Examination of the TCPI & TSPI Threshold …using Real Data

EVM/ES Indicators TCPI & TSPI

Examination of the Threshold – Real Data

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Abstract

From time to time in the Earned Value Management (EVM) literature a claim is made that exceeding the To Complete Performance Index (TCPI) value of 1.10 spells doom for the project. That is, when the threshold value of 1.10 is exceeded, the project is out of control and the project manager has little chance of successfully recovering to the desired project cost. An article from a few years ago examined the threshold theoretically, concluding that it appears to have validity. As well, the same article extended its assessment to the comparable Earned Schedule (ES) indicator, the To Complete Schedule Performance Index (TSPI). This presentation examines the threshold value empirically for both TCPI and TSPI, using real data from 25 projects of differing type and varying sources. Conclusions drawn from the research findings add to the analysis capability of EVM and ES.

Objective

- Examine the claim that the value of 1.10 for TCPI and TSPI is a reliable management threshold

- Validate/invalidate the assertion that exceeding the value of 1.10 indicates the project is not recoverable

- Provide evidence that "period of opportunity" is a viable management tool

- Understand the impact of reserves (cost or schedule) on the threshold value

Overview

- Introduction
- Previous Research
- Evaluation Methodology
- Analysis and Test Results
- Summary
- Conclusion
- Final Thoughts
- Acknowledgment

Introduction

TCPI & TSPI

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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 / TCPI & TSPI

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

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

where   BAC = Budget at Completion

         EV = Earned Value

         TC = Target Cost

         AC = Actual Cost

- Historically, TCPI > 1.10 has been assumed to be the point at which project cost performance is out of control

- Empirical evidence has not been established to confirm

Introduction / Earned Schedule

The ES idea is to determine the time at which the EV accrued should have occurred.

PV_{cum} = EV_{cum}

Actual Time

Planned Value

Earned Value

Earned Schedule
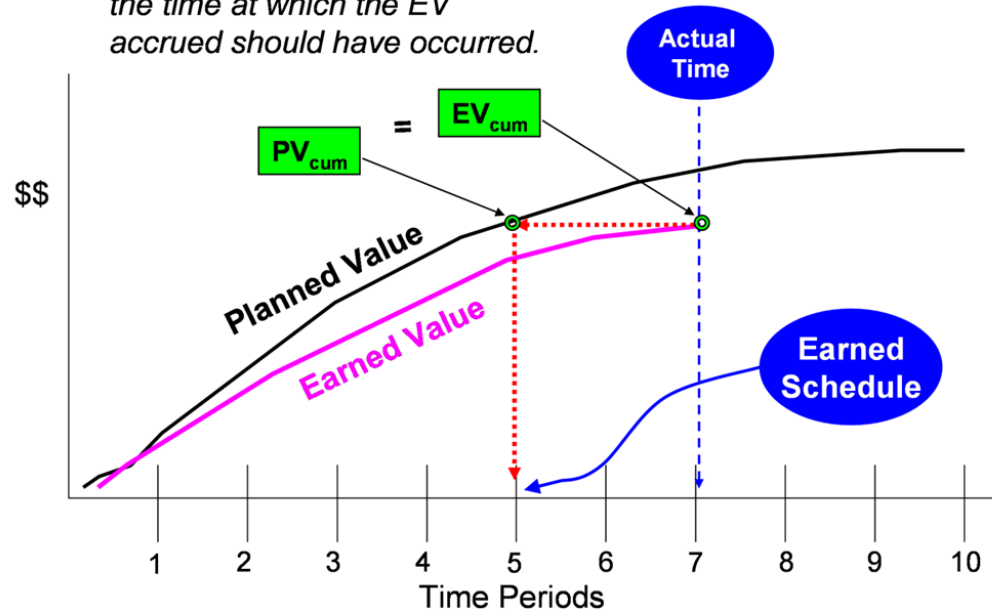
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Time Periods: 1 2 3 4 5 6 7 8 9 10

