International Journal of Engineering Science Invention Research & Development; Vol. II Issue IV October 2015 www.ijesird.com e-ISSN: 2349-6185

Effect of Schedule Performance Index on Cost Estimation in Earned Value Management and Earned Schedule using Weibull, Gamma and Exponential Function.

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Abstract- **Earned Value analysis (EVA) is the most effective tool used for intermediate review of project execution .It is helpful to project managers and management team to understand the progress of project work throughout the project life cycle. The Earned Schedule (ES) is used to estimate the time or duration of project/ s for appropriate evaluation project execution. ES also help to forecast the time required to complete the project. When combined with schedule analysis, ES can enhance the project. EVA provides the powerful tool for better decision making in project management. The paper discuss about the comparison of correlation and regression coefficient using three distribution. Function exaction using correct distribution for forecasting project duration and cost will prevent the great loss in future. So an attempt is made to find the alternative distribution of CPI and SPI for better decision making. If the project schedule performance shows poor results then manager need to take the corrective action with help of this tool. Weibull ,Gamma and Exponential Distribution functions are used to study the effect of SPI on CPI. For making better decision in project scheduling, Project managers can review the parameters using EVM tool. The tool is useful in all types of civil engineering and software engineering projects.**

Keywords **— Earned Value Analysis(EVA) , Earned Value Management(EVM), Earned Schedule(ES) ,Actual Cost(AC), Budget At Completion(BAC) , Cost Performance Index(CPI) , Scheduled Performance Index(SPI) , Planned Value(PV), Earned Value (EV) ,Weibull, Gamma, Exponetial function**

I. INTRODUCTION

Every project must be completed in scheduled time and in budgeted cost, but meeting with customer's dynamic expectation, it becomes very difficult to manage the things for project manager. Guiding the project team in appropriate direction with proper risk assessment associated with project activities is not very easy task. If the project manager is capable of executing the project plan as per schedule with minimum variation, then it will definitely show great performance as the project progresses.

If some crises are arises during the execution, then some reserves are used to compensate that impact on project. EVA minimizes the use of reserves by anticipating and estimating the performance of activities during the execution of project. The effective use of EVA and ES will provides great opportunities to complete the project within time and cost.

In EVM, Earned value analysis (EVA) is used for measuring project progress in an objective manner. EVA has the ability to combine measurements of scope, schedule, and cost in a single integrated system.

Earned value is the cumulative value of work completed at that point of time. Planned value is the approved budget or cost for accomplishing that activity. Actual cost is the cumulative money spent to accomplish that activity at given point of time. The Earned Value Management (EVM) indicators are Schedule Variance (SV) is used to compute the cost difference, i.e.SV= Earned Value –Planned Value, while the Cost Variance (CV) = Earned Value – Actual Cost. The Cost and Schedule Performance Indexes, CPI and SPI, respectively, are ratios. SPI is computed from the ratio, EV/PV, while CPI equals EV/AC.

The cost indicators behave differently from those for schedule. The cost indicators appear to establish a trend with some variation. Similarly, the schedule indicators initially appear to establish a trend, the study of Cost Performance Index (CPI), Schedule Performance Index (SPI), Variances and regression analysis will be studied to develop the new regression model to forecast the project cost.

1.1Problem statement:

Controlling the risk, delay in time and cost of the project using Earned Value Management and Earned Scheduled.

1.2.2 Research objective:

The main objective of this paper is to study the best suited distribution for CPI and SPI

i) To reduce risk, ii) To study delay time in completion ii) To estimate the minimal over budget cost.

II LITERATURE REVIEW

2.1PROJECT MANAGEMENT

There are many tools to measure the project progress and evaluate the performance of the project. But EVA and ES gives the efficient way of measuring the performance using cost performance index , schedule performance index, ,earned scheduled and the various indices associated with it. During project execution if CPI is equals to 1, it indicates that the project is as per scheduled and completed at planned or budgeted cost , If SPI is equals to 1 then it indicates that the project is on schedule and it will be completed in estimated time, Now the project manager is capable of estimating the delay time and over budgeted cost and can use the reserved resources to deliver the project in forecasted time and with minimal use of reserve funds.

2.1.1Elements of earned value management

(i) There are 3 major elements of project management: scope, cost and time management. In EVM the review is taken after specific interval of time and continuous monitoring is required to find the actual expenses and actual amount of work completed. The periodic comparison is done between actual expenses and planned or budgeted cost of that work done and

ii) Actual amount of work done and scheduled amount of work to be done in that period.

