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INTEGRATING EARNED VALUE MANAGEMENT WITH RISK MANAGEMENT TO CONTROL THE TIME-COST OF THE PROJECT

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ABSTRACT

According to PMBOK standard, eighth process of project management is risk management. Technique of Earned Value Management (EVM) as well as project planning and control system in recent decades has been widely used. Integration of risk management and earned value management to predict and estimate the cost and time of completion of the project is an effective tool in the management and control of the project. Each of these techniques has at least one key weakness; the main weakness of EVM is focus of this way on predicting future development based on past progresses. The event that has happened in the past is not concerned by risk management; now according to this importance, in this paper outlines two methods and explains benefits of integrating earned value management with risk management in order to achieve maximum performance.

KEY WORDS
Earned Value Management (EVM); Risk Management (RM); Project Management

Published: 1 October 2016

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INTRODUCTION

One of the most effective performance measurement and feedback tools for managing a project is earned value management (EVM). It provides a means to forecast future performance of the project based upon its past performance by utilizing a fundamental principle that patterns and trends in the past can be good predictors of the future. EVM allows the calculation of cost and schedule variances and the forecast of a project's cost and schedule duration [1]. Although EVM was set-up to follow time and cost, the majority of the research have focused on the cost aspect alone. Nevertheless, EVM provides two well-known schedule performance indices: the schedule variance and the schedule performance. These two measures are useful indicators to analyze a project's performance; however, they have some problems. For example, they are based on monetary unit and not on time. They can behave in ways that are not normally expected of schedule indicators and predictors. Furthermore, it is also possible that an earned value analysis may show that the project is delayed; on the contrary, the project would be on time. In this study, we consider these aforementioned problems and propose two new methods to resolve them.

EVM was introduced by agencies of the U.S. federal government as a part of the control system criteria. Nowadays, it is believed that EVM has many advantages and would control the performance of a project, but there are a few studies on EVM. Lipke [2] developed cost and schedule ratios to manage cost and schedule reserves in projects. Lipke [3] also introduced the earned schedule. Henderson [4,5] studied the applicability and reliability of the earned schedule. Anbari [1] enhanced the effectiveness of earned value implementation. Kim et al. [6] studied the implementation of earned value in different types of organizations and projects. Lipke [7] developed project cost and time performance probabilities. In addition, Vandevoorde and Vanhoucke [8] concluded that the best and the most reliable method to estimate time at completion is the earned schedule method. A new notation for the earned value analysis is presented in Cioffi [9] to make EVM mathematics more transparent and flexible. Lipke et al. [10] provided a reliable forecasting method of the final cost and duration to improve the capability of project managers for making informed decisions. Moslemi-Naeni et al. [11] presented a new fuzzy-based earned value model with the advantage of developing and analyzing the earned value indices and the time and the cost estimates at completion under uncertainty. Pajares and López-Paredes [12] introduced two new metrics for integrating EVM and project risk management methodologies: cost control and schedule control indices. These two indices compare EVM measures with the maximum value that a project should exhibit if the project was running under the risk analysis hypothesis. Moslemi-Naeni and Salehipour [13] developed new indices under fuzzy circumstances and evaluated them using alpha cut method. Acebes et al. [14] proposed a graphical framework for EVM to integrate the dimensions of project cost and schedule with risk management. Hunter et al. [15] focused on the implementation of EVM on the Radiation Belt Storm Probes project to improve cost monitoring and control. Czemplik [16] applied EVM to progress control of construction projects. Recently, some more studies have been published regarding other aspects of EVM [17,18 ,19].

EVM and risk management (RM) encourage the use of management techniques based on the results. Since earned value management and risk management both have been considered to solve similar

problems as well as gives us information about the decisions and performance many measures have been done for synergy of integration results of these two techniques in order to achieve maximum possible efficiency of project management [20].

MATERIALS AND METHODS

According to PMBOK standard, eighth process of project management is risk management. Technique of Earned Value Management (EVM) as well as project planning and control system in recent decades has been widely used. Integration of risk management and earned value management to predict and estimate the cost and time of completion of the project is an effective tool in the management and control of the project. Each of these techniques has at least one key weakness; the main weakness of EVM is focus of this way on predicting future development based on past progresses. The event that has happened in the past is not concerned by risk management; now according to this importance, in this paper outlines two methods and explains benefits of integrating earned value management with risk management in order to achieve maximum performance.

