MULTIDIMENSIONAL APPROACH TO CONSTRUCTION PROJECT PERFORMANCE EVALUATION: AN EMPIRICAL STUDY

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This paper presents a novel and accessible 4D approach to project performance evaluation, surpassing traditional techniques. The conventional method relies on physical, time, and financial factors that may be insufficient for complex projects, particularly in developing countries. To address this, the paper suggests a 4D approach that considers different scenarios, analyzed with graphs and tables to achieve a more accurate evaluation of project performance. The proposed approach effectively identifies hidden issues, predicts their occurrence, possible delay, over cost and enables project managers to take proactive measures to ensure success, similar to what is done in the medical world. This method facilitates informed decision-making and resource allocation, essential for achieving project objectives. A hypothetical project demonstrates the effectiveness of this approach. In conclusion, adopting this 4D approach can help project managers identify potential issues, make informed decisions, and take appropriate action for project success in different stage of project life time.

Keywords: Project performance, Evaluation, Hidden issues, Project success, Informed decisions.

1 INTRODUCTION

Managing large-scale engineering projects mostly in developing countries can be challenging due to short professional lifespans of project managers, frequent changes in higher levels of project management, and a semi-professional and semi-political atmosphere that leads to biased priorities determined by the employer's control system (Haque 1997, Hays and Kearney 2001). This could encourage project managers to shift their focus from project objectives to achieving satisfactory progress and promoting exemplary performance for themselves, even unintentionally and without realizing the consequences.

To address these challenges, a practical approach can be employed by utilizing a hypothetical project to decode project progress parameters. Through a multidimensional evaluation of the project's progress, solutions can be found for the issues in project planning and control (Anvary and Yazdi 2015).

2 HYPOTHETICAL PROJECT

Implementing concrete structures over 200 days, pouring 20,000 cubic meters in four parts. Assumptions and restrictions include: (R1) Due to site restrictions, only one asset of the same type can be executed simultaneously. / (R2) Avg. daily concrete req. 100 m$^3$, optimal at 120 m$^3$ / (R3) Pouring capacity 145 m$^3$/d, and $S2$ depreciation and overtime charge over 120 m$^3$ / (R4)
Excess concrete at 145 m$^3$ incurs $4/m^3$ cost / (R5) Daily financing rate up to $1,900, borrowing may increase costs by 20%.

The project is evaluated in three perspectives: physical improvements (WORK), financial development (COST), and time progress (TIME).

Table 1. The hypothetical project overview and reporting on Day 100, 150, 200 based on 3 scenarios.

<table>
<thead>
<tr>
<th></th>
<th>Assets Name</th>
<th>Asset Num.</th>
<th>Conc. Vol. (1000 m$^3$)</th>
<th>Dur. / Asset</th>
<th>Cost (1000$)</th>
<th>1st Scen. on DAY 100</th>
<th>1st Scen. on DAY 150</th>
<th>1st Scen. on DAY 200</th>
<th>2nd Scen. on DAY 100</th>
<th>2nd Scen. on DAY 150</th>
<th>2nd Scen. on DAY 200</th>
<th>3rd Scen. on DAY 100</th>
<th>3rd Scen. on DAY 150</th>
<th>3rd Scen. on DAY 200</th>
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<tbody>
<tr>
<td>A1</td>
<td>S. Bridge</td>
<td>100</td>
<td>5</td>
<td>2</td>
<td>60</td>
<td>8</td>
<td>33</td>
<td>58</td>
<td>15</td>
<td>40</td>
<td>55</td>
<td>50</td>
<td>75</td>
<td>100</td>
</tr>
<tr>
<td>A2</td>
<td>M. Bridge</td>
<td>4</td>
<td>1</td>
<td>50</td>
<td>50</td>
<td>10</td>
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<td>75</td>
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<td>50</td>
<td>75</td>
<td>100</td>
</tr>
<tr>
<td>A3</td>
<td>Rd. Walls</td>
<td>50</td>
<td>1</td>
<td>60</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
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<td>100</td>
<td>100</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>A4</td>
<td>Walls</td>
<td>20</td>
<td>8</td>
<td>5</td>
<td>40</td>
<td>100</td>
<td>100</td>
<td>100</td>
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<td>90</td>
<td>5</td>
<td>55</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td>PROJECT</td>
<td>200</td>
<td>300</td>
<td></td>
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3 DIFFERENT SCENARIOS AND RELATED ANALYSIS

Reviewing the project from the owner's perspective, using physical, time (critical path method) and financial progress as progress monitoring tool.

