CONSIDERING FINANCIAL ISSUES TO ESTIMATE THE PROJECT FINAL BUDGET IN EARNED DURATION MANAGEMENT

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Abstract
Earned Value Management (EVM) has provided methods to estimate the final budget of projects. The standard EVM, however, lacks some features which needs further improvement to make it a more efficient and reliable technique. Lack of concentrating on the financial aspects in estimating the final budget provides some illusory results. This paper suggests considering the time value of money, delay in employer payment and contractor cash flow in different phases of the construction projects in calculating the final budget of the project. Moreover, using a traditional schedule performance index which is a monetary based method may mislead project managers in managing construction projects. However, a better metric of schedule performance has been introduced in Earned Duration Management (EDM) which is illustrated in this paper. A case study demonstrates the preference of the new method versus the traditional ones.

Keywords
Project Management, Earned Value Management, Earned Duration Management, Estimate final budget, Cash Flow, Delay in Payment

1. Introduction

Earned Value Management is one of the powerful tools in analyzing and controlling projects. The Project Management Body of Knowledge (PMBOK) Guide defines EVM as “a management methodology for integrating scope, schedule, and resources for objectively measuring project performance and progress” (PMI, 2008). In fact, it calculates the cost and schedule indices, estimates final budgets and completion time of the projects, and measures the progress of projects. Because of its simplicity and ability of control in different situations, the EVM has used by a variety of organizations. Lipke (2003) and Anbari (2003) were the pioneer researchers who identified EVM in some executive cases. Vandevooode and Vanhoucke (2005) have conducted the usage of EVM in some executive cases. Assisting project managers in making a more precise decision by estimating a completion process, EVM has been used by a wide variety of organizations. Using the past performance of projects helps EVM to estimate its future performance. Anbari (2003) introduced an index for estimating the future performance in term of costs. Dillibabu and Krishnaiah (2005) estimated cost performance in term of effort spent on a software project. Lipke et al. (2009) enlisted a statistical approach in forecasting final cost and time. Having an effective approach and making the result more realistic, Salari et al (2015) considered fuzzy time series to estimate the future performance of a construction project.
Considering the financial aspects was one of the points of interests of some researchers. Hwee (2003), Gorog, M (2009), and Maravas (2012) were the ones who considered EVM and cash flow separately. But in none of their researches EVM and financial aspects are considered in a unique system. Moreover, there are some factors effect on estimating the final budget which are not considered in their studies, such as delay in payment. Bagherpour (2011) introduced a model to estimate project final budgets by considering the time value of money and a delay in payment. The main deficiencies of Bagherpour (2011) model are first considering the monitory-based index for the schedule performance which may led some illusory results, he also analysed the entire construction project in one phase. While in the real world the different phases of a project need to be analysed separately. In this research, a model is introduced which relieves the more reliable result for estimating final budgets by considering the duration-based index for schedule performance and analyse the different phases of projects separately and considering the financial factors which effect on estimation at completion. The remainder of this paper is organized as follows: First, in chapter 2, it introduces the traditional approaches for estimating the final budget of projects and provides the more precise performance index by providing a brief explanation of Earned Duration Management. Chapter 3 introduces the method which considers the appropriate indices, financial aspect of a construction project and separate different phases of projects. A case study is discussed in chapter 4. And the paper ends with a discussion and conclusion in chapter 5.

2. A brief explanation of estimating techniques

Estimating project final budgets is one of the main concerns of project managers. One of the widely used formula for estimating the final budget is shown as follow. This equation brings the information about the amount of budget should be spent to complete the project; hence, knowing this information helps project managers to control their projects in a better way.

\[
EAC = AC + ETC \\
ETC = \frac{BAC - EV \times P.F}{PF}
\]

Where \(EAC\) is estimate at completion. \(AC\) is the actual cost from the beginning of the project till that current point of time, \(ETC\) is the estimated to complete, \(BAC\) is the project whole budget, \(EV\) is the earned value and \(P.F\) is a performance factor. Calculating the Performance Factor is the main difference of some researchers’ studies. Covach (1981) and Christensen (1993) studied the difference factors which can influence final budgets. Schedule and cost were the main two factors they considered in their studies. Equation (2) is the estimation of final budgets which is considering cost and schedule factors. However, the efficacy of schedule and cost indices are not equal, so different weights according to their importance should be assigned to each of them. For example, in a specific phase of a construction project the schedule is more important that its cost, so for measuring the required budget to completion, more weight should be assigned to the schedule performance index than the cost performance index. In equation (3) \(W_1\) and \(W_2\) are the weights for schedule and cost performance of the project.
\[ EAC = AC + \frac{BAC - EV}{W_1 \times SPI + W_2 \times CPI} \] (3)

