouraged for fixed-price contractsas stated by Carol and Christensen (2010),sincethe customer has transferred the cost risk to the contractor and earned value is perceived to be less useful. Since the customer's cost risk is already mitigated by shifting the risk to the contractor while it is required on high value cost plus projects. On cost plus contracts, the customer assumes the lion's share of risk. Earned value, applied effectively, provides early visibility into cost and schedule performance issues and for that reason is a tool that the customer uses to mitigate their risk.

On the other hand, Lipke (2003) criticized the classic SPI indicators which may provide false and unreliable time forecasts near the end of the project. He introduced the concept of Earned Schedule (ES) that translates the monetary indicators into a time dimension and presents a modified schedule performance indicator [SPI(t)] that can measure the performance along the whole life of the project. Vandervoord and Vanhoucke(2006) had noted that SPI and SPI(t) are true indicators for project performance as long as they are used on the activity level, and not on the control account level or higher WBS levels. For estimating the cost, during the 1990s a considerable amount of research was performed which examined the behavior of the cumulative value of the Cost Performance Index (CPI) and generated the various formulas for estimating final cost depending on various performance indices as shown in the following table:

Table 1 cost forecasting equations

Cost forecasting equations	
$EAC_1 = AC + (BAC - EV)$	$EAC_5 = AC + \dfrac{BAC - EV}{CR}$
$EAC_2 = AC + \dfrac{BAC - EV}{CPI}$	$EAC_6 = AC + \dfrac{BAC - EV}{CR(t)}$
$EAC_3 = AC + \dfrac{BAC - EV}{SPI}$	$EAC_7 = AC + \dfrac{BAC - EV}{0.2 \cdot SPI + 0.8 \cdot CPI}$
$EAC_4 = AC + \dfrac{BAC - EV}{SPI(t)}$	$EAC_8 = AC + \dfrac{BAC - EV}{0.2 \cdot SPI(t) + 0.8 \cdot CPI}$

In the last four EAC formulas it is supposed that both the cost and schedule performance indicators have an impact on the cost of remaining work. The discount factor in EAC5 is called the critical ratio (CR) (Anbari, 2001; Lewis, 2001) or cost - schedule index (CSI) (Barr, 1996; Meredith & Mantel, 2000) or schedule - cost index (SCI) (Christensen, 1999; Vanhoucke, 2010). It attempts to combine cost and schedule indicators into one overall project health indicator For estimating the duration of a project, the traditional IEAC(t) formulas and three generally accepted methods had been found in the literature: Planned Value (PV), Earned duration

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ED and Earned schedule ES. The Planned Value method (Anbari, 2003) and Earned Duration method (Jacob, 2003) are confronted with similar SPI problems which influence the accuracy of the forecasts for late finish projects (supra, p.8) from the sixty percent completion point. The Earned Schedule method (Lipke, 2003) overcomes this SPI problem.

Table 2 duration forecasting equation

Duration forecasting equations		
Planned Value method(Anbari)	**Earned Duration method(Jacob)**	**Earned schedule method(Lipke)**
$EAC(t)_{PV1} = PD-TV$	$EAC(t)_{ED1} = AD+(PD-ED)$	$EAC(t)_{ES1} = AD+(PD-ES)$
$EAC(t)_{PV2} = \dfrac{PD}{SPI}$	$EAC(t)_{ED2} = AD + \dfrac{(PD-ED)}{SPI}$	$EAC(t)_{ES2} = AD + \dfrac{(PD-ES)}{SPI(t)}$
$EAC(t)_{PV3} = \dfrac{PD}{CR}$	$EAC(t)_{ED3} = AD + \dfrac{(PD-ED)}{CR}$	$EAC(t)_{ES3} = AD + \dfrac{(PD-ES)}{CR(t)}$

Shu and ZHANG (2010) provided an analytic review for empirical and non-empirical studies for EVM and its applications, key issues for empirical studies reviewed include the effective implementation of EVM, behaviors of cost performance index, accuracy of time control techniques, for non-empirical studies, key issues reviewed include schedule performance index, accuracy of time control techniques and the integration of EVM with other project management techniques. They concluded that EVM outputs depend on the collection and processing of cost and schedule integrated data and by reviewing a number of studies they found that the potential errors caused by adopting SPI(t) at higher WBS level, an appropriate model should be employed to facilitate detailed schedule analysis and mitigate the disrupting effects on the project team and the assumption for linear planned value makes EVM outputs in potential errors.

