روش ارزش کسب شده بر اساس نظریه خاکستری برای پروژه‌های سرمایه‌گذاری

نویسندگان

نوید مرادی، سید میثم موسوی

چکیده

مدیریت ارزش کسب شده یک تکنیک شناخته شده در مدیریت پروژه با هدف ارزیابی و کنترل عملکرد و پیشرفت پروژه از طریق یکپارچه سازی سه عامل هزینه، زمان و محدوده پروژه می‌باشد. در این مقاله یک روش تحلیل ارزش کسب شده بر پایه نظریه خاکستری برای بازه‌های تخمین زمان و هزینه اتمام پروژه تحت شرایط عدم قطعیت برای بهینه‌سازی زمان و هزینه پروژه ارائه می‌گردد. در نهایت، یک نمونه در پروژه‌های سرمایه‌گذاری گزارش برای راهکارهای مدل ارائه شده در شرایط عدم قطعیت در پروژه‌های سرمایه‌گذاری ارائه می‌گردد.

واژگان کلیدی: ارزش کسب شده، تحلیل خاکستری، عدم قطعیت، پروژه‌های سرمایه‌گذاری

* Corresponding Author
A Grey-based Earned Value Approach for Investment Projects

Navid Moradi *, Seyed Meysam Mousavi *

M.Sc. Student, Industrial Engineering Department, Faculty of Engineering, Shahed University, Tehran, Iran, navid114@gmail.com
Assistant Professor, Industrial Engineering Department, Faculty of Engineering, Shahed University, Tehran, Iran, sm.mousavi@shahed.ac.ir

Abstract: Earned value management (EVM) is a renowned project management technique in evaluating and controlling the performance and progress of the project by integrating time, cost and scope. In this paper, a new grey-based earned value analysis model has brought to develop the analysis of earned value indices and the cost and time estimates at completion under uncertainty to optimize the time and cost of the project. Finally, a case study in investment projects is presented to show the implication of the proposed model in real-life situations.

Keywords: Earned value analysis, grey numbers, uncertainty, investment projects.

1. INTRODUCTION

Earned value project management is a valuable tool to be used in the management of projects. This technique is used to measure and communicate the real physical progress of a project and to integrate three critical elements of project management, i.e., scope, time and cost. It takes into account the work completed, the time taken and the cost incurred to complete the project, and it helps to evaluate and control project risks by measuring project progress in monetary terms [1]. This paper discusses the EVM methodology under real-life uncertain conditions. Considering this uncertainty into interpretations and calculations helps not only in measuring the performance and progress of the investment project, but also in extending the applicability of the EV techniques. In this paper, a new grey-based EV technique is presented to measure the progress and performance of the investment projects under uncertainty circumstances.

As a different model for uncertain representations, grey systems were proposed by Deng in 1982 [2]. In grey systems, the information is classified into three categories: white with completely certain information, grey with insufficient information and black with totally unknown information. Interval grey numbers are the basic concepts in this paper. The following definition represents an interval grey number [3].

\[ \Theta = [a, \bar{a}], \ a < \bar{a} \]  

(1)

1. EVM INDICES AND COMPUTATIONS

One of the EVM techniques to estimate the completion cost and time of a project is percent complete method that uses the experts’ judgments for the estimation. Based on the percent complete
method, the interval grey numbers for showing the progress of project by linguistic terms represents as follows:

- \([0, 0] \) as very low,
- \([0, 0.4] \) as low,
- \([0.4, 0] \) as half,
- \([0, 0.9] \) as high
  and
- \([0.9, 0] \) as very high.

In expressing the completion percent of each activity on the basis of a grey number, the interval grey earned value of each activity \( i \) \( \otimes EV_i \) can be calculated using the Eq. (1):

\[
\otimes EV_i = \otimes F_i \times BAC_i \in \left[ \frac{E_i}{E}, \frac{E_i}{E} \right] \in [a_{i}, a_{i} \times BAC_i]
\]

where \( \otimes F_i \) is the grey completion percent of the activity \( i \).

\[
\otimes F_i = \left[ a_{i}, a_{i} \right]
\]

and \( BAC_i \) is the budget at completion of activity \( i \). The total grey earned value is calculated as follows:

\[
\otimes EV = \sum_{i=1}^{n} \otimes EV_i \in \left[ \sum_{i=1}^{n} E_i, \sum_{i=1}^{n} E_i \right] \in \left[ E_i, E_i \right]
\]

The schedule performance index is a measure of the conformance of actual progress to schedule and calculated as follows:

\[
\otimes SPI = \otimes EV / PV \in \left[ \frac{E_i}{PV}, \frac{E_i}{PV} \right]
\]

where PV is the planned value.

The cost performance index is a measure of the budgetary conformance of the actual cost of work performed and is calculated as follows:

\[
\otimes CPI = \otimes EV / AC \in \left[ \frac{E_i}{AC}, \frac{E_i}{AC} \right]
\]

where AC is the actual cost.

Among several formulas available to calculate cost estimate at completion (EAC), a common formula assuming the future trend of the project cost performance remains intact, represented as follows:

\[
\otimes EAC = \frac{BAC}{\otimes CPI} \in \left[ \frac{AC + BAC}{E_i}, \frac{AC + BAC}{E_i} \right]
\]

Earned schedule (ES) is the time equivalent of the EV which measures schedule performance using time.

\[
ES_i = N_i + \left( \frac{E_i - PV_N}{PV_{N+1} - PV_N} \right), \quad i = 1, \forall \ so, \ \otimes ES \in \left[ ES, ES \right]
\]

where \( N \) is the longest time interval in which the \( PV_N \) (planned value at time \( N \)) is less than the EV.