Risk management

From the organization of project management, risk management is introduced as one of the nine original level of "Project Management Body of Knowledge" (PMBOK); definition of this organization of project risk management is: "All processes associated with identifying, analyzing and responding to any uncertainty which contains maximizing desired events results and minimizing the adverse events results". PMBOK standard has described risk management processes in six stages [21]:

1- Risk Management Planning
2- Risk Identification
3- Qualitative Risk Analysis
4- Qualitative Risk Analysis
5- Risk Response Planning
6- Risk Monitoring and Control

EVM: Earned value management

EVM integrates a project's scope, schedule, and cost into a unified set of prescribed metrics to monitor and forecast the project's performance. Building blocks of all EVM metrics are the following three elements [22]:

- Earned value (EV) or budgeted cost of work performed (BCWP): it is the budgeted amount for the work actually completed on the schedule activity or work breakdown structure (WBS) component during a given time period.
- Planned value (PV) or budgeted cost of work scheduled (BCWS): it is the budgeted cost for the work scheduled to be completed on an activity or WBS component up to a given point in time.
- Actual cost (AC) or actual cost of work performed (ACWP): it is the total cost incurred in accomplishing work on the schedule activity or WBS component during a given time period. It is also called spent cost.
- BAC: Budgeted At Completion: total budget allocated to a project.
- SV: Scheduled Variance: This quantity measures the deviation between the supposed progress in the program with the actual progress.
- CV: Cost Variance: This quantity compares the deviation between the actual cost of the work done with the projected cost for them.
- Timing behavior index (Genuine Progress Index): This indicator shows how desirable or undesirable are real progress of things.
- CPI: Cost Performance Index: This indicator shows how much the real cost process is favorable or unfavorable.

These data points can be used to analyze the current status of a project and forecast its likely future. EVM analysis has two parts: cost analysis and schedule analysis. In schedule analysis, EVM uses both schedule variance (SV= EV−PV) and schedule performance index (SPI= EV/PV). Also, cost variance (CV= AC−PV) and cost performance index (SPI= AC/PV) are used in cost analysis of the EVM.

Whenever CV<0 and CPI<1, the project is over budgeted (otherwise, if CV>0 and CPI>1 the project is under budgeted). Furthermore, if SV<0 and SPI<1, the project is delayed (otherwise, if SV>0 and SPI>1 the project is ahead of schedule). When CV= 0 (CPI= 1) and/or SV= 0 (SPI= 1) the project is respectively on cost and/or timely.
Whenever SV<0 and SPI<1, the project is delayed (otherwise, if SV>0 and SPI>1 the project is ahead of schedule). If CV<0 and CPI<1, the project is over budgeted (otherwise, if CV>0 and CPI>1 the project is under budgeted). When CV= 0 (CPI= 1) and/or SV= 0 (SPI= 1) the project is respectively on cost and/or timely.

By means of monitoring the evolution of these indices over the project's life cycle, managers can detect deviations from plan so that they can take early corrective actions.

RESULTS

Weaknesses of each technique

Each of these techniques has at least one key weakness; the main weakness of EVM is focus of this way on predicting future development based on past progresses [20]. Cleland and "A Ireland" in his book "Management - Project: Design and implementation of the strategy", writes: It's like someone driving at a speed of 160 kilometers per hour, but his eyes are constantly on rearview mirror". EVM power is at great care that does in evaluation of past of project using quantitative measurement criteria. EVM is to predict the project future based on its past. You cannot just drive a car by looking at the rear-view mirror, you should look forward and this is what risk management does. While planning of the project looks a step further, risk management looks the more distant horizon EVM acts such as radar that examines the uncertain future. But the risk management identifies the risks should be avoided and also future benefits. The event that has happened in the past is not concerned by risk management because there is no ambiguity about them. If EVM predicts the future only with respect to the past, but risk management looks only to the future, so if you merge these two aspects you can create a positive synergy. By combining sight of the car side mirror and radar that looks forward weaknesses of each can be covered. As a result, by the use of forward-looking of risk management we can achieve advantages in Earned Value Management [20].

The synergy derived from the integration of the two techniques

According to common goals of EVM and risk management, the assessment of the implementation problems of the project, and also by knowing their differences it seems that there are several areas of synergy between the two techniques. These limits are discussed in the following sections.

Creating measurement of function (BCWS / PV / PMB)

To evaluate aspects of a project in terms of time and expense a measurement base is required that is specified from the beginning of the project and the project situation can be evaluated and compared to that case. The basis that is used in the EVM is the program value (PV) that is called Planned Baseline or Budgeted Cost of Work Scheduled (BCWS) or Performance Measurement Baseline (PMB). The first thing a project manager learns is that the reality does not match exactly with project planning. One of the features of integration of risk management and EVM is attention to the risk and uncertainty in the PV. Before the project began with a thorough assessment of the risk of the project plan the uncertainty of the time and cost can be predicted and the degree of risk can be assessed at baseline of project plan.

