The Probability of Project Recovery

Application of the TCPI & TSPI Threshold

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Abstract

A few years ago, a theoretical study was made of the To Complete Performance Index of Earned Value Management. The study concluded that when the value of 1.10 is exceeded recovery of the project is very unlikely. Recent analysis using real data has shown that the value 1.10 for the To Complete indexes from Earned Value Management and Earned Schedule is a reliable threshold, adding credence to the conclusion from the theory assessment. This presentation describes how to use project performance measures with the established threshold to compute the probability of schedule and cost recovery. Knowing the probability provides additional and beneficial information, thereby enhancing the decision making capability of project managers.

Objective

- Connect the TCPI & TSPI threshold to the probability of project recovery
- Understand the methodology for computing the probability of project recovery …for cost and schedule
- Incorporate the application of the probability of recovery into PM's tool-set

Overview

- Introduction
- Probability Calculation Dilemma
- Application of Established Statistical Behavior
- Probability Calculation & Analysis
- Notional Data Example
- Summary
- Calculation Aid

Introduction

Formulas, Research, Theory

Introduction / TCPI & TSPI

- General acceptance – TCPI is an important cost performance indicator
- What is TCPI? …*the indicator is defined as the work remaining to be accomplished divided by the unexpended portion of available funding*
- Why is TCPI important for PMs? …*it describes the cost performance efficiency needed for the remainder of the project to achieve the desired final cost*
- The TCPI value has a powerful influence on the need or urgency for intervention and management action.

Introduction / Formulas

- The *To Complete Performance Index* formula is defined as follows:

$$TCPI = (BAC - EV) / (TC - AC)$$

where BAC = Budget at Completion

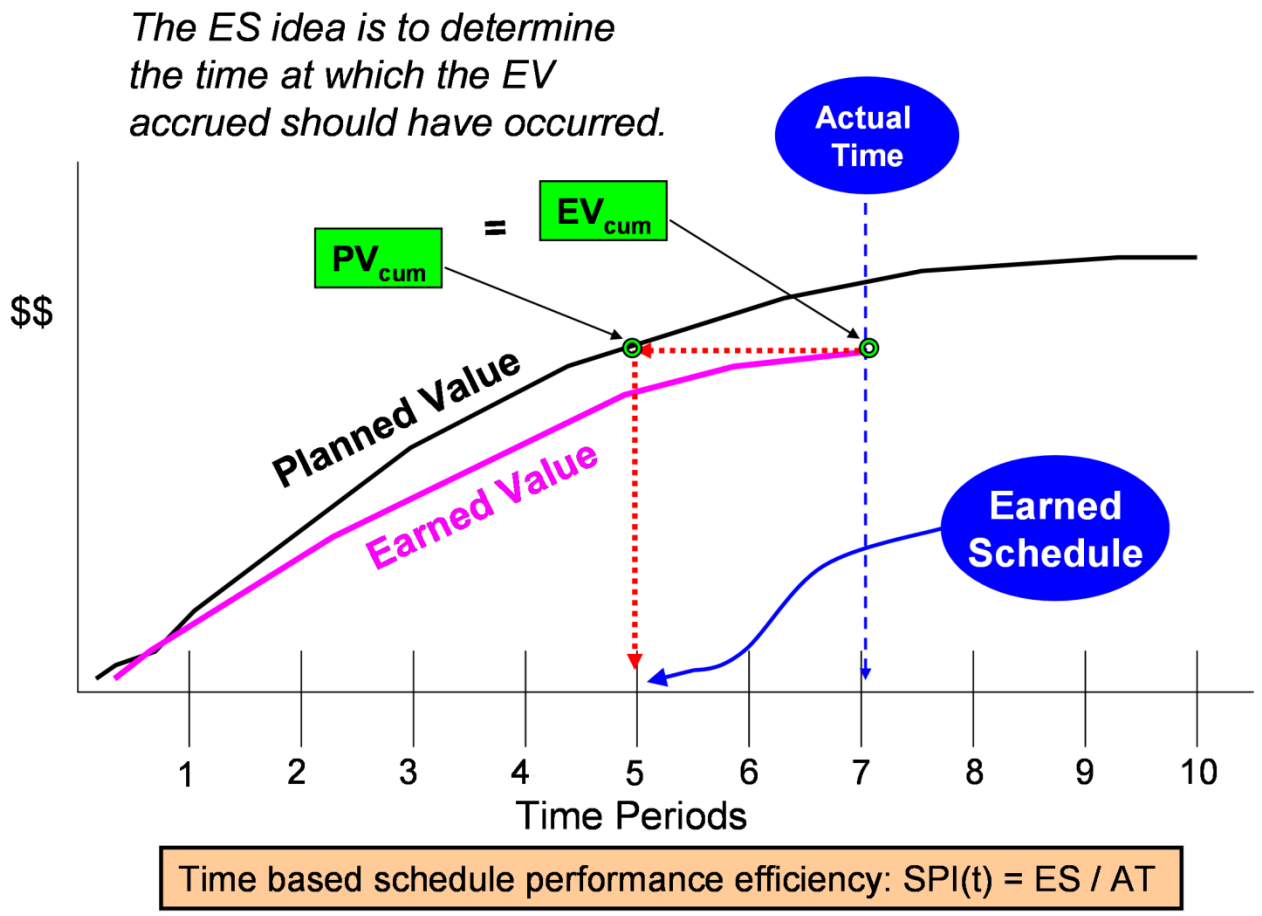
EV = Earned Value

TC = Total Cost

AC = Actual Cost

- Historically, TCPI > 1.10 has been assumed to be the point at which project cost performance is out of control
- Theoretical and empirical evidence indicates the threshold is valid

Introduction / Earned Schedule



Introduction / Formulas

- With the development of Earned Schedule (ES), the *To Complete Schedule Performance Index* (TSPI) has been created for schedule performance management:

  $$TSPI = (PD - ES) / (TD - AT)$$

  where PD = Planned Duration
  ES = Earned Schedule
  TD = Total Duration
  AT = Actual Time Duration

- As for TCPI, evidence indicates the value of 1.10 for TSPI is a valid threshold …when TSPI > 1.10, schedule performance is out of control

Introduction / Research

- "The To Complete Performance Index …an expanded view," *The Measurable News*, 2009 Issue 2: 18-22
  - *"…the TCPI value of 1.10 is a reasonable criterion for determining when a project is not recoverable (to its desired cost) and is 'out of control'"*
- "Examination of the Threshold for the To Complete Indexes," *The Measurable News*, 2016 Issue 1: 9-14
  - *"…it is reasonably clear the value 1.10 is a reliable threshold for both TCPI and TSPI.When the threshold is exceeded after the project has achieved 20 percent completion, recovery is very unlikely.When the index value is equal to or less than the threshold, a successful project can be expected."*

Introduction / Probability Theory

- The probability that the mean (M) of a number of observations (O) is larger than a selected value (V):

$$X = (M - V) \,/\, (\sigma / \sqrt{n})$$

$$\sigma = \sqrt{(\Sigma (O_i - M)^2 \,/\, (n - 1))}$$

X = the statistically normalized difference of M minus V

σ = the estimated standard deviation of the observed measures

n = the number of measures

O_i = one of the observations

- Convert X to probability using normal or t-distribution
- Finite adjustment factor: $\sqrt{((N - n) \,/\, (N - 1))}$

Calculation Dilemma

TCPI & TSPI Behavior

- To compute probability, two questions need answering:
  - *Are the values from the periodic measures of the index distributed normally?*
  - *Is the number of index measures finite?*
- Number of status values is limited by project completion, and therefore finite
- TCPI & TSPI exhibit odd behavior …and lack of meaning for periodic values …statistical distribution unknown
- The indexes do not satisfy the requirements and we have a conundrum: *How can the probability be computed without discerning their statistical characteristics?*