Kym Henderson (2007) described the results of the application of earned schedule in conjunction with the traditional EVM and network schedule based measures to manage the project, he concluded that the value of ES in providing time based units of measure from EVM data should not be underestimated as matrices using common time based units of measure greatly simplified comparative analysis with the network schedule indicators. Moreover, the ES metrics provided an independent means of sanity checking the critical path predicted completion date prior to communicating overall schedule status to management.ES will become the" bridging technique" between EVM and the network schedule.

4. DATA COLLECTION

As the objective of this research is to identify problems facing EVMs implemented in the construction control process, it is first important to define problems facing EV information recording by:
- Rating the level of importance for each factor affecting the ability of effectively control the cost and time of your construction projects.
- Actual cost recording process.
- Evaluation of EV indices.

Based on these basic factors, a questionnaire model had been conducted to define the major factors that affect EVMs. Direct and indirect interviews had been conducted with experts in construction field whom choice is based on judge mental sampling methodology.

Structured interviews with experts and their answers on the questionnaire model are helpful to collect all data required to identify the difficulties facing the implementation of EVM in the construction industry in Egypt.Our sample cluster consists of 92 respondents, many of them replied on us by email and other by direct interviews. The selected sample has different field of experience to actually typify the different construction projects. The sample of questionnaire respondents according to organization's category is shown in Figure 1

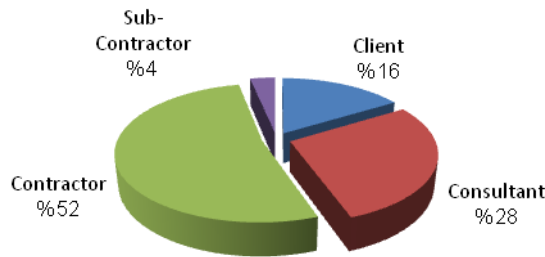# International Journal of Engineering Researches and Management Studies

Figure 1 Organizations categories of respondants

the sample of questionnaire respondents according to contractor's classification according to *Egyptian Federation Construction* and *Building Contractors* (EFCBC) is shown in figure 2.
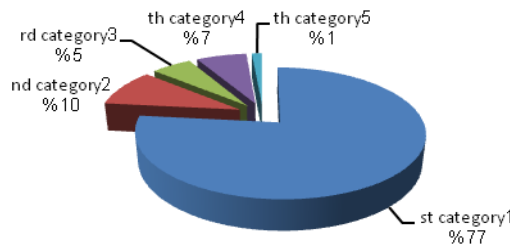

Figure 2 Contractor's categoriesaccording to contractor's classification according to EFCBC

5. ANALYSIS

A. Factors affecting time and cost control for a construction project

Main factors affecting time and cost control for construction projects had been investigated and classified into four categories as shown in Table 3.

Table 3 Factors affecting time and cost control

Technical Factors	Financial Factors	Contractual Factors	Other sources
- Design Changes - Weak regulation and control - Inaccurate evaluation of projects time" - Lack of proper training and experience of PM - Low skilled manpower - Nonperformance of subcontractors and nominated suppliers - Lack of appropriate software	- Inflation of prices - Dependency on imported materials - financing and payment of completed work - Risk and uncertainty associated with projects	- Contract and specification interpretation disagreement - Conflict between project parties	- Unstable government policies - Unpredictable weather conditions

The importance indicescalculated for differentcategories are illustrated in the following subsection.