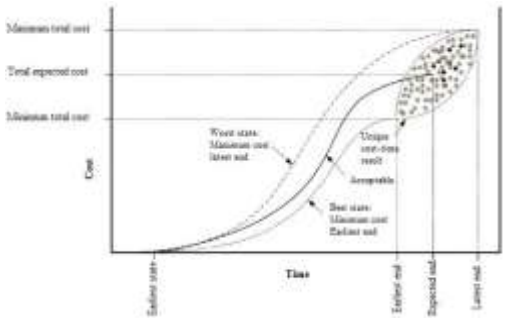

Fig. 1: Diagram of accumulation of risk-based cost

For this purpose, quantitative techniques of risk analysis such as "Monte Carlo" are very useful that specifies the assessed likelihood of events and results of the time or cost of project risks. In each risk, scheduled reaction to risk should be considered and should be brought in the expected cost of the project as well. In the risk analysis three modes of optimistic, pessimistic and likely are intended for project implementation and as three S-shaped diagrams are shown. The three states are shown in [Fig. 1]. The area at the right and the highest point is obtained shows the worst case (highest cost, longest timing schedule). The best case is at the lowest point and at left direction. (Cheapest and fastest) And the center of the curve indicates the desired outcome. These curves are called "Eyeball Plot or in USA are called" football diagram ". One of suggestions of combination approach of EVM and risk management is that the diagram in which time-cost risk is considered be used as PV. In other words, the central S-shaped curve in [Fig. 1]be used instead of the original curve as a baseline. So we can be sure that EVM baseline has fully

considered risks related to the project plan. It is clear that risk analysis should be made with the same units by which EVM have been done.

Forecasting future results (EAC)

EVM and risk management wants to predict the future based on available information of the project. Earned Value Management predicts the future using the formulas used in the "Estimate at Completion (EAC)". Most of times these formulas are started with actual costs (BCWP / AC) and remaining funds will be added to it. Risk management predicts the future for the project by analyzing the effects of known risks and remaining uncertainties for the project. In the case of using the integrated model of cost - time, the result of the S-shaped diagrams would be like [Fig.1], but with this difference that it also covers incomplete part of the project.

As at risk and EVM we should determine the baseline of primacy cost, other factors of project should also be estimated. You can also use the results of the risk analysis in order to show the effect of specific risks (opportunities or threats) on the project and compare it with what has been obtained from earned value. Since risk analysis includes estimations of "uncertainty" and "specific risks", this model can be used to perform the analysis of states with low uncertainty and also indicate the effects of a specific risk. For example, if a key risk was modeled using this potential method, an analysis of "if it happened - what to do" can reach risk probability to zero. The result of this action is a sequence of the accumulation diagrams of probable distribution of accumulation (S curve). This allows identifying important risks that must be identified on a priority basis. If the same technique is used to make PV, risk analysis shows which of the risks has the maximum impact on earned value and implementation of the project.

Risk model shows the effects of different risks and the planned reactions of the project rest. EVM approach occurs in cases where specific changes as a result of change of the range or the risk event and take into consideration probabilities at baseline. The results of the quantitative risk analysis show that, in order to cover a level of the remaining risks of project how much probability should be considered in the baseline.

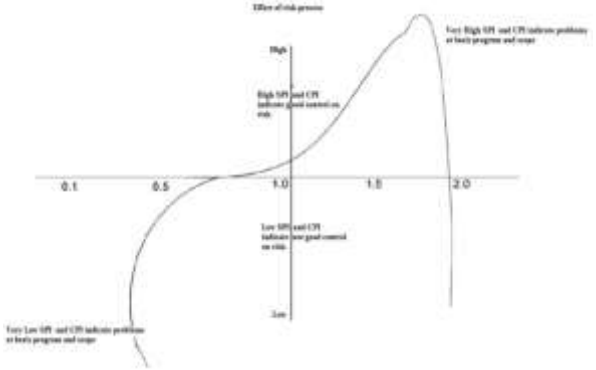

Fig. 2: The relationship between indicators of EVM with risk management

Evaluation of the effectiveness of risk process

Since Earned Value Management index (CPI, SPI) shows advanced deviations from the program, these indices can show the effectiveness of risk process in the assessment of uncertainty and control of its effects. [Fig.2] shows (CPI, SPI) and the efficient risk management process.

• If CPI or SPI is less than 1, project progress is further back to program, and one of its reasons is risk process failure in keeping project on the primary base. And when these risks are turned into problems, there will be delay or additional cost in project. In this case, the manager should consider risk management and evaluate its efficiency.

• If CPI or SPI is higher than 1, the development project has been more than the program and the risk process must focus on the use of available opportunities, it examines the best risk management process and the opportunity together and seeks to minimize risk and maximize opportunity. When the Earned Value Management represents opportunities in the project, the risk process identify these opportunities and tries to earn additional profits from the project.