Resolving the Dilemma

- Set TCPI and TSPI = 1.10 and solve for CPI and SPI(t), respectively

$$CPI_T = 1.10\ EV\% \ /\ (1.10\ CR - 1 + EV\%)$$

$$SPI(t)_T = 1.10\ ES\% \ /\ (1.10\ SR - 1 + ES\%)$$

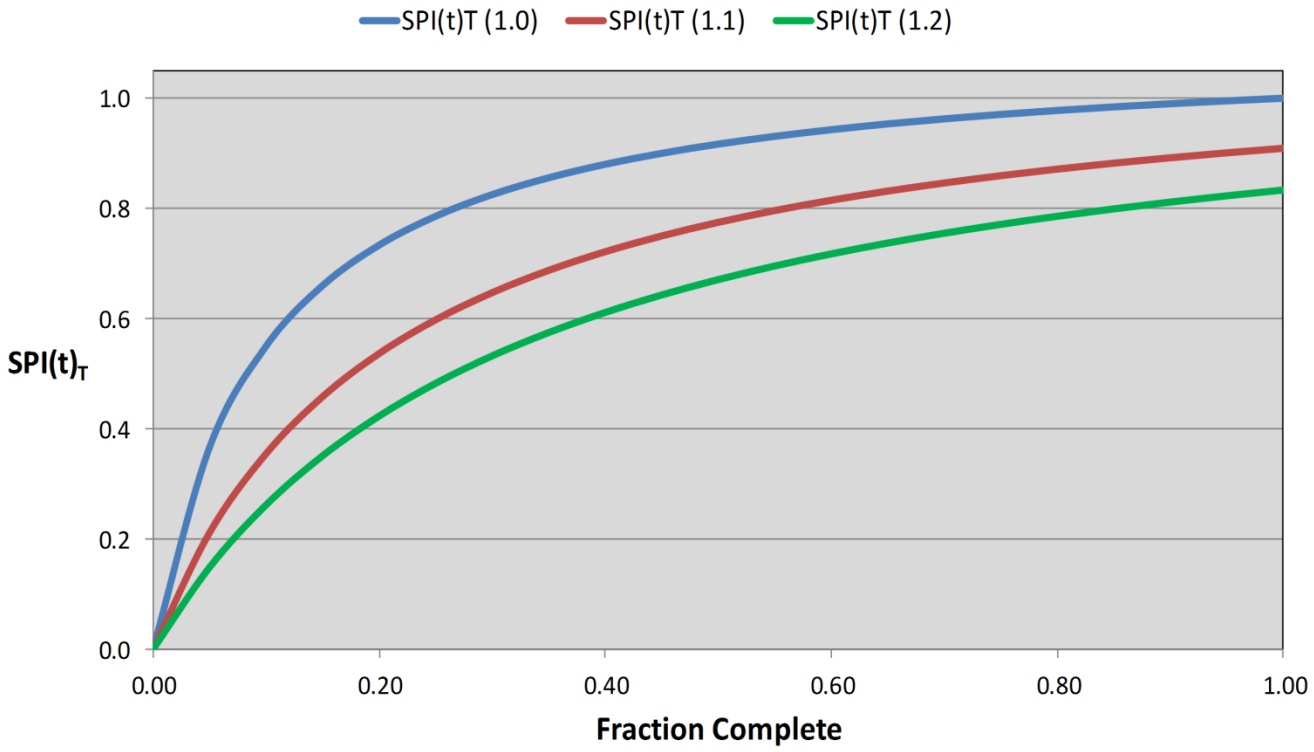
where $EV\% = EV/BAC$ $\quad ES\% = ES/PD$

$CR = TC/BAC$ $\quad SR = TD/PD$

- "T" functions facilitate comparison to performance indexes, CPI and SPI(t)
- When $CPI < CPI_T$ or $SPI(t) < SPI(t)_T$, the threshold is breached

Behavior of Threshold Function

- Three plots illustrate the effect of various values of reserves; i.e., as values of SR



Application of Statistics

CPI & SPI(t) Statistical Behavior

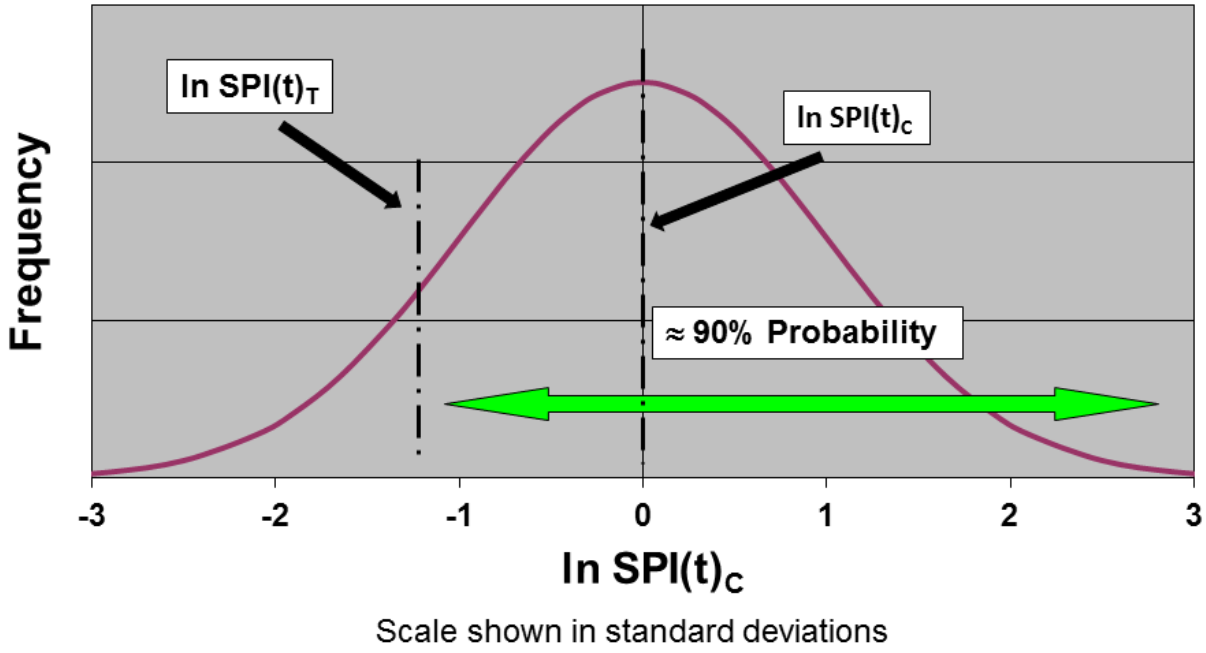
- Periodic values of CPI and SPI(t) from real projects have been tested and determined to be lognormally distributed
- The mean of the lognormal distribution can be shown, mathematically, to equal the log of the cumulative index:

$$\ln SPI(t)_C = \Sigma(\ln SPI(t)_i)/n$$

- Thus, by transforming the threshold for TCPI and TSPI to CPI_T and $SPI(t)_T$ functions, the statistical characteristics of CPI and SPI(t) can be utilized to compute the probability of recovery

Probability Example

- The probability is determined from the area beneath the normal curve beginning at ln $SPI(t)_T$ and extending to plus infinity
- The example project has an estimated 90 percent probability of recovering to its TD



Probability Calculation & Analysis

Equation Substitutions

- To perform the probability of recovery calculation, substitutions for variables, M, V, and O_i, are made in the equations for X and σ described previously:

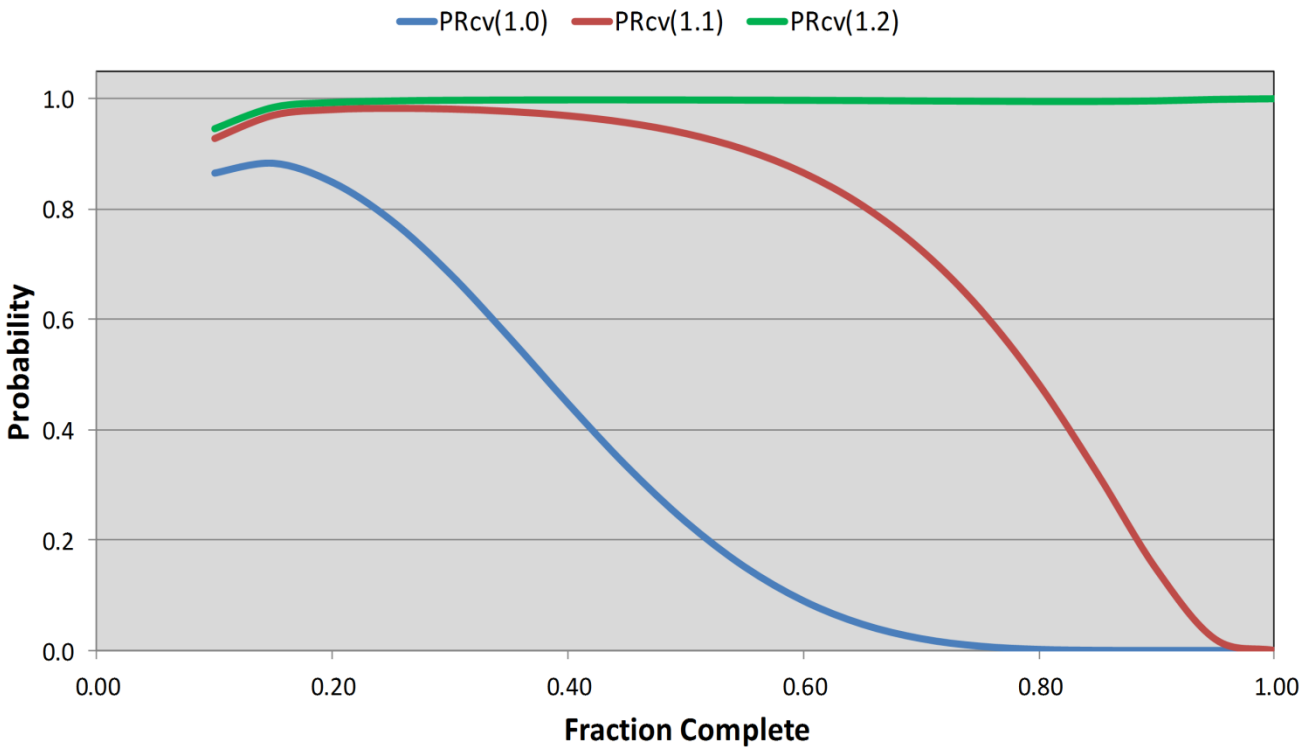
$$X = (M - V) \,/\, ((\sigma/\sqrt{n}) \bullet \sqrt{((N - n) \,/\, (N - 1))})$$