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Timecontrol

As shown in Figure 3, technical factors are found to have the highest impact on the time control and make EVM difficult to be implemented during the construction.
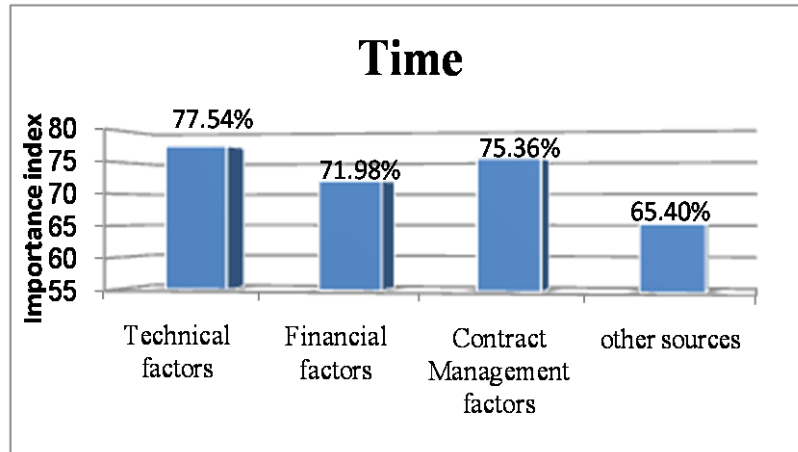

Figure 3 Importance indices for time control factors

Cost control

Financial factors form the predominant difficulty facing the EVM implementation for cost control process as shown in figure 4 .
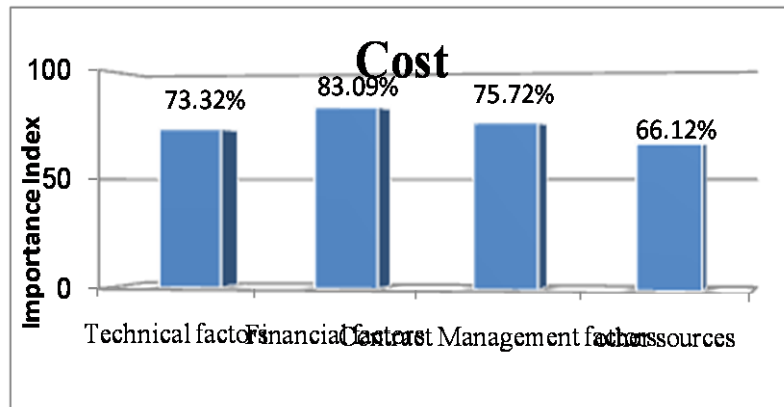

Figure 4 Importance indices for cost control factors

B.   Usage of Earned value as a cost control tool

The percentage of respondents using EV as a control technique in the construction industry in Egypt is shown in Figure 5. 68.5 % of the sample size is using EV as a control techniquewhereas 31.5% found difficulties in EV implementation.
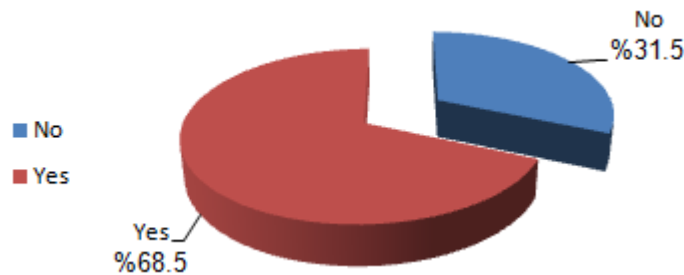
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Figure 5 Usage of EVM in the Egyptian construction industry

Difficulties facing the implementation of EVM
The difficulties mentioned by the respondents are as follows:
- Limited experience in construction management field since the usage the EVM needs training to the employees and changing.
- The additional cost required to the application of EV as a control technique.
- Simple means to control budget seem to be satisfactory enough for some practitioners.
- The type of the contract.
- Changes in work scope.
- Impacts of variances are not usually forecasted and estimates at completions are not usually prepared.

C. Actual cost calculations
During the construction process, actual cost of work must be calculated to measure the performance of work; some problems face the actual cost collection in site, inaccurate actual cost calculation is a main barrier that faces the implementation of earned value in the construction industry since it's the main factor in measuringperformance progress of work.