• It should be noted, being too high CPI or SPI (much greater than 1) does not represent an opportunity for project but also show there are other problems in the project. Usually, if real progress is so much more expected program, it can be concluded that in determining the initial baseline, a poor planning has been done or areas have been marked by mistake.

• Similarly, if the CPI or SPI is so much less than 1, it is not only the result of not managed risks, it can also be the result of problems in the program or scope baseline.

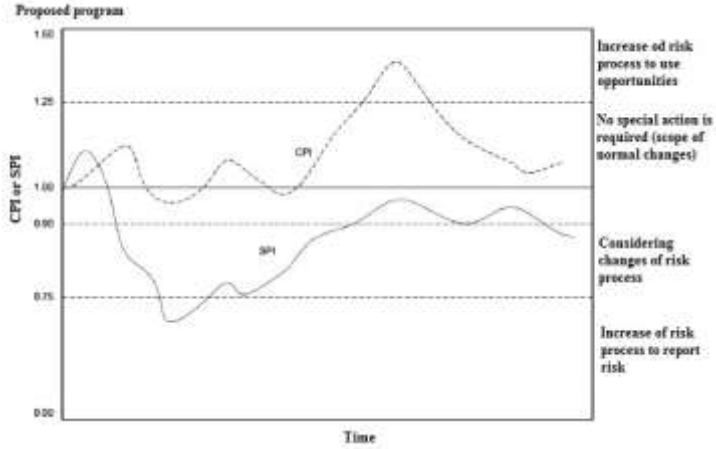

Fig. 3: EVM indicators process as a sign of the effectiveness of risk management process

Important point in the use of EVM indicators is to determine the effectiveness of risk management in that we should identify appropriate threshold where the focus is on risk process. Clearly, with the progress of the project, changes in the EVM are made, and lack of risk process adjustment is considered as a result of these wrong changes. In any case, if a process starts and passes the threshold of "normal deviations", actions should be considered; [Fig. 3] shows this. Threshold of "normal deviation" for CPI and SPI has been considered greater and equal to 0.9 and smaller than 1.25. A threshold has been specified as "alert threshold" that indicates a problem is underway and initial steps should be taken. Thresholds of 0.75, and 1.25 and 0.9 have been only marked for use in [Fig.3] and in the case of further research better thresholds can be determined.

Drawing CPI and SPI against these thresholds gives us useful information about the risks that we face at every point of the project. The recommended measures in the form of (4) have been drawn that are as a result of the following four situations:

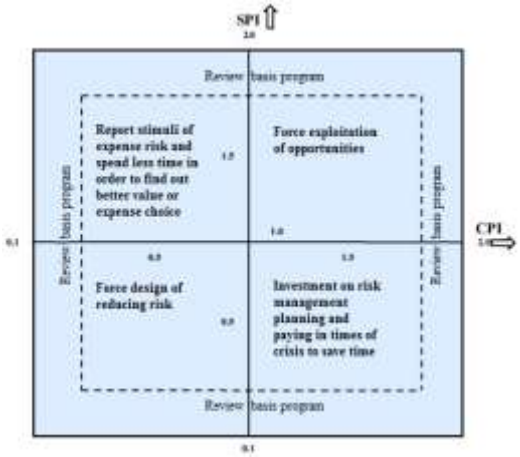

Fig. 4: Risk management decisions and EVM indicators

1. High CPI and SPI (highest right corner), creation of opportunity.
2. Low CPI and SPI (lowest left corner), an active effort should be made to evaluate the hazards.
3. High SPI and low CPI (highest left quadrant) shows a need to pay attention to the risk of costs, and likeliness to spend more time to evaluate it.
4. High CPI but low SPI (lowest right quadrant) shows we must pay more attention to the risk of schedule program and costs of the work end should be considered [23].

CONCLUSION

EVM and risk management seek to improve decision-making using rational framework based on project progress. EVM examines past progresses against the defined quantitative scales and uses them to predict

future of project. Risk management to identify and assess the uncertainties with the ability to influence the progress of the project (positive or negative) considers future and creates reactions necessary against risks. Both methods are common in focusing on the development of projects and have a common goal in creating effective measures to correct the unpleasant processes, and in order to maximize the probability of achieving the project goal.

EVM does this with the review of past as an indicator of future progress, and risk management looks to the future and possible results of project. The two approaches are not inconsistent with each other. In fact, their common points create a powerful synergy that it can be achieved by combining their strengths and the use of view of one to use one else.

CONFLICT OF INTEREST
There is no conflict of interest

ACKNOWLEDGEMENTS
None

FINANCIAL DISCLOSURE
None

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