Where SPI is the schedule performance index and CPI is the cost performance index which are calculated as shown in equation (4) and (5), where PV is the planned value

\[ SPI = \frac{EV}{PV} \] (4)

\[ CPI = \frac{EV}{AC} \] (5)

CPI and SPI are the two indices which are used for measuring the cost and schedule performance of a project in traditional EVM. However, as it is shown in equation (4) for calculating the schedule, the planned value and earned value are used; while these parameters are cost based. Calculating the schedule performance index which is monitoriy-based may cause some inaccurate results. Lipke (2003) introduced new concept of Earned Schedule (ES) to solve the inaccuracy of SPI. SPI(t) was the Lipke (2003) introduced index for measuring the schedule performance of project.

\[ ES(t) = 1 + \frac{EV - PV_t}{PV_{t+1} - PV_t} \] (6)

\[ SPI(t) = \frac{ES(t)}{AD} \] (7)

Where ES(t) is Earned Schedule at the status date, EV is the Earned Value at the status date, PVt is the Planned Value at time t. The actual duration which is the time from the beginning of project until the current status of time is noted as AD. Although the SPI(t) is the preferred schedule index comparing to SPI, Khamooshi (2014) introduced some of its shortcomings which makes it inapplicable in all cases. Since in calculating SPI(t), the EV is used as the main proxy, it cannot solve the problem of being monitoriy-based schedule performance index. Hence, performance measures which are cost based cannot be an accurate index for schedule measuring. Khamooshi (2014) brought an example of a construction project with the high PV and short duration. In this example, there are two parallel paths. The longer path including activities A, B, and E, and the other path contains activity C, and activity D (which has the highest Value). Figure 1 shows the EVM output of Microsoft Project report.
If all the activities are on plan and on budget, except activity B (one of the critical path activities) which has not been started yet, we should have a low schedule performance index. While we have the follow SPI, and SPI(t):

$$SPI = \frac{EV}{PV} = \frac{210,000}{227,500} = 0.92$$

$$SPI(t) = \frac{ES(t)}{AD} = \frac{13}{14} = 0.93$$

Therefore, it is evident that the 0.92 and 0.93 are approximately high performance, so both the SPI and SPI(t) which are cost-based cannot be a good index to measuring the schedule performance of projects. For resolving this inaccurately, Khamooshi (2014) introduced a new approach described Earned Duration Management (EDM) which decouple the cost and schedule dimensions and introduced a new index for schedule performance of project duration based. EDM definitions and notations are separated in two categories of EDM “Micro” or activity level and “Macro” or project level at the micro level we have the follow equation for activity i.

$$EDI_i = \frac{ED_i}{PD_i}$$  \hspace{1cm} (8)

Where $ED_i$ is the Earned Duration for activity $i$ at any point in time, and $PD_i$ is the duration which is planned for activity $i$. At macro level EDI is calculated as follow:

$$EDI = \frac{TED}{TPD}$$  \hspace{1cm} (9)
Where $EDI$ is Earned Duration Index, $TED$ is the Total Earned Duration for any point in time, which is the sum of $ED$ for all the activities in progress and completed. And Total Planned Duration ($TPD$) is the sum of $PD$ for the activities in progress and completed. The comparison of Duration earned and planned is what $EDI$ measures; indeed, it measures the schedule performance of the project. Since at any point of time, the project might have achieved more, less, or the same amount of work in comparison with the work planned to be achieved by that time, this index can have values of greater than one, lower than one or equal to one. It is suggested to use the $EDI$ as the schedule performance index in estimating the final budget of project using equation (3).

3. Considering financial aspects in estimating the final budget

Recent researches did not consider the delay in payment and cash flow in estimating the final budget of projects. Bagherpour (2011) studied the influence of these factors in estimating the final budget of projects. The notations of parameters used in his method is introduced as below:

- $CM$: Cash Money
- $CP$: Contract Price
- $EM$: Earned Money
- $FPI$: Financial Performance Index

The $CM$ is paid on basis of $CP$ throughout the project, and the $CM$ should be calculated within the limits of the $BAC$. $CP$ is normally included with $BAC$, contract deductions (such as tax and insurance), profits and organization over-head. $EM$ is the earned money in the current point of time according to the actual progress of the project. And it is calculated as shown in equation (10):

$$EM = CM \times \frac{BAC}{CP}$$

(10)

The $FPI$ can be calculated using equation (11) which represents how much money earned versus how much money is spent. From a financial point of view, an $FPI > 1$ indicates a favorable position, and $FPI < 1$ a less than favorable position. By using the financial performance indices, the efficacy of the financial issues is considered in the final budget estimation.

$$FPI = \frac{EM}{AC}$$

(11)