Performance checks intervals vary between organizations; various intervals of performance checks done by the respondents are shown in Figure 6.
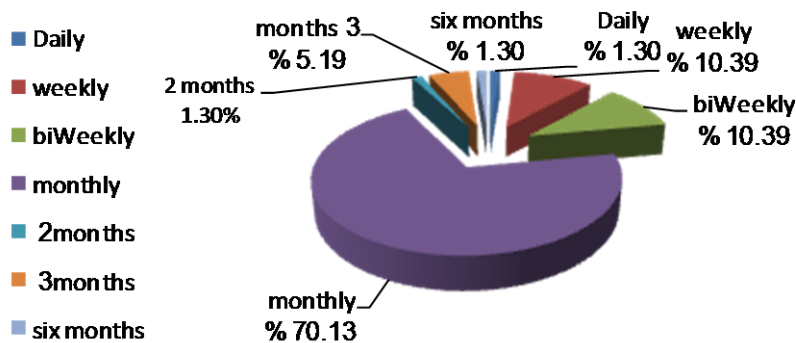

Figure 6 Performance check intervals

Respondents that identified problems facing actual cost recording are mainly contractors and consultants, since clients are not responsible of the actual cost recording.
1. The dependency on subcontractors makes the recording of actual cost more difficult.
2. Inaccurate quantity surveying of the project causes a misestimating of project's time and cost, inaccurate time and cost estimation leads to generating an unreal baseline, this means that the comparison between the actual and planned work is useless.
3. Lack of appropriate system for actual cost calculations makes the recording process difficult since there are some items can be disregarded and not taken into account

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4. One of the problems that may face the actual cost calculation is the inappropriate resource allocation

5. Indirect cost, overheads and in-situ expenditures are some of the major problems that may lead to inaccurate calculation for monthly actual cost.

6. Timing of change orders between contractor and consultant can make troubles in the analysis and may lead to wrong indicators.

7. Delay of invoices at submission of work; some organizations rely on the invoices values to determine the actual cost used in the analysis process. However, the dependency on the invoices values may lead to inaccurate actual cost due to the time laps between the date of generating the invoice and the date of approval.

8. In recent years in Egypt, the unstable economical state caused changes in materials cost; to eliminate the losses that may occur, new laws had been generated to diminish variances, but the instability is still making the comparison between planned values and actual costs difficult.

9. Sometimes the percentage of completion is determined according to activities duration in other times this is done according to activities cost.

10. Late approval of inspections requests (IR) by the engineer at the end of the month; this means that some works cannot be counted as completed yet, but has been counted as monthly actual cost.

D. Effect of using EVM on project management tools

Based on respondent's answers the implementation of EVM as a control technique had been found to have the highest effect on monitoring project schedule, controlling project cost and analyzing delays. The technique has a minimal effect on the project scope and change orders; a change order is a work that may be caused by the incorrect estimation or by the request of additional or reduced items, and should then be added to or deleted from the original scope of work as agreed in the contract. The following table shows the importance to show the effect of EVM on project management tools.

Table 4 Effect of EVM on project management tools

	Importance index
Monitoring Project Schedule	0.85
Controlling Project Cost	0.81
Evaluating and analyzing delays	0.77
Acceptance of completed work	0.68
Post-project audit	0.70
Evaluating and analyzing claims	0.71
Project scope	0.67
Evaluating and processing payment requests	0.69
Evaluating and processing change orders	0.68

The questionnaire had been followed by implementation of EVA on two construction projects to verify the results obtained by the questionnaire survey.

The Case Study of projects has been taken using the information of an actual project its cost and scheduling. The basic goals of this phase are:

1. To identify the main problems affected project cost and time control.
2. To analyze stability of cost and time performance indices
3. To determine the accuracy of the different EVM forecasting methods, both cost and time related, are tested on their predictive power
4. To develop the effect of applying re-baselining in the project.

The results of cost and duration forecasting equation are verified using statistical tests; this should allow the reader to get a better understanding of EVM in all its aspects.

6. CASE STUDY

A. Case study 1

Problems affecting cost and time control

1) Instability of the economic and political state in Egypt.
2) Delay of work permits.
3) Inaccurate cost estimation.
4) Actual cost are recorded from invoices, this may cause missing of information   about monthly actual cost.

