Examination of the TCPI & TSPI Threshold ...using Real Data
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
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:

\[
TCPI = \frac{BAC - EV}{TC - AC}
\]
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.

\[ PV_{\text{cum}} = EV_{\text{cum}} \]

Actual Time

Planned Value

Earned Value

Earned Schedule

Time based schedule performance efficiency: SPI(t) = ES / AT
• With the development of Earned Schedule (ES), the To Complete Schedule Performance Index (TSPI) has been created for schedule performance management:

\[
\text{TSPI} = \frac{\text{PD} - \text{ES}}{\text{TD} - \text{AT}}
\]

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
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.

<table>
<thead>
<tr>
<th>EV%</th>
<th>TCPI</th>
<th>Rate of Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.714</td>
<td>1.100</td>
<td>1.131</td>
</tr>
<tr>
<td>0.750</td>
<td>1.149</td>
<td>1.614</td>
</tr>
<tr>
<td>0.800</td>
<td>1.259</td>
<td>3.032</td>
</tr>
</tbody>
</table>
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.
Also, this research described how the “to complete” indexes could be used to determine the period of opportunity for project recovery.
Evaluation Methodology
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 ≤ 1.10 – Ho: Completion within budget is unlikely
  - For projects having TCPI > 1.10 – Ho: Cost recovery is possible
  - For projects having TSPI ≤ 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
The effect of reserves is observed in project outcomes – adding reserves increases the likelihood of successful project completion.

The table informs as to the impact of reserves on the hypothesis test evaluation - Sample size affects reliability of test result.
### Analysis & Test Results

<table>
<thead>
<tr>
<th>Projects</th>
<th>TSPI</th>
<th>E, O, L</th>
<th>Sign</th>
<th>TSPI</th>
<th>E, O, L</th>
<th>Sign</th>
</tr>
</thead>
<tbody>
<tr>
<td>#1</td>
<td>1.250</td>
<td>L</td>
<td>0</td>
<td>1.250</td>
<td>L</td>
<td>-</td>
</tr>
<tr>
<td>#2</td>
<td>1.118</td>
<td>L</td>
<td>0</td>
<td>1.118</td>
<td>L</td>
<td>-</td>
</tr>
<tr>
<td>#3</td>
<td>1.601</td>
<td>L</td>
<td>0</td>
<td>1.601</td>
<td>L</td>
<td>-</td>
</tr>
<tr>
<td>#4</td>
<td>1.134</td>
<td>O</td>
<td>0</td>
<td>1.134</td>
<td>O</td>
<td>+</td>
</tr>
<tr>
<td>#5</td>
<td>0.905</td>
<td>E</td>
<td>-</td>
<td>0.905</td>
<td>E</td>
<td>0</td>
</tr>
<tr>
<td>#6</td>
<td>1.118</td>
<td>L</td>
<td>0</td>
<td>1.118</td>
<td>L</td>
<td>-</td>
</tr>
<tr>
<td>#7</td>
<td>1.200</td>
<td>L</td>
<td>0</td>
<td>1.200</td>
<td>L</td>
<td>-</td>
</tr>
<tr>
<td>#8</td>
<td>1.006</td>
<td>E</td>
<td>-</td>
<td>1.006</td>
<td>E</td>
<td>0</td>
</tr>
<tr>
<td>#9</td>
<td>1.156</td>
<td>L</td>
<td>0</td>
<td>1.156</td>
<td>L</td>
<td>-</td>
</tr>
<tr>
<td>#10</td>
<td>1.129</td>
<td>L</td>
<td>0</td>
<td>1.129</td>
<td>L</td>
<td>-</td>
</tr>
<tr>
<td>#11</td>
<td>1.115</td>
<td>L</td>
<td>0</td>
<td>1.115</td>
<td>L</td>
<td>-</td>
</tr>
<tr>
<td>#12</td>
<td>1.115</td>
<td>E</td>
<td>0</td>
<td>1.115</td>
<td>E</td>
<td>+</td>
</tr>
<tr>
<td>#13</td>
<td>0.928</td>
<td>E</td>
<td>-</td>
<td>0.928</td>
<td>E</td>
<td>0</td>
</tr>
<tr>
<td>#14</td>
<td>0.782</td>
<td>E</td>
<td>-</td>
<td>0.782</td>
<td>E</td>
<td>0</td>
</tr>
<tr>
<td>#15</td>
<td>0.893</td>
<td>E</td>
<td>-</td>
<td>0.893</td>
<td>E</td>
<td>0</td>
</tr>
<tr>
<td>#16</td>
<td>0.833</td>
<td>E</td>
<td>-</td>
<td>0.833</td>
<td>E</td>
<td>0</td>
</tr>
</tbody>
</table>