Time based schedule performance efficiency: SPI(t) = ES / AT

Introduction / TCPI & TSPI

- 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 = Target Duration
                    AT = Actual Time Duration

- As for TCPI, the value of 1.10 for TSPI is believed to be the point at which, when exceeded, schedule performance is out of control
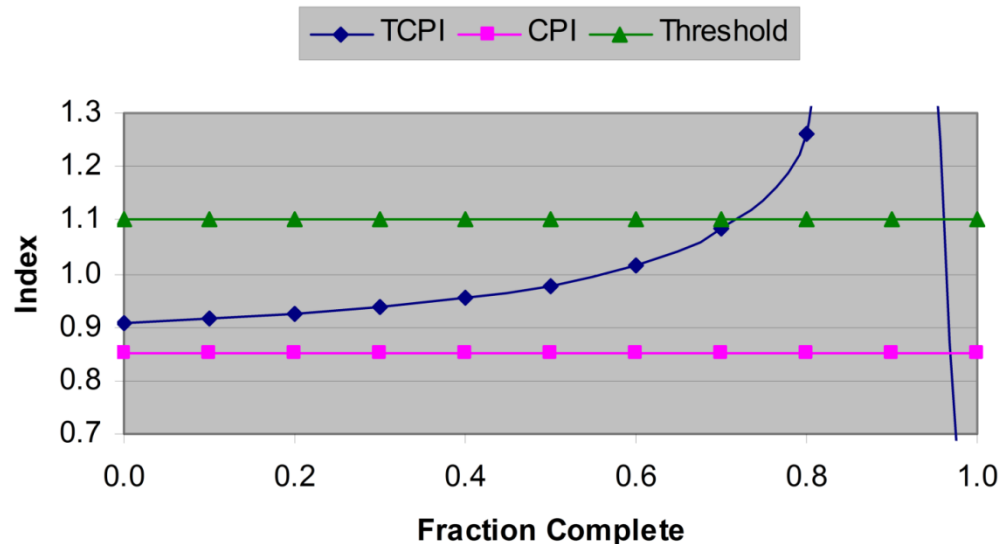
Background

Previous Research

Previous Research

- In 2009 TCPI was examined, theoretically, as to its behavior when the value approaches and then exceeds the value of 1.10

Previous Research

- As observed from the graph, TCPI increases gradually until its value is 1.10 … from that point, TCPI and its rate of change becomes markedly larger for small increases in project fraction complete

| EV%	TCPI	Rate of Change
0.714	1.100	1.131
0.750	1.149	1.614
0.800	1.259	3.032

Previous Research

- The probability of successfully achieving the desired project cost becomes extremely low when the cost efficiency required is 1.259 and is increasing at the rate of 303 percent

- The conclusion from the research analysis was

  "…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'"

- Because the formulation and behavior of TSPI is analogous to TCPI, it was likewise concluded that exceeding the TSPI value of 1.10 indicates the project most likely cannot achieve its desired duration

Previous Research

- Also, this research described how the "to complete" indexes could be used to determine the period of opportunity for project recovery

Evaluation Methodology

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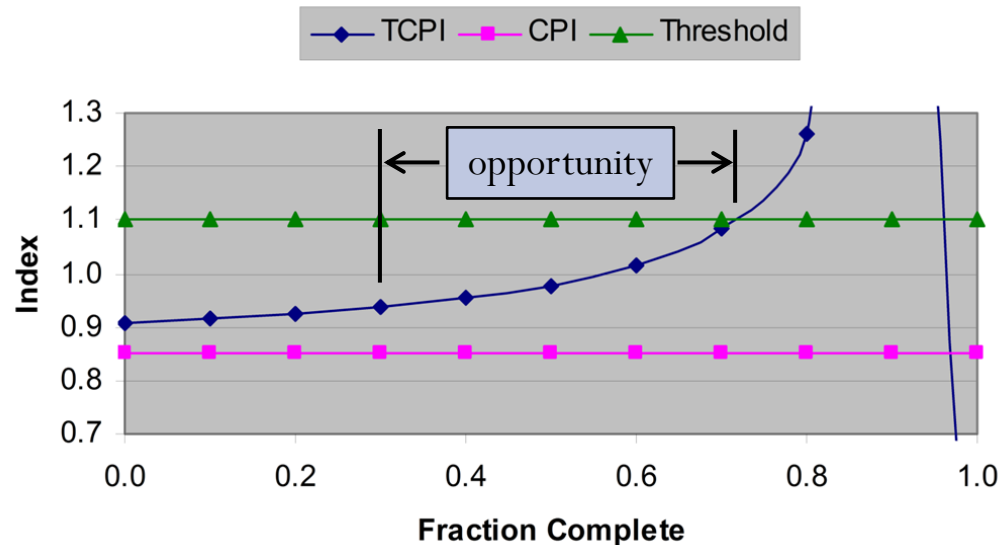
Data Description