$$\sigma = \sqrt{(\Sigma(O_i - M)^2 \,/\, (n - 1))}$$

Variable	Cost	Schedule
M	$\ln CPI_C$	$\ln SPI(t)_C$
V	$\ln CPI_T$	$\ln SPI(t)_T$
O_i	$\ln CPI_i$	$\ln SPI(t)_i$
$\sqrt{((N - n) \,/\, (N - 1))}$	$\sqrt{((BAC - EV) \,/\, (BAC - EV/n))}$	$\sqrt{((PD - ES) \,/\, (PD - ES/n))}$

Probability & Reserves

- The figure illustrates the influence of schedule reserve on the probability of recovery (PRcv)



Cost & Schedule Analysis

- The examples and figures throughout have been presented in reference to schedule performance
- The discussion points are equally applicable to cost …cost and schedule analysis are perfectly analogous
  - The threshold behavior of CPI_T is identical to the $SPI(t)_T$ graph shown earlier
  - The interpretation of the probability example is unchanged when CPI is substituted for SPI(t)
  - The PRcv graphs are identical for cost, when performance and risk reserve mimic the values employed for schedule

Notional Data Example

Data & Computed Results

- Abbreviations . . . Mo, PV, EV, IEAC(t)

  PO% = Period of Opportunity . . . the portion of PD from the present status point until the threshold is exceeded if present SPI(t) continues

Mo	PV	EV	ES	SPI(t)	TSPI	PO%	IEAC(t)	PRcv
1	3023	928	0.307	0.307	1.099		26.1	
2	7828	7152	1.859	0.930	1.023	31.3%	8.6	0.574
3	13951	13302	2.894	0.965	1.021	35.1%	8.3	0.591
4	19967	17077	3.520	0.880	1.120	Unlikely	9.1	0.477
5	24286	23061	4.716	0.943	1.095	1.2%	8.5	0.505
6	30989	28681	5.656	0.943	1.172	Unlikely	8.5	0.440
7	36709	32526	6.269	0.896	1.731	Unlikely	8.9	0.219
8	38140	34513	6.616	0.827	#DIV/0!	None	9.7	0.000
9		36709	7.000	0.778	-1.000	None	10.3	0.000
10		38140	8.000	0.800	0.000	None	10.0	0.000

Analysis

- Project planned for 8 month delivery / Low risk, no reserve
- Observed ➡ SPI(t) < 1.00 and IEAC(t) > 8.00 …project in trouble early
- Is project recoverable? …sufficient opportunity? …probability of success?
- Enough data to have confidence in the management information?

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Management Decision

- At month 2 there is sufficient data (1.8 mo > 1.2 mo)
- Management information, months 2 & 3 –
  - SPI(t) & IEAC(t) – poor performance
  - TSPI ≤ 1.10 – recovery possible
  - PRcv = 0.574 & 0.591 – worth a try
- PM does not know that if he chooses not to act that threshold will be exceeded in month 4
- PM must balance inefficiency caused by intervention with the possibility of improvement
- Utilizing PRcv facilitates making earlier decisions with greater confidence

Summary

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- Theoretical and recent empirical research has shown that the value of 1.10 is very likely a valid threshold for both, TCPI and TSPI
- Having evidence the threshold is valid it was thought the probability of recovery could be computed
- The calculation method incorporates the 1.10 value and the established lognormal characteristics of CPI and SPI(t)
- Notional data example illustrated how PRcv in conjunction with TSPI and PO%, along with SPI(t) and IEAC(t) are used together for making the decision to take recovery action
- The probability of recovery is foreseen to be a very useful aid in determining when project management intervention can be beneficial


Thank You!!
TM

Probability of Recovery Calculator