Earned Value Management is a system which integrate the scope . Cost and time management of project by using the resource –loaded project schedule and facilitate the systematic measurement of various factors involved in it [11]. EVM is endorsed by the Project management Institute [10] and is implemented by public and private organization for project progress evaluation .The main benefit of EVM is that it is applicable to all types and sizes of projects.

In this regard, two performance indices SPI and CPI are measured in terms of four indicators using three functions.

2.1.2Three functions of EVM:

1) Planned value,(PV) 2) Earned value (EV) and 3) Actual cost (AC)

Four indicators used to in Earned value Analysis : -

1) Cost variance (CV) = EV – AC
2) Cost Performance Index (CPI) = EV /AC
3) Schedule Variance (SV) = EV – PV
4) Schedule Performance Index (SPI) = EV/ PV

Earned Value Management (EVM) has been applied for several years. It has proven to be a tremendous aid to project planning, tracking, and decision-making. And, the Reporting methods of EVM serve as a good tool for communicating with management and customers, as well. Over the years, the in Software Development Industry, the EVM is applied to study the project performance. Statistical techniques are used to predict project outcomes, and historical data is used for new project planning. To confidently apply EVM data for outcome prediction and project planning, the numbers must reflect the real performance of the project. It is known that the schedule indicators of EVM fail to provide good information. To overcome this deficiency, the Software Development Industry has been applying the concept and methods of "Earned Schedule" for several years.

2.2EARNED VALUE ANALYSIS (EVA)

Earned Value Analysis is calculated by multiplying budgeted cost per activity and completion percentage and sum all activities in the project. Basic elements needed for Earned Value Analysis:

Budget At Completion (BAC). Total budgeted cost of project.

Planned value (PV): Earlier it is also called as Budgeted Cost of Work Scheduled (BCWS). Budgeted cost of work performed (BCWP) : Budgeted cost of work that is completed in given point of time in project.
Actual cost (AC) or Actual Cost of Work Performed (ACWP). Actual incurred cost of actual completed job at any given point of time in project.

2.3 ES:

"Earned Schedule (ES) is an extension to Earned Value Management (EVM) providing the capability of schedule analysis.1 ES was introduced in 2003 by Lipke in article "Schedule Is Different" [6]. For those applying ES, the method is broadly considered to be a significant advancement to the practice of EVM. ES has propagated across the world, including the USA, Australia, United Kingdom, Belgium, Spain, Canada, India, Japan and other countries, as well. It is being used across all industries applying EVM for all sizes of projects.

Furthermore, the method is being used in research, instructed in several universities, and is included in recent project management texts and the newer EVM analysis tools. Presently an appendix describing ES is being prepared for inclusion in the *PMI Practice Standard for Earned Value Management* [9].
The measure of ES has provided schedule analysis and forecasting capability to those using EVM, previously was not easy to implement because many calculations are involved in it. ES facilitates a simple calculation for the forecasting of project duration and completion dates. Furthermore, it has been shown that the forecasting is enhanced through the application of statistical methods [16]. "Earned Schedule is a fairly new method for analyzing schedule performance; it is a derived application of Earned Value Management (EVM) data. Created three years ago, the method has propagated to several countries and been used for various types of work spanning a large range of project sizes. During this period of infancy, a misperception may have emerged that ES is only applicable to the total project and thus is limited for schedule performance analysis. As has been shown in the article, "Connecting Earned Value to the Schedule," [6]. "ES can be used for much more. It facilitates the ability to identify constraints, impediments, and the possibility of rework at the task level. This information is very useful for management purposes, but it does not provide performance indicators below the project level. This paper describes how ES can be applied to sub-levels of the project. Using this capability, the project manager can analyze schedule performance at virtually any level desired – control accounts, work packages, and critical path activities" [6].

2.4 FORECASTS

According to Lipke ,"A significant advantage from applying ES is that the method provides the capability to forecast the project duration and the expected completion date. Other methods exist; however, through studies it has been shown that ES is the most reliable forecasting method using EVM data." [15] ,[17].

2.5.1ELEMENTS OF EARNED SCHEDULE MANAGEMENT

A new technique will be suggested for forecasting the project duration and expected project completion date for better decision making.
The standard deviation of the forecasts from the actual final duration will be computed for each project and percentage of complete range will be studied for the projects under study.