- EVM data from twenty five projects was used to evaluate the validity of the TCPI and TSPI threshold value, 1.10

- The project data comes from three sources and is highly varied:
  - Four projects are information technology
  - Twelve come from high technology product development
  - Nine are construction type projects

- The projects range in duration from a few months to several years and have not undergone re-planning

- There is no indication in the data of reserves for cost or duration

TCPI/TSPI Values for Evaluation

- TCPI/TSPI values are analyzed including reserve amounts of 0, 5, 10, and 15 percent
- Project cost and duration outcomes for each reserve scenario are classified as Over, At, or Under
- For projects exceeding cost or duration (to include reserves), the first TCPI or TSPI value > 1.10 was recorded (≥ 20% BAC or PD)
- For those projects completing at/within cost or duration (including reserves), the largest value for TCPI or TSPI was recorded (≥ 20% BAC or PD)
- Rationale for groupings
  - If value 1.10 determines delinquency then 1st instance is sufficient
  - Largest value provides information concerning recoverability

Hypothesis Testing

- Hypothesis Testing – a statistical method for assessing the likelihood of the proposition

- Four hypothesis tests performed for each of the percentage levels (0, 5, 10, 15) for reserves:

  - For projects having TCPI $\leq$ 1.10 – Ho: Completion within budget is unlikely

  - For projects having TCPI > 1.10 – Ho: Cost recovery is possible

  - For projects having TSPI $\leq$ 1.10 – Ho: On-time/early delivery is unlikely

  - For projects having TSPI > 1.10 – Ho: Duration recovery is possible

- The Sign Test is used …the test statistic, computed using the binomial distribution, is compared to the significance level of 0.05

Analysis & Test Results

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Analysis & Test Results

- The effect of reserves is observed in project outcomes – adding reserves increases the likelihood of successful project completion

Reserve	Cost Outcomes			Schedule Outcomes		
	Under	At Budget	Over	Early	On Time	Late
0%	6	0	19	3	4	18
5%	9	2*	14	9	2	14
10%	11	0	14	9	3	13
15%	13	0	12	14	1	10

* Projects for which final cost was very close to budget, one within 0.8% and the other 0.3%.

- The table informs as to the impact of reserves on the hypothesis test evaluation - Sample size affects reliability of test result

Analysis & Test Results

Projects	TSPI	E, O, L	Sign	TSPI	E, O, L	Sign
#1	1.250	L	0	1.250	L	-
#2	1.118	L	0	1.118	L	-
#3	1.601	L	0	1.601	L	-
#4	1.134	O	0	1.134	O	+
#5	0.905	E	-	0.905	E	0
#6	1.118	L	0	1.118	L	-
#7	1.200	L	0	1.200	L	-
#8	1.006	E	-	1.006	E	0
#9	1.156	L	0	1.156	L	-
#10	1.129	L	0	1.129	L	-
#11	1.115	L	0	1.115	L	-
#12	1.115	E	0	1.115	E	+
#13	0.928	E	-	0.928	E	0
#14	0.782	E	-	0.782	E	0
#15	0.893	E	-	0.893	E	0
#16	0.833	E	-	0.833	E	0
Calc Values						
R+	Selects the projects having TSPI $\leq$ 1.10 identifying those that completed Late		0	Selects the projects having TSPI $>$ 1.10 identifying those that completed On-Time or Early		2
N			16			16
n			10			6
S+			0.01563			0.05469
α			0.10			0.10
Test Result						
Ho or Ha	Ho: On-time delivery is unlikely		**Ha**	Ho: Recovery is possible		**Ha**
	Ha: On-time delivery is likely			Ha: Recovery is unlikely		
	Legend: E = Early O = On Time L = Late					