For considering the financial aspects such as delay in payment, cash flow and time value of money equation (12) is developed in this paper. Its first part is $AC$ which is the actual cost of the project until the current point of time, the second part is the remaining budget that should be
spent by considering the schedule, cost and financial factors’ impacts. The third part is the amount of money which is expected to be paid by the employer but still hasn’t been paid

\[
EAC = AC + \frac{BAC - EV}{W_1 \times EDI + W_2 \times CPI + W_3 \times FPI} + \frac{(EV - EM) \times (1 + I)^D - (EV - EM)}{FPI}
\] (12)

Where \(D\) is the delay in cash payment in units of time, and \(I\) is the interest rate per units of time used to express \(D\). The amount of money that the employer has not paid is equal to \((EV - EM)\), and for considering the time value of money the multiplication of \((EV - EM)\) to \((1+i)^D\) is suggested. Therefore, subtracting \((EV - EM)\) from \((EV - EM) \times (1+i)^D\) can illustrate the extra money should be paid by employer for his delay.

Moreover, considering the same condition for all the different phases of a construction project may cause some inaccurate results. In actual projects in the real life each project may contain some different phases of implementations which need to be analyzed separately. Therefore, considering one schedule, cost and financial index for the entire project may result misleading interpretation and estimates. Mortaji (2013) in his research tried to consider various phase of a construction project separately. Equation (13) suggests inclusion of construction phases.

\[
EAC_{new} = \sum_{i=1}^{n} \left( AC_i + \frac{BAC_i - EV_i}{W_1 \times SDI_i + W_2 \times CPI_i} \right)
\] (13)

In fact, if a project has \(n\) different phase, we should estimate the final budget separately for each phase and then the sum of them may cause an accurate result. However, as mentioned in this paper, considering the \(SPI\) as the schedule performance factor is not correct, so the following equation is suggested to solve all the mentioned issues.

\[
EAC_{new} = \sum_{i=1}^{n} \left( AC_i + \frac{BAC_i - EV_i}{W_1 \times EDI_i + W_2 \times CPI_i + W_3 \times FPI_i} \right) + \frac{(EV_i - EM_i) \times (1 + I)^D - (EV_i - EM_i)}{FPI_i}
\] (14)

4. Case study

In this section, to illustrate the accuracy of the introduced method a construction project with three main phases of founding, skeleton, and installation is studied. Table 1 is all the information about this construction project such as actual cost, the budget considered for each phase, earned value, earned money, delay in payment in months, schedule performance index, cost performance index, and financial performance index. In addition, the interest rate considered is 20%. And the actual budget spent for this project was 1,420,000 US dollar.
Table 1. Information of a construction project

<table>
<thead>
<tr>
<th>Phase</th>
<th>AC</th>
<th>BAC</th>
<th>EV</th>
<th>EM</th>
<th>D</th>
<th>EDI</th>
<th>CPI</th>
<th>FPI</th>
<th>W</th>
</tr>
</thead>
<tbody>
<tr>
<td>Founding</td>
<td>20</td>
<td>350</td>
<td>100</td>
<td>80</td>
<td>2</td>
<td>0.8</td>
<td>0.75</td>
<td>0.5</td>
<td>0.4</td>
</tr>
<tr>
<td>Skeleton</td>
<td>35</td>
<td>450</td>
<td>120</td>
<td>90</td>
<td>3</td>
<td>0.6</td>
<td>0.62</td>
<td>0.7</td>
<td>0.4</td>
</tr>
<tr>
<td>Installation</td>
<td>10</td>
<td>280</td>
<td>50</td>
<td>30</td>
<td>1</td>
<td>0.82</td>
<td>0.77</td>
<td>0.6</td>
<td>0.2</td>
</tr>
</tbody>
</table>

To make the results plainer, the final budget of this construction project is calculated with three different methods. The comparison of Bagherpour (2011) method, Mortaji (2013) method, Christensen (1993) method and the method proposed in this paper using equation (14) clarifies the preference of the new method other than existing methods.

Figure 2. Comparison of estimated final budget by different methods.
According to figure 2 the new approach presented in this paper results in a higher estimated final budget compared to the other methods. In Christensen (1993) method considering SPI as the schedule performance index estimates the final budget lower than the actual budget. Mortaji (2013) separated these three different phases and it has a more accurate result compared to Christensen (1993), however, ignoring financial factors such as delay in payment in this case makes this method less appropriate compared to proposed method and Bagherpour (2011). Figure 3 also shows the errors of estimation final budget by using different methods. As it is obvious proposed method has the lowest error comparing to other estimation methods.

Considering monetary based performance indices in Bagherpour (2011) Method is the main reason of difference with proposed method. As it is shown in figure 2, proposed method estimates the final budget very close to actual budget spent in this construction project.

Moreover, sensitivity analysis of each factor such as delay in payment and interest rate illustrates the preference if proposed method better. Table 3 contains different scenarios by changing the delay in payment of each phase.
Table 2. Notation of each phase

<table>
<thead>
<tr>
<th>Founding</th>
<th>Phase 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Skeleton</td>
<td>Phase 2</td>
</tr>
<tr>
<td>Installation</td>
<td>Phase 3</td>
</tr>
</tbody>
</table>

Table 3. Delay in payment of each phase

<table>
<thead>
<tr>
<th>Scenario number</th>
<th>Delay in different phases in month</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2 in phase 1, 3 in phase 2, 4 in phase 3</td>
</tr>
<tr>
<td>2</td>
<td>3 in phase 1, 4 in phase 2, 5 in phase 3</td>
</tr>
<tr>
<td>3</td>
<td>4 in phase 1, 5 in phase 2, 6 in phase 3</td>
</tr>
<tr>
<td>4</td>
<td>5 in phase 1, 6 in phase 2, 4 in phase 3</td>
</tr>
<tr>
<td>5</td>
<td>6 in phase 1, 7 in phase 2, 5 in phase 3</td>
</tr>
<tr>
<td>6</td>
<td>8 in phase 1, 9 in phase 2, 7 in phase 3</td>
</tr>
<tr>
<td>7</td>
<td>10 in phase 1, 11 in phase 2, 9 in phase 3</td>
</tr>
</tbody>
</table>

Figure 4. The effect of delay in payment on estimating final budget

Figure 4 can clearly indicate that the sensitivity of delay in payment of the method presents in this paper for estimating the final budget is greater than the previous methods. Mortaji (2013) and Christensen (1993) methods are no sensitive to delay in payment. Although Bagherpour (2011) method considers the delay in payments, but analysing the whole project in one phase and using the less reliable schedule performance index results in trustworthy results.

Moreover, figure 5 can clearly shows that the pervious methods were not sensitive in interest rates, while the proposed method can represent that by changing the interest rate from 0.2
to 0.9 the estimated final budget will change from $1,360,000 to $1,904,000. Since, Bagherpour (2011) method considers interest rates in estimating the final budget, by increasing the interest rate the estimated final budget increases. However, separating the different phases of the construction project makes the difference between Bagherpour and proposed method.

Figure 5. The effect of Interest Rate on estimating final budget

Figure 6 indicates the sensitivity analysis for changing weights of each phase by using information of table 1, and considering interest rate of 20%. Different scenarios for changing weights of each phase indicates in table 4. Scenario 1 in this table is the same as used in previous figures.

<table>
<thead>
<tr>
<th>Scenario number</th>
<th>Weights of each phase</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Phase 1</td>
</tr>
<tr>
<td>1</td>
<td>0.4</td>
</tr>
<tr>
<td>2</td>
<td>0.3</td>
</tr>
<tr>
<td>3</td>
<td>0.5</td>
</tr>
<tr>
<td>4</td>
<td>0.3</td>
</tr>
</tbody>
</table>
In figure 6, there is no change on final budget estimation using Bagherpour (2011) and Christensen (1993) methods. These two methods consider the whole project as one phase, so they are not sensitive to change of weights. Moreover, the proposed method and Mortaji (2013) method separate the different phase of the construction project, so by changing the weights of each phase, the final budget estimation using these two methods changes.

In scenario number 2, the weight for phase 2 is the highest weight, and base on table 1, since the delay in payment for phase 2 is the longer one, it led to the highest final budget estimation. Moreover, phase 1 has the highest weight in scenario 3; hence, the proposed method and Mortaji (2013) method estimate the final budget less than estimation for scenario 2 and greater than estimation for scenario 4 which assigns highest weight to phase 3.

5. Conclusion

Several studies have been done for estimating the final budget of projects. In this study we attempt to introduce a better method which shows more realistic results. Considering a monetary-based schedule performance index may lead some misleading results, because schedule and cost are different diminutions of projects. Therefore, having a more accurate schedule index should be calculated based on duration. Hence, the EDM’s schedule performance is used instead of SPI in traditional methods. Moreover, delay in payment, cash flow, and time value of money are some financial aspects which have significant impacts on estimating the final budget of projects. By considering the financial aspects in estimating at completion the results are realistic. In addition, different phases of the construction projects have various condition, so considering
them as a whole system causes project managers to analyse these projects erroneously. Assigning
diverse weights to schedule, cost and financial factors for different phases of a project helps
managers to have a more accurate estimation for final budget. For future studies it is suggested
that fuzzy factors will be used for considering the uncertainty conditions.

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