Project Risk and CPI

Why Should CPI = 1?

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Abstract

The expectation when applying Earned Value Management is to control performance such that $\text{CPI} = 1.00$. This presentation examines that premise. Two influences are identified: schedule and risk. Each is shown to have negative impact on CPI. Recognizing how the influence is exhibited, an alternative management approach is proposed.
Overview

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**Introduction**

- **Should we rightfully expect CPI = 1.00?**
- To refresh, CPI is the cost performance efficiency, CPI = EV / AC
- Project managers desire to guide the cost performance such that CPI = 1.00
- Those who receive and analyze project status reports examine with reference to CPI = 1.00
- When the CPI value is less than a threshold (CPI\textsubscript{T} = 0.85) an explanation and a planned action for performance improvement is expected
Introduction

- That’s today’s practice of EVM
- Nevertheless …
  - *Is CPI = 1.00 a reasonable expectation?*
- Commonly, when CPI < CPI_T for an extended time, the PM requests approval to re-baseline
- By establishing a revised baseline, the pressure to improve is relieved …and, momentarily, status reports become acceptable
Introduction

- This practice diminishes the management effectiveness of EVM – for the current project and for future planning and evaluation of process improvement initiatives.
- If EVM practitioners could view CPI with an expectation of something other than the value of 1.00 – it may be possible to minimize revising project baselines and preserve project history.
CPI and Schedule

- For small projects that may require different skills there may be gaps for certain skills.
- For example, the project requires 12 engineers, but for a two week period only 10 have planned work.

**Shouldn’t this affect CPI?**

- Unless the engineers are pooled with another project, they will accrue cost and not have PV available to be earned.
CPI and Schedule

- From the outset, we know the resource cost for the project ($AC_R$) is greater than the budgeted cost, $BAC$. Thus the expectation for cost efficiency is
  \[ CPI_S = \frac{BAC}{AC_R} < 1.00 \]
- In turn, this affects management reserve
  \[ MR_S = AC_R - BAC \]
- During planning, $CPI_S$ could be used as a measure of scheduling effectiveness. Skills having time gaps could be evaluated and minimized so as to bring $CPI_S$ closer to 1.00
CPI and Risk

- Over the years there have been several initiatives and efforts to couple EVM and Risk Management (RM)
  - In 2005, NDIA survey results indicated a strong desire within the EVM community to integrate the two methodologies
  - At the 2006 IPMC, Patti Tisone presented the Northrop Grumman process
  - In a 2004 paper, David Hilson developed a method connecting EVM performance to risk management reactions
  - Lauren Bone, at the 2007 IPMC, described an approach of interfacing EVM and RM
CPI and Risk

- The risk evaluation for the project should directly relate to the creation of the EVM Management Reserve (MR).
  - MR is intended to fund the effort needed to address the impact of a risk, should it occur.

- Although the other references cited imply this connection, only the presentation by Bone explicitly makes the relationship.
  - The Bone method is a probabilistic approach which produces the PMB, MR, and schedule reserve.
CPI and Risk

- From the Bone presentation, potential risks are categorized into – **known & unknown**
- For the known risks, plans are created and put into action upon risk occurrence
  - The risk plan is integrated into the PMB, as needed, removing funding from MR
  - BAC and the project duration is increased
  - The risk action can then be tracked and managed using EVM methods … *integration of EVM & RM is achieved*
CPI and Risk

- The handling of the unknown risks is not so well defined – the presumption is the same method is used …with the exception that the planning needed for the mitigation action is included as part of the action.
- The Bone method is very good …however, there may be circumstances for which management may not choose to integrate the risk action into the PMB …it may be seen as not worth the effort.
CPI and Risk

- When the risk action is not integrated into the PMB, costs are accrued for the project but no EV is accrued
  - Risk cost must appear in the project …somewhere
  - MR is used to fund the risk mitigation action …where did it go? …consumed by inefficiency
- CPI should be expected to decrease when the risk action plan is not integrated into PMB
- In this instance, the practice of using the CPI threshold may cause unnecessary management actions and project re-baselines
Risk Impact on CPI

- The Bone presentation indicated the distribution of possible project outcomes as right-skewed
  - The distribution is caused by the uncertainty of the occurrence of the risks …and is consistent with my previous research
  - My hypothesis is the risk impact distribution is right-skewed, as well – and has relationship with the concentration of dependent activities (the number of dependent activities is, itself, right-skewed with respect to percent complete)
Risk Impact on CPI

- We have established
  - As risks occur, MR is consumed
  - When the mitigation action is not integrated with the PMB, CPI suffers