Various parameters used in Earned Value Management and Earned Schedule:
Actual Time (AT): This is the duration from the beginning of the project to status date.
Schedule at Completion (SAC): This is the original planned completion duration of the Project.
Earned Schedule (ES): This is the duration from the beginning of the project to the date on which PV should have been equal to the current value of EV.
ES = % Complete x SAC
Time Variance (TV): The Time variance is a measure of schedule performance in time units rather than cost units.
TV = ES – AT

If TV value is negative the project is behind schedule, and if it is positive it is ahead of schedule.

Planned Value (PV) is the estimated value of the work planned to be done.

Earned Value (EV) is the estimated value of the work actually accomplished.

Actual Cost (AC) is the actual cost incurred for the work accomplished.

Cost Variance CV = EV - AC If it is negative then project is going to be over Budget.

Cost Performance Index (CPI) = EV / AC

Critical Ratio (CR) = CPI * SPI Overall Performance of the Project.

III Comparison of Correlation and Regression Coefficient using Weibull , Gamma, Exponential Distribution

3. Data analysis for CPI and SPI in EVM and ES for performance measures.

TABLE I
CORRELATION AND REGRESSION COEFFICIENTS BETWEEN CPI AND SPI

CPI and SPI			
Function	Weibull	Gamma	Exponetial
Correlation coefficient	0.4692	0.4692	0.4586
Regression coefficient	0.4968	0.4968	0.4843

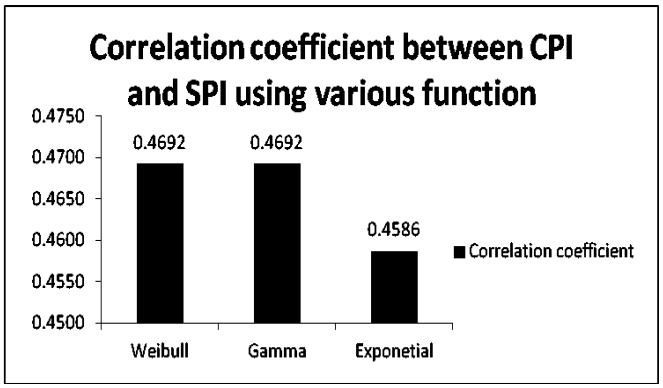

Fig. 1

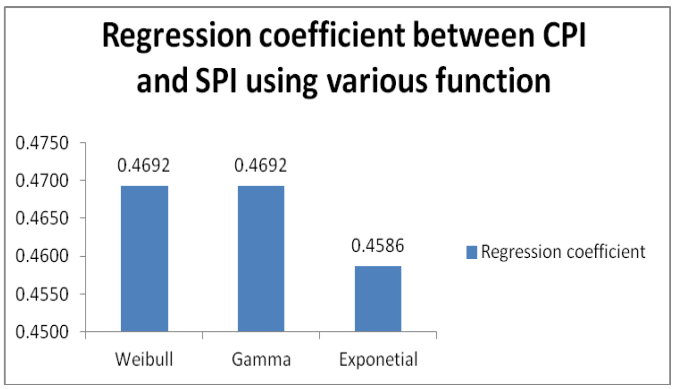

Fig. 2

In Data analysis, secondary data [14] of eight projects is used for study and data analysis done using MS- Excel and SPSS Version 20.

The correlation and regression analysis are used to describe the existence of linear relationship between variables.

Pearson Correlation coefficients are used to evaluate the correlation between two variables is. It is denoted by 'r' and it lies between -1 and 1.

If r = 1, then there is prefect positive correlation between variables under consideration.

Regression equation of SPI on CPI is using Weibull function

TABLE II
CORRELATION ANALYSIS
CORRELATIONS

		Weibull-CPI	Weibull-SPI
Weibull-CPI	Pearson Correlation	1	.469
	Sig. (2-tailed)		.241
	N	12	8
Weibull-SPI	Pearson Correlation	.469	1
	Sig. (2-tailed)	.241	
	N	8	8

TABLE III
MODEL SUMMARY , REGRESSION ANALYSIS

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.469[a]	.220	.090	.0095881

TABLE IV
COEFFICIENTS[A]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	.054	.043		1.265	.253
	Weibull-SPI	.497	.382	.469	1.302	.241

a. Dependent Variable: Weibull-CPI

The Model summary TABLE III provides the correlation coefficient summary . the value of R is found to be 0.469. It is the simple correlation between CPI and SPI. The value of R^2 is 22% which tells us that explained variation in CPI is 22% due to SPI using Weibull distribution.

