

Causes of Poor EVM Indicators in Digital Construction Projects: Analysis of Delay and Cost Risks

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Abstract: *Earned Value Management (EVM) is a project control methodology that is highly adopted to measure performance of construction project by combining schedule, cost, and scope parameters. The important performance measures like the Schedule Performance Index (SPI) and Cost Performance Index (CPI) are indications of schedule slippage and cost increase and thus they enable project managers to take corrective measures. Although there have been increased advances in the use of digital construction technology, such as Building Information Modeling (BIM), enterprise resource planning (ERP) as well as real-time monitoring systems, numerous projects still show low EVM signs. To have a better performance in a project, it is still relevant to know the underlying reasons that cause such deviations. This research work explores major aspects that lead to unfavorable EVM pointers in digital projects in the construction sector, especially on delay and cost-related risks. The quantitative case study method was applied with the project performance data that was acquired on a digitally iterated commercial construction project. The metrics of EVM were studied within a specific duration of monitoring period and some cases where the ratio of the SPI and CPI was found to be below unity were studied with a view of establishing the underlying operational and managerial aspects. The findings indicate that poor planning of the baselines, fluctuations in labor productivity, slowness in procurement processes, variability of the material costs, and lack of coordination are the subjective factors of poor EVM performances. The paper has identified the need to combine risk-conscious project management processes with digital monitoring technologies to improve the quality and accuracy of EVM-based performance appraisal of construction projects.*

Keywords: Earned Value Management, Construction Project Performance, Schedule Delay, Cost Overrun, Digital Construction, Risk Analysis

1. Introduction

Constructions are complex projects requiring a number of stakeholders, resources and mutually dependent activities that have to be finished within set time and cost constraints. Implementation of efficient project performance monitoring is, therefore, necessary to have successful project execution. Nevertheless, there are reports of late schedule and cost increase in quite a number of construction projects in the world and this greatly impacts the project efficiency and satisfaction by stakeholders. Such issues underscore the sensitive nature of the project regarding the evaluation measures of performance, which will offer early warning of the occurrence of deviations against the intended objectives of the project (Pajares and Lopez-Paredes, 2011).

One of the best known methods of managing project performance that has found popularity in the management of construction projects is the Earned Value Management (EVM). EVM will combine three basic project parameters such scope, schedule and cost into a integrated performance measurement system. The methodology will help project managers to evaluate the project performance based on these key indicators Planned Value (PV), Earned Value (EV), and the Actual Cost (AC). Based on these measurements two performance indices are obtained, including Schedule Performance Index (SPI) and Cost Performance Index (CPI), which are used to examine schedule and cost performance. The principle behind an SPI value is lower than one means that the project is being delayed, when compared to the planned, whereas a CPI value of less than one indicates that the project is suffering cost increases (Khan and Reza, 2018). These indicators can give warning on time that, by the time the project deviations become crucial, the project managers

will have taken corrective measures to put the situation back on track.

Over the past few years, the development of digital technologies has largely changed the practices of construction project management. The technology (Building Information Modeling (BIM), enterprise resource planning (ERP) systems, cloud-based project management platforms) allows integrating data in real time and enhancing the monitoring of project activities. These electronic systems increase the precision and trustworthiness of the EVM computations as it provides constant updates of the project progress and resource performance. Consequently, project performance monitoring and making well-planned decisions would be at