Indices stability

-CPI stability had been achieved at 54% completion of the project.

-SPI achieved stability at 81% completion.

- SPI (t)achieved stability at 90% completion.

Performance indices

- The project had finished behind schedule with cost saving.
- SPI approaches to one with a value of 0.905, at the end of the project although the delay occurred in the project.
- SPI(t) indicated a schedule performance index 0.81 since it is late for 8 months with an original duration 63 months.
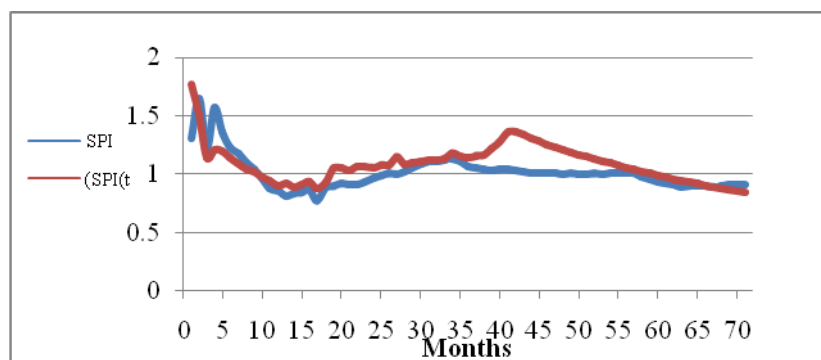- SPI and SPI (t) behavior during the project construction is shown in Fig**7.**

Figure 7 SPI and SPI(t)behavior

Re-baselining

Data for this project weren't available to apply re-baselining.

B. Case study 1

Problems affecting cost and time control

- Design Changes at the start phase of the project.
- Conflict between project parties.
- Changes in scope (reducing the work).

Indices stability

- CPI achieves stability at **67% completion** point.
- SPI didn't achieved stability after updating the value of the planned value of the remaining work after the reduction of work due to the high deviation occurred.
- SPI (t) didn't affected by the reduction of work, it showed the delay occurred at the end of the project and achieved at **50% completion** point.

Performance indices

- CPI achieves stability at **67% completion** point.
- SPI didn't achieved stability after updating the value of the planned value of the remaining work after the reduction of work due to the high deviation occurred.

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- SPI (t) didn't affected by the reduction of work, it showed the delay occurred at the end of the project and achieved at **50% completion** point**.**
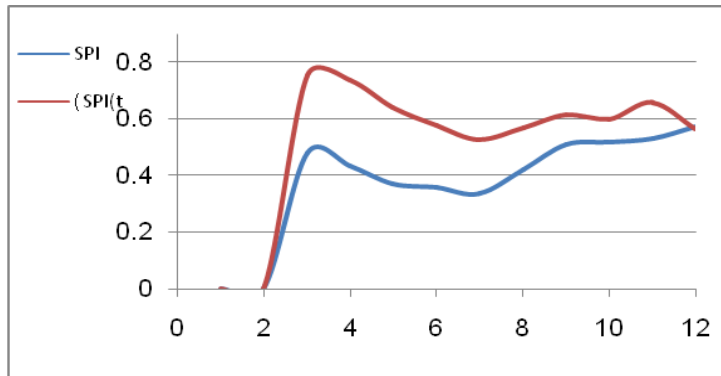- SPI and SPI (t) behavior during the project construction is shown in Figure8:

Figure 8 SPI and SPI(t) behavior before re-baselining

Re-baselining

- CPI indicator stability isn't affected when re-baselining is done.
- SPI achieved stability at **42% completion**
- SPI (t) reached stability earlier than before re-baselining. it reached stability at **25% completion point**
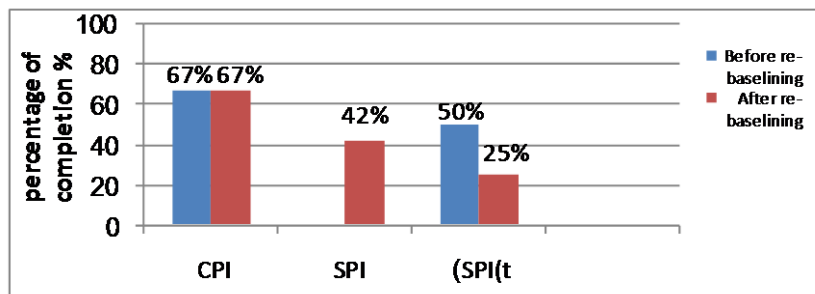 A comparison between indices stability before and after re-baselining is shown in Figure9