#### Calculate Values

- **R+**: Selects the projects having TSPI < 1.10 identifying those that completed Late
- **N**: 16
- **n**: 10
- **S+**: 0.01563
- **α**: 0.10

#### Test Result

- **Ho or Ha**: Ho: On-time delivery is unlikely
  - **Ha**: On-time delivery is likely
- **Ho**: Recovery is possible
  - **Ha**: Recovery is unlikely

Legend: **E** = Early, **O** = On Time, **L** = Late

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The result from each of the TCPI hypothesis tests, regardless of reserve level, is $H_a$

- When $TCPI \leq 1.10$ completion within the desired budget is likely
- When $TCPI > 1.10$ recovery to the desired budget is unlikely

<table>
<thead>
<tr>
<th>Reserve</th>
<th>$TCPI \leq 1.10$</th>
<th>At/Under Budget</th>
<th>Test Statistic</th>
<th>$\alpha = 0.05$ Ho or Ha</th>
<th>$TCPI &gt; 1.10$</th>
<th>Over Budget</th>
<th>Test Statistic</th>
<th>$\alpha = 0.05$ Ho or Ha</th>
</tr>
</thead>
<tbody>
<tr>
<td>0%</td>
<td>6</td>
<td>6</td>
<td>0.01563</td>
<td>$H_a$</td>
<td>19</td>
<td>19</td>
<td>0.00000</td>
<td>$H_a$</td>
</tr>
<tr>
<td>5%</td>
<td>10</td>
<td>10</td>
<td>0.00098</td>
<td>$H_a$</td>
<td>15</td>
<td>14</td>
<td>0.00049</td>
<td>$H_a$</td>
</tr>
<tr>
<td>10%</td>
<td>12</td>
<td>11</td>
<td>0.00317</td>
<td>$H_a$</td>
<td>13</td>
<td>13</td>
<td>0.00012</td>
<td>$H_a$</td>
</tr>
<tr>
<td>15%</td>
<td>14</td>
<td>13</td>
<td>0.00092</td>
<td>$H_a$</td>
<td>11</td>
<td>11</td>
<td>0.00049</td>
<td>$H_a$</td>
</tr>
</tbody>
</table>
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

<table>
<thead>
<tr>
<th>Reserve</th>
<th>TSPI ≤ 1.10</th>
<th>On Time / Early</th>
<th>Test Statistic</th>
<th>α = 0.05 Ho or Ha</th>
<th>TSPI &gt; 1.10</th>
<th>Late</th>
<th>Test Statistic</th>
<th>α = 0.05 Ho or Ha</th>
</tr>
</thead>
<tbody>
<tr>
<td>0%</td>
<td>3</td>
<td>3</td>
<td>0.12500</td>
<td>Ho</td>
<td>22</td>
<td>18</td>
<td>0.00217</td>
<td>Ha</td>
</tr>
<tr>
<td>5%</td>
<td>8</td>
<td>8</td>
<td>0.00391</td>
<td>Ha</td>
<td>17</td>
<td>14</td>
<td>0.00636</td>
<td>Ha</td>
</tr>
<tr>
<td>10%</td>
<td>9</td>
<td>9</td>
<td>0.00195</td>
<td>Ha</td>
<td>16</td>
<td>13</td>
<td>0.01064</td>
<td>Ha</td>
</tr>
<tr>
<td>15%</td>
<td>13</td>
<td>13</td>
<td>0.00012</td>
<td>Ha</td>
<td>12</td>
<td>10</td>
<td>0.01929</td>
<td>Ha</td>
</tr>
</tbody>
</table>
Summary
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.
References

Thank You!!

ES

TM
Prediction Analysis Calculator
Probability of Recovery