In contrast to SPI, the \( SPI_i \) is expressed in time units and represented as follows:

\[
\otimes SPI_i = \otimes ES / AD \in \left[ \frac{ES}{AD}, \frac{ES}{AD} \right]
\]

where AD is the actual duration of the project.
The generic ES-based equation to estimate the time at the completion of a project, or the project duration is:

\[
\otimes EAC_t = AD + \left(\frac{PD - ES}{\otimes SPI_t}\right)
\]

(10)

where the PD is the planned duration to complete the project and the PF is the performance factor which depends on the project status. Usually there are three cases considered for the PF, but the one with \(PF = \otimes SPI_t\) is brought here as follows:

\[
\otimes EAC_t = AD + \left(\frac{PD - ES}{\otimes SPI_t}\right) = AD + \left(\frac{PD - ES_t, PD - ES_s, PD - ES_i, PD - ES_e}{ES_t, ES_s, ES_i, ES_e}\right)
\]

\[
\in [AD + \min \left\{\frac{PD - ES_t, PD - ES_s, PD - ES_i, PD - ES_e}{ES_t, ES_s, ES_i, ES_e}\right\}, AD]
\]

\[
+ \max \left\{\frac{PD - ES_t, PD - ES_s, PD - ES_i, PD - ES_e}{ES_t, ES_s, ES_i, ES_e}\right\}
\]

(11)

In this section based on the case study that illustrated in the paper by Naeini et al. [4], the new grey-based EV calculations are represented.

**TABLE 1: THE PERCENT COMPLETE AND THE EV OF ACTIVITIES.**

<table>
<thead>
<tr>
<th>Activity</th>
<th>BAC</th>
<th>Progress</th>
<th>(\otimes F_L)</th>
<th>(\otimes EV_L)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>A..</td>
<td>Very high</td>
<td>[(\cdot, A, 1)]</td>
<td>[(\cdot, A, 0)]</td>
</tr>
<tr>
<td>2</td>
<td>1..</td>
<td>High</td>
<td>[(\cdot, 1, 1)]</td>
<td>[(\cdot, 1, 0)]</td>
</tr>
<tr>
<td>3</td>
<td>2..</td>
<td>High</td>
<td>[(\cdot, 1, 1)]</td>
<td>[(\cdot, 1, 0)]</td>
</tr>
<tr>
<td>4</td>
<td>3..</td>
<td>Low</td>
<td>[(\cdot, 3, 4)]</td>
<td>[(\cdot, 3, 0)]</td>
</tr>
<tr>
<td>5</td>
<td>4..</td>
<td>Very low</td>
<td>[(\cdot, 4, 5)]</td>
<td>[(\cdot, 4, 0)]</td>
</tr>
<tr>
<td>6</td>
<td>5..</td>
<td>Not started</td>
<td>[(\cdot, 5, 6)]</td>
<td>[(\cdot, 5, 0)]</td>
</tr>
</tbody>
</table>

\(\otimes EV \in [\{\cdot, A, 0\}, \cdot]\)

\(\otimes CPI \in [\{\cdot, A, 0\}, \cdot] = [\{\cdot, 1, 1\}]\)

\(\otimes SPI \in [\{\cdot, A, 0\}, \cdot] = [\{\cdot, 1, 1\}]\)

So, the kernel grey numbers of \(\otimes CPI\) and \(\otimes SPI\) [a] are respectively \(\otimes CPI = \frac{1}{\cdot}(\cdot, 9, 4 + \cdot, 2, 6) = \cdot, 9, 4\) and \(\otimes SPI = \frac{1}{\cdot}(\cdot, 9, 4 + \cdot, 2, 6) = \cdot, 9, 4\) that shows they are on the planned cost and schedule.

**TABLE 2: THE ES CALCULATIONS.**

<table>
<thead>
<tr>
<th>I</th>
<th>(E_i)</th>
<th>(N_i)</th>
<th>(E_i - PV_{N_i})</th>
<th>(PV_{N_{i+1}} - PV_{N_i})</th>
<th>(ES_i = N_i + \frac{E_i - PV_{N_i}}{PV_{N_{i+1}} - PV_{N_i}})</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>(\cdot, A, 1)</td>
<td>(\cdot, A, 1)</td>
<td>(\cdot, A, 1)</td>
<td>(\cdot, A, 1)</td>
<td>(\cdot, A, 1)</td>
</tr>
<tr>
<td>2</td>
<td>(\cdot, 1, 1)</td>
<td>(\cdot, 1, 1)</td>
<td>(\cdot, 1, 1)</td>
<td>(\cdot, 1, 1)</td>
<td>(\cdot, 1, 1)</td>
</tr>
</tbody>
</table>
\[ EAC_t \in \left[ 6 + \min \{ \text{cost} \text{ variances} \} \right] \]

\[ + \text{ value} \]

\[ = \text{value} \]

\[ \tau. \text{ CONCLUSION} \]

EV is a management technique that assists project managers to have better control on their project. It evaluates project with indices related to cost and time of the project and estimates the final cost and time either. Here, considering the values of cost and time performance indices of the project shows that the project is doing well and is on the planned program in two categories of cost and schedule. The values of estimations of cost and time are predicted as well. Implementing grey theory in calculating EVM indices makes it more closer to the reality, according to the existance of uncertainty in real life projects.

\textbf{References}