Figure 9 Comparison between indices stability before and after re-baselining

The difference between SPI and SPI(t) has diminished since the planned values has been updated tobe closer to the actual work completed as shown in Figure 10
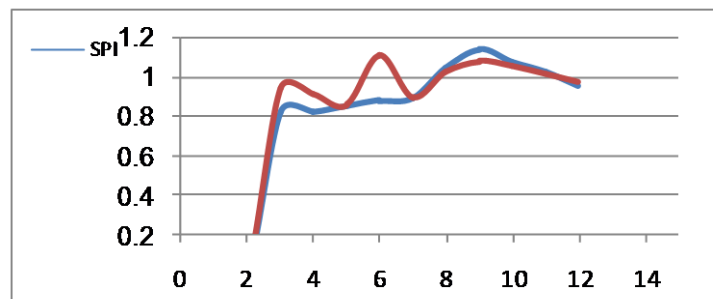

Figure 10 SPI and SPI(t) behavior SPI and SPI(t) behavior after re-baselining

Re-baselining calculations indicated an SPI(t) about 0.97.and a SV= - 0.3 months only in project related to the completed works without taking into consideration the time must be reduced due to the reduction of work.

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7. VALIDATION

By applying cost and duration forecasting equations discussed on literature on case studies,it's found that:

A. Forecasting

Cost forecasting
EAC_1, EAC_2,EAC_7 and EAC_8 perform on average best for the project cost estimate.The equation that performed the best is EAC_1 that has a performance factor equal to 1.

It should be noted that the other three equations have a performance factor that depends heavily on the CPI. EAC_7 and EAC_8 add a fraction of the SPI(t), respectively SPI to the performance factor. However, the CPI is with a fraction of 0,8 still the dominant component. EAC_2, the generally most accepted cost forecasting equation by project managers, also performs wellby applying the re-baselining, forecasting equations with performance SPI(t) performs well than without re-baselining, as indicated before, by applying re-baselining earned schedule showed a very small schedule variance and by consequence a perfect SPI.

Duration forecasting
$EAC(t)_{PV3}$, $EAC(t)_{ED1}$ and $EAC(t)_{ED2,PV2}$ provide on average the most accurate duration forecasts. These are three different methods with a different performance factor. It is observed that the best duration forecasting equation which is depending on CR (SPI *CPI), since CPI is more stable than SPI as indicated before
Earned Schedule method provides the worst duration forecasts of the three forecasting methods, as indicated before due to the overestimation of the **Planned values (BCWS)** .

By applying the re-baselining as equations with ES indicators performed the best forecasting equations due to the very small schedule variance calculated after the re-baselining.