Linear Regression equation of CPI(y)= 0.497SPI(x) + 0.054

Regression equation of SPI on CPI is using Gamma function

TABLE V
CORRELATION ANALYSIS

Correlations

		CPI-Gamma distribution	SPI-Gamma-distribution
CPI-Gamma distribution	Pearson Correlation	1	.469
	Sig. (2-tailed)		.241
	N	10	8
SPI-Gamma-distribution	Pearson Correlation	.469	1
	Sig. (2-tailed)	.241	
	N	8	8

TABLE VI
MODEL SUMMARY, REGRESSION ANALYSIS

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.469[a]	.220	.090	.0095881

a. Predictors: (Constant), spi-gamma-distribution

TABLE VII
COEFFICIENTS[A]

Model		Unstandardized Coefficients		Standardized Coefficients	T	Sig.
		B	Std. Error	Beta		
1	(Constant)	.054	.043		1.265	.253
	SPI-Gamma-distribution	.497	.382	.469	1.302	.241

a. Dependent Variable: cpi-gamma distribution

The Model summary TABLE VI provides the correlation coefficient summary . the value of R is found to be 0.469. It is the simple correlation between CPI and SPI. The value of R^2 is 22% which tells us that explained variation in CPI is 22% due to SPI using Gamma distribution.

Linear Regression equation of CPI(y)= 0.497SPI(x) + 0.054

Regression equation of SPI on CPI is using Exponential function

TABLE VIII
CORRELATION ANALYSIS
CORRELATIONS

		CPI-Exponetial	SPI-Exponetial
CPI-Exponetial	Pearson Correlation	1	.459
	Sig. (2-tailed)		.253
	N	10	8
SPI-Exponetial	Pearson Correlation	.459	1
	Sig. (2-tailed)	.253	
	N	8	8

TABLE IX
MODEL SUMMARY

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.459[a]	.210	.079	.0340462

a. Predictors: (Constant), SPI-Exponetial

TABLE X
REGRESSION ANALYSIS , COEFFICIENTS[A]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	.309	.235		1.313	.237
	SPI-Exponetial	.484	.383	.459	1.264	.253

a. Dependent Variable: CPI-Exponetial

The Model summary TABLE IX provides the correlation coefficient summary. The value of R is found to be 0.459. It is the simple correlation between CPI and SPI. The value of R^2 is 21% which tells us that explained variation in CPI is 21% due to SPI using Exponential distribution.