- The pieces are all connected
  - Risk planning ⇒ MR
  - MR ⇒ Risk mitigation
  - Percent complete ⇒ Risk occurrence
  - Risk occurrence ⇒ Cost performance
Risk Impact on CPI

Risk Impact to CPI

- Risk Occur
- MR Applied
- CPI Profile

High risk project

MR/BAC = 30%
Risk Impact on CPI

- Risk Occur and MR Applied are normalized representations.
- Risk Occur increases for the first third and then decreases.
- If well-planned, MR will be equal to the expected impact of risk.
- Then, MR becomes the integration of the risk occurrence impact.
Risk Impact on CPI

- On the figure, CPI is shown decreasing with project progress – beginning at 1.00 and ending at 0.77
- Risk mitigation is not integrated into the PMB …and, thus, there is no PV to earn
- For this situation
  \[
  CPI = \frac{EV}{AC_P + AC_R}
  \]
  - \(AC_P\) = actual cost associated with tasks in the PMB
  - \(AC_R\) = cost to mitigate risk not integrated into PMB
Risk Impact on CPI

- If MR is utilized as expected, $AC_R$ will follow the graph of MR Applied
- For perfect cost efficiency, CPI is equal to
  $$CPI = \frac{EV}{EV + MR_A}$$
  - $MR_A = MR Applied$ (function of project progress)
- Thus, for perfect cost efficiency, it is obvious that CPI must decrease as risks occur
Risk Impact on CPI

- The equation yields the value 0.77 shown on the graph

\[
CPI = \frac{EV}{EV + MR_A} = \frac{BAC}{BAC + 0.3 \times BAC} = \frac{1}{1.30} = 0.77
\]

- The example demonstrates that as project risk becomes high the CPI can be expected to have a final value much lower than 1.00
In today’s practice of EVM, the CPI threshold does not consider project risk

- Whether high or low risk, $CPI_T = 0.90$
- PMs are compelled to react to breach of threshold

For the graph, CPI falls below 0.90 early …and not understanding …PM reacts unnecessarily
Because risk events continue to occur, the mitigation actions taken don’t halt the decline of CPI.

As conditions worsen, to avert criticism …a revised baseline is created …consuming time and diverting effort from the project.
The graph is the outcome of the project planning considering the anticipation of risk.

The CPI as a function of project progress could be used for comparison to actual value ...rather than the threshold comparison presently used.
The alternative method proposed should
- Improve management information and decision making
- Prevent pointless effort to improve cost efficiency
- Avoid cost and time expended for project re-baselining
- Improve project histories
Forecast and Schedule Application

- An interesting point – cost forecasting is not dependent upon integrating risk actions into the PMB

- To illustrate – MR = 0.3 BAC and CPI\textsubscript{final} = 0.77

- When risk is integrated, the budget = 1.3 BAC
  - Forecast = Project Budget / CPI
    = 1.3 BAC / 1.00 = 1.3 BAC

- When risk not integrated, budget = BAC
  - Forecast = BAC / CPI
    = BAC / 0.77 = 1.3 BAC
Forecast and Schedule Application

- Presentation has been focused on cost performance.
- It is reasonable to think that schedule performance using SPI(t) from Earned Schedule will behave analogously to the description for CPI.
- Thus, the method presented for cost may be applied to schedule, as well.
Summary

- The idea of CPI = 1.00 being a constant point of reference is questioned
- It was shown ... when resources are not fully utilized in the plan, there is cost without EV
- Relationship was described between risk occurrence, MR consumed, and CPI as a function of project progress
- A method of managing cost performance utilizing the expectation of worsening CPI is proposed
Final Comment

- The idea that CPI is expected to worsen during project execution is unsettling.
- It is contrary to the application concept of EVM.
- The underlying thinking is when inefficient performance is reacted to early in the execution, the possibility of a successful project is enhanced.
Final Comment

- However, studies have shown that decreasing 
  CPI is very “normal”
- Dr. Christensen & S. Heise noted in a study 
  that, “…the cumulative CPI …usually declined 
  as the contract proceeded to completion”
- A recent study by USAF Major Jack tested for 
  improvement in CPI after a project re-baseline. 
  His finding was that CPI tended not to improve: 
  “…we find there is no statistically significant 
  change in cumulative CPI slope (negative) after 
  an OTB intervention”
Final Comment

- The two studies give credence to the idea: *Risk negatively impacts CPI throughout the project*
- With acceptance of the connection between risk and CPI, the application of the CPI comparison method proposed can be seriously considered
- Research is needed to explore, prototype, and validate the idea presented
- Those having good EVM data are challenged to pursue this research topic
References

References