Analysis & Test Results

- The result from each of the TCPI hypothesis tests, regardless of reserve level, is Ha

  - When TCPI ≤ 1.10 completion within the desired budget is likely

  - When TCPI > 1.10 recovery to the desired budget is unlikely

Reserve	TCPI ≤ 1.10	At/Under Budget	Test Statistic	α = 0.05 Ho or Ha	TCPI > 1.10	Over Budget	Test Statistic	α = 0.05 Ho or Ha
0%	6	6	0.01563	Ha	19	19	0.00000	Ha
5%	10	10	0.00098	Ha	15	14	0.00049	Ha
10%	12	11	0.00317	Ha	13	13	0.00012	Ha
15%	14	13	0.00092	Ha	11	11	0.00049	Ha

Analysis & Test Results

- Hypothesis test results of the TSPI threshold – all Ha, with one exception …the sample size is only three projects …none finished late, all completed on-time or early - in essence the Ha result

- Thus, TSPI results mirror those for TCPI

  - When TSPI ≤ 1.10 on-time/early delivery is likely

  - When TSPI > 1.10 recovery to the desired duration is unlikely

Reserve	TSPI ≤ 1.10	On Time / Early	Test Statistic	α = 0.05 Ho or Ha	TSPI > 1.10	Late	Test Statistic	α = 0.05 Ho or Ha
0%	3	3	0.12500	Ho	22	18	0.00217	Ha
5%	8	8	0.00391	Ha	17	14	0.00636	Ha
10%	9	9	0.00195	Ha	16	13	0.01064	Ha
15%	13	13	0.00012	Ha	12	10	0.01929	Ha

Summary

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Summary

- Previous research concluded that exceeding the value 1.10 has merit in identifying those projects with low probability of achieving the desired completion (cost/duration)

- The objective, using real data, was to confirm/reject the conclusion from the theoretical research

Summary

- The results from the examination of real data are confirmative …*the threshold value provides reliable management information, remaining independent from reserve amounts*

- An unexpected significant finding …*when the To Complete Index (TCPI or TSPI) does not exceed 1.10 after 20 percent complete, the project can be expected to meet its desired outcome (cost or duration), including reserves*

Conclusion

- From the two studies, 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

Conclusion

- Confirming the threshold value adds credence to the period of opportunity analysis …PMs have the capability to identify performance problems early enough to make effective correction

- PMs can, with high probability, assure successful project completion by maintaining index values at or below the threshold

Final Thoughts

- This empirical research has yielded additional confirming evidence for the TCPI and TSPI threshold value of 1.10. However, further examination is welcomed.

- The Prediction Analysis Calculator is available from the Earned Schedule website to assist in the analysis. Although it is created for TSPI, the spreadsheet can be very easily adapted to TCPI.

- The threshold for TCPI & TSPI has facilitated the creation of the Probability of Recovery Calculator

Acknowledgment

- Obtaining real data for studies, such as this one, is incredibly difficult. Companies regard their EVM data as proprietary; generally, there is fear that if released the data somehow will provide advantage to competitors. I feel very fortunate to have available the data from 25 projects for this study. I am very appreciative to these gentlemen for generously sharing their data: Dr. Ofer Zwikael, Kym Henderson, and Dr. Mario Vanhoucke. Thank you.

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Prediction Analysis Calculator

Probability of Recovery