Linear Regression equation of CPI(y)= 0.484SPI(x) + 0.309

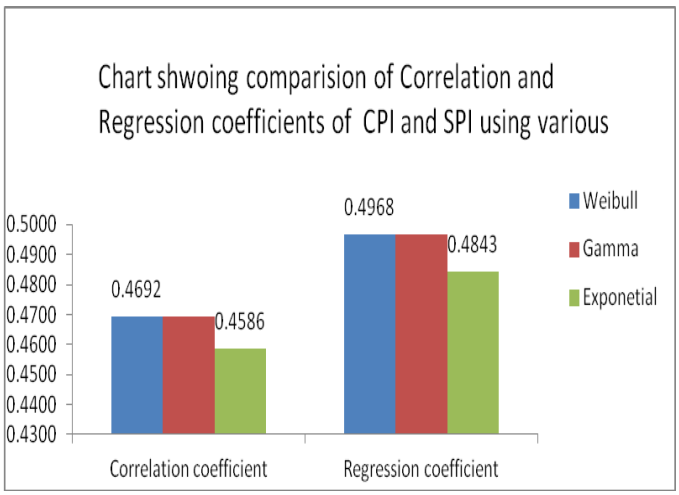

Fig.3

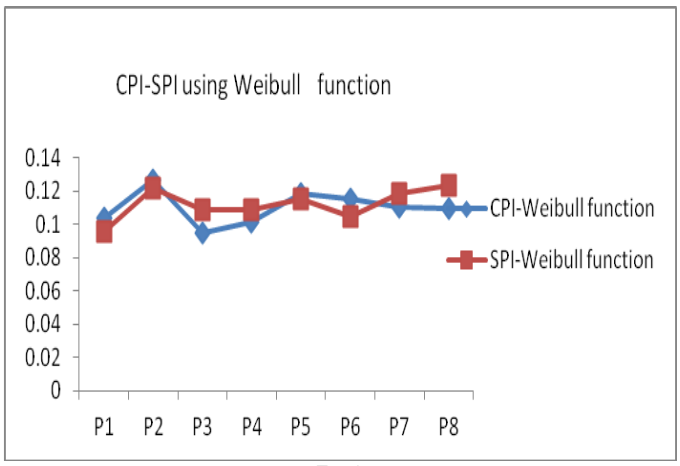

Fig.4

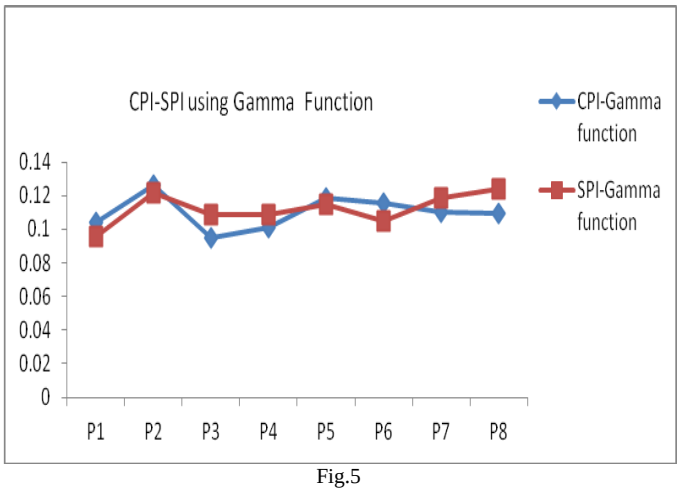

Fig.5

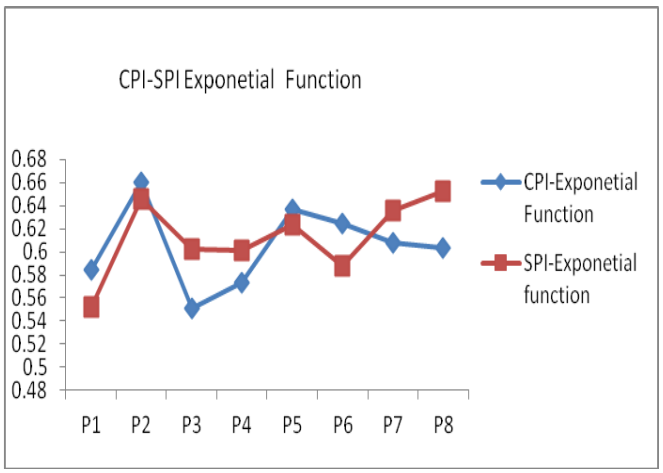

Fig.6

IV CONCLUSIONS

Project management is concerned with planning, controlling , checking project progress , monitoring milestones, deliverables and managing risk in project execution .

Earned Value Management provides the alarming signals to project manager for making strategic decisions to avoid future loss. Earned Value Management technique helps Project Manager to take corrective actions if project is not going as per schedule. It also helps to reduce the risk involved in it by changing strategy and implementing corrective action to meet the dead lines and complete the project in budgeted cost.

This paper discusses about effectiveness of Earned Value Management and Earned Schedule for better results and proper decision making in Project and risk management. By knowing the over exact function form of CPI ans SPI , Project manager can work better on cost and time so as to reduce delay time. Project manager can prepare alternative contingency plan to reduce risk and avoid the delay in project completion in minimal over budget cast.

From the discussion , it has be concluded that Weibull , Gamma and Exponential distribution are most suitable distribution to study the cost and schedule performance indices .

Weibull distribution function and Gamma distribution function showed the same result while Exponential distribution gave in less value as compared Weibull and Gamma distribution.

Weibull and Gamma distribution can be used very effectively to forecast the project cost on the basis of schedule performance index.

Further research can be carried out to study the factors which are significantly contributing in variation. Multiple factors are contributing in variation in CPI which may have inter dependency.

The study of interdependency and its measurable outcome will prove better tool in EVM for engineering project to control overhead cost and overrun schedule projects. The nature of CPI and SPI will help to understand the factors responsible for variation.

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