B. Statistical tests
Statistical tests were applied using SPSS to measure the forecasting accuracy of the different forecasting methods. First the eight cost forecasting equations are compared with each other. Next a similar test is done for the nine duration forecasting equations. The Friedman test, a test for multiple related samples, is used to test whether the forecasting methods perform on average equally good. If a significant difference would be detected, further post-hoc analysis is required.
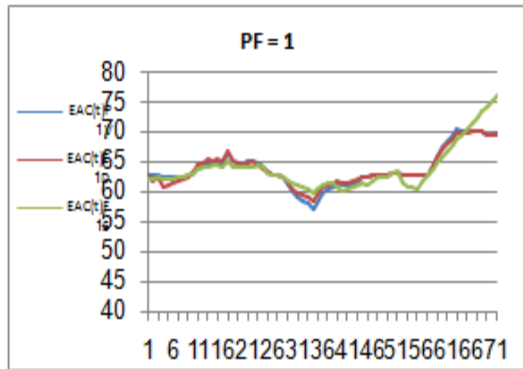
Cost forecasting equations
Statistical tests also confirm that there is a significant difference between the performances of the eight cost forecasting methods. Moreover, a post-hoc analysis with the Wilcoxon signed ranks test shows that EAC_1, EAC_2, EAC_7 and EAC_8 perform significantly better than EAC_4 and EAC_6
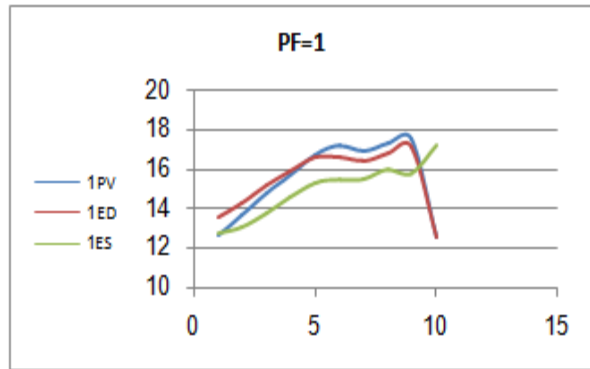
Duration forecasting equations
A very small significant difference is found between the rankings of the nine forecasting equations when assuming the complete sample). This significant difference is found between the nine forecasting equations is due to the reduction of work occurred in Feb 2016 in Project 2. From these results we found that EAC_{PV3} performed better than other equations followed by $EAC_{ED1}$and Earned schedule method performed the worst.
the difference between results of duration forecasting equations using different performance factors in case studies shown in Figure 11 and Figure 12:
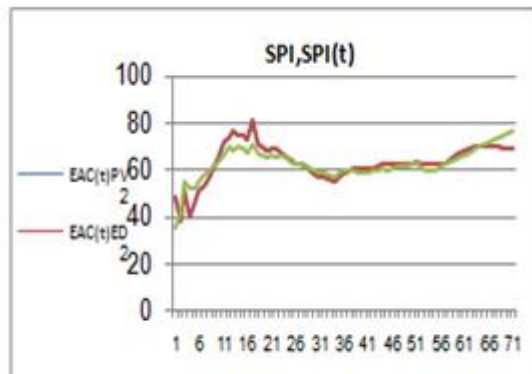
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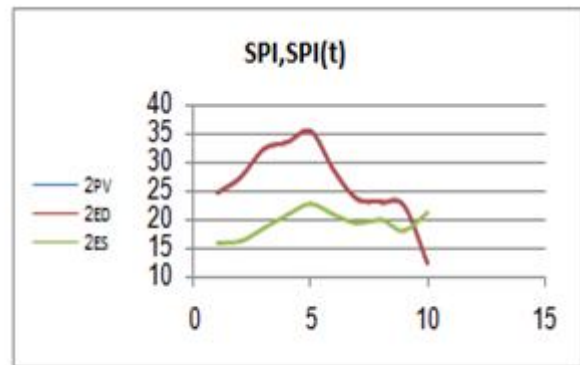

11-a) Duration forecasting equations with PF =1
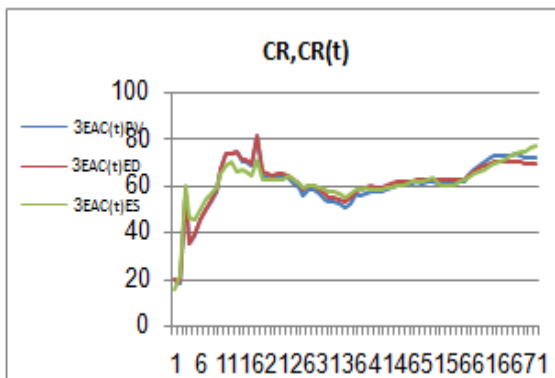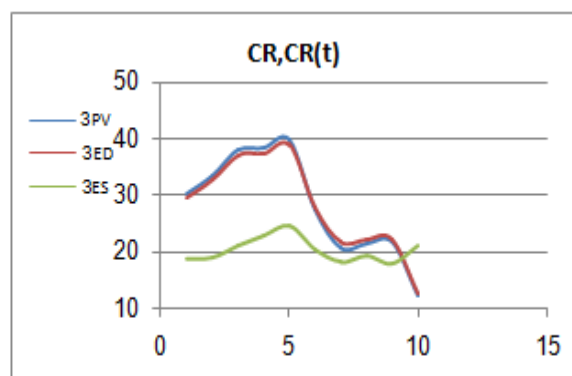