3.1 Using Physical Progress as a Monitoring Tool - Scenario 1:

Table 1 indicates progress reaching 73% on day 100, and 80% on day 150. However, the project faced an unacceptable 84-day delay. Although construction project delays are a frequent occurrence globally, they can significantly impact project success and should be minimized. Therefore, it is crucial to identify the root causes of the delay and implement effective solutions. In this regard, some questions to consider for initiating this process are as follows:

1) Has the physical progress been miscalculated?
2) Was using concrete pouring to measure progress a mistake?
3) Should project managers reconsider using physical progress to control projects and revise parameter selection?
4) What stage and part of operations caused this problem?
5) Can existing tools identify and address project issues early on?
6) Are there indicators of potential project issues during implementation or only recognizable after a delay?
7) Can parallels be drawn between diagnosing human diseases and diagnosing project issues?
8) Is there any reference system that monitors project reports to identify hidden problems before they become visible and enable prompt issue resolution?
By reviewing the project and exploring different scenarios, answers and solutions are sought that can help all construction projects, particularly those in developing regions.

A simple analysis shows that prioritizing the walls, which were identified as having high concrete consumption, led to a fast progress slope. However, between days 100-150, operations in A1 and A2 assets slowed down due to mentioned restriction (R1), resulting in just 1500 m³ of concrete pouring, 88% physical progress, and an 84-day delay (Table 1).

3.2 Using Financial Progress as a Monitoring Tool - Scenario 2:

As shown in Table 1, the financial progress of 63% on day 100, and only 13% more by day 150. Despite the overall progress of 76% was deemed acceptable, a 70-day delay (Table 1) with progress of 92% was on 200th day even by the best management efforts.

Here, the reinforced walls and main bridges of A3 & A2 were given priority due to their high income-generating potential. However, delays were caused by (R1) slow executive operations in A1, as well as a lack of willingness by the time manager to prioritize concrete pouring operations in A4 due to its lower cost. As a result, the project suffered a 70-day delay.

3.3 Using Time Progress (CPM) as a Monitoring Tool - Scenario 3:

Table 1 indicates that the project was completed without delay, but the project owner received an unexpected bill after the project inauguration. Excess fees for concrete procurement (R4), depreciation and overtime charge of concrete production machinery (R3), and additional borrowing costs (R5) were not accounted for in the project budget, leading to cost overruns as another common challenge in similar projects.

In this scenario, project managers prioritize longer-execution time departments while neglecting others, resulting in assets A3 & A4 being transferred to the project's last days and requiring significant resources to prevent delays. This approach increases costs without justification and potentially creates new issues in the project based on mentioned assumption.

3.4 Evaluation of Outcomes from Different Scenarios:

In summary, the discussion highlighted the prevalence of challenges and issues in construction projects, which often lead to delays and cost overruns. These challenges are systemic problems in project management, and current tools and methods have failed to effectively address or prevent them. They can be described as project "ailments", "maladies", or "challenges" that require a more proactive and holistic approach to management.

Before attempting to answer the questions, it is crucial to acknowledge that controlling physical progress is essential for project health and selecting concrete pouring as the basis for progress was an acceptable. Our analysis, based on empirical study, provided answers to some questions about the project's simpler aspects. However, for more complex projects, a four-dimensional analysis is needed to determine the root cause of the problem. The fourth dimension is typically time-based, but it is important to note that traditional time progress calculation methods may not accurately reflect progress on the critical path.

Critical path analysis is an essential tool for monitoring project progress and identifying potential delays. However, time progress calculation methods based solely on the number of days required for each activity may not provide an accurate reflection of progress on the critical path (Kerzner 2022). Completing all critical path activities may not always result in expected time progress, as other factors such as resource availability and task dependencies may impact the project timeline (Raz et al. 2003).
MULTIDIMENSIONAL (4D) APPROACH ANALYSIS OF THE SCENARIOS

Comparing a particular parameter at different time points and creating graphs of project progress has been a commonly used approach to assess project status. However, a more effective method is to perform multidimensional analysis of the project by identifying several parameters at a specific time and comparing them to obtain a more comprehensive view. This approach enables project managers to identify potential issues and address them before they have irreversible effects.

Now back to reviewing the progress report of the sample project in the first scenario and calculating other essential parameters for project progress analysis, including parameters based on work, cost, time-weight (TIME-w), and critical path method (TIME-c). Through a careful analysis of these parameters as in shown in Figure 1, project managers can identify any potential issues and assess their impact on the project. For instance, the TIME-c progress rate of just 8% on the critical path indicates a delay of 84 days in the project, even at DAY 100. Additionally, the TIME-w progress rate of 34% implies that the activities carried out in the project are mostly summarized in parts that require less time for execution. Comparing this number with the physical and financial progress further suggests that the project's main financial and physical weight lies on several short items.

It is evident that the project progress reports from various analysis parameters and project status reports are inconsistent, indicating that the assessment of the project status at a particular point can differ significantly based on documented numbers. By analyzing these parameters simultaneously, project managers can obtain valuable information about the project. This information can be used to gain insight into the nature of the project, even without detailed knowledge of the project type. Therefore, through multidimensional analysis of project parameters, project managers can obtain a more comprehensive view of the project's progress, identify potential issues, and take corrective actions to mitigate the risks associated with the project.
Figure 2. Project report (4D) on DAY100 / 2nd Scenario.

Figure 2 demonstrates the progress of a project with a focus on economic progress. The physical and financial progress graphs show that there is a significant difference in unit prices for different activities (WORK) on different sides. The analysis indicates that the departments with high unit prices and that were the manager's first priority had relatively little physical weight, and their completion could not gain high physical progress compared to financial progress, with almost a 23% difference between these two parameters.

Figure 3. Project report (4D), all scenarios in one view.

It is noteworthy that the intriguing and invaluable insights garnered from the present analysis were derived from a singular data point. Undoubtedly, the monitoring of multiple data points and the comparison of progress trends across various parameters can markedly augment project guidance and efficacy. This assertion is demonstrated through Figure 3 in the following hypothetical project, which will be refrained from further analysis due to its similarity.
To answer the questions raised in the paper, a deeper exploration into the nature of the project is needed. The project can be considered as a living creature, enabling the investigation of how diagnosing project issues is similar to diagnosing human diseases. Furthermore, a reference system needs to be defined and introduced, which monitors project reports and assists in identifying hidden problems before they become visible, thus enabling prompt issue resolution.

Just as doctors use blood tests and other diagnostic tools to assess a patient's health, a reference system could be developed that uses specific indicators and metrics to monitor the health and progress of a project. Such a system should be tailored to the specific needs and characteristics of the project, and should be flexible and adaptable to changing circumstances. To achieve this, it would be helpful to define indexes for different types of projects, such as roads, buildings, refineries, airports, and other similar infrastructure projects, based on the nature of the project.

5 Conclusion

The paper argues that managers overseeing large and complex projects can use a multidimensional decoding approach to identify hidden project issues. This approach involves analyzing information and evidence from progress reports based on different project views, such as work, cost, time-based on time weight, and time-based on critical path. Despite potential inconsistencies among these views, they can offer valuable insights into the project's overall health. Drawing on an analogy to how clinicians diagnose human diseases, the paper emphasizes the importance of treating project issues similarly. The 4D-decoding information method can serve as a simple reference system to uncover hidden problems and help managers develop effective treatment strategies.

References