12-a) Duration forecasting equations with PF =1

11-b) Duration forecasting equations with PF = SPI &SPI(t)

12-b) Duration forecasting equations with PF =SPI &SPI(t)

11-c) Duration forecasting equations with PF =Cr &Cr(t)

Figure 11 duration forecasting for case study 1

12-c) Duration forecasting equations with PF =Cr&Cr(t)

Figure 12 duration forecasting for case study 2

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8. CONCLUSIONS

Earned Value methodology provides many different indicators for measuring project performance, and they are relatively easy to compute.The main problems that may diminish the effectiveness of EVM as a control tool in the Egyptian construction industryhad been identified and analyzed.Earned value analysis (EVA) is implemented on two different construction projects showing the effect of these difficulties on EVA results, asurvey was conducted based on judgmental sampling and made direct and indirect interviews with experts in construction field and from analysis of data collected and implementing EVM on construction projects it's found that:

The technical factors are the most predominant project's time control; contract management and financial factors appear thereafter. Regarding cost control, the financial factors are mostly predominant and are followed by contract management factors and technical factors respectively.

The limited experience in construction management field by the project parties, the cost added for the implementation of the control technique, the fixed price contracts and the scope changes and variances occurring during the construction phase are the main barriers that prevent the implementation of EVM as a control technique.

The process of recording actual cost faces numerous problems such as dependency on subcontractors, collecting of indirect cost, delay of invoices, change orders between project parties, inaccurate estimation and changes in material's cost, all these factors affect the accurate implementation of EVM.

The implementation of the EVM as a control technique has a high impact on monitoring project schedule, controlling project cost and analyzing delays. A lower impact is found on the project scope and change orders since the addition or deletion of any work from the original scope of a contract can be caused by the incorrect estimation of the additional features or options perceived as requested.After analyzing case studies results,it's found that the main problem that made schedule indices inaccurate is the overestimation of monthly planned values; the high deviation between planned values and actual cost made the SPI and SPI(t) misleading indicators to some extent. It had been proved throughout the case studies that changes in scope may affect the accuracy of EVM indicators and cause withdrawals in the calculations and misleading information about the status of the project

After analyzing the stability of other indicators, namely SPI and SPI (t), it had been noticed that no stability could be found early in the project life. At the start phase of the project, SPI and SPI (t) have high values since the slow start-up phase has then no coincidence as a significant delay.Cost estimation equations using the performance factors SPI and SPI(t) have the worst accuracy due to the instable schedule indicators.

The performance of the forecasting equations using SPI(t) is improved by applying re-baselining,

Duration forecasting resulting from Earned Schedule method had been less accurate than other equation obtained from the planned duration method and the Earned Duration method. This is explained by the delay appeared in the earned schedule calculations,

By applying the re-baselining, the equations with ES indicators had been the best among forecasting equations.

9. RECOMMENDATIONS

For an effective implementation of EVM as a control tool in the Egyptian construction industry, some key insights were obtained which are very important for the useful implementation. For best implementation of EVM as a control tool is to avoid design changes during the construction and to present an accurate cost and time estimation for the project.Variances in time and cost must be taken into consideration by applying re-baselining to show the changes occurred during the project. Actual cost must be calculated periodically to avoid the problems exhibited due to indirect cost in-situ that can cause misleading information about actual

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cost that may affect the cost control of the project.Conclusively we strongly believe that EVM methodology as a control tool for construction project could help projects in achieving a better understanding of the project performance.Moreover, when EVM would be incorporated as a general project management tool by construction companies and its methodology would be understood well by project managers, it could definitely serve as a powerful tool to follow up all types of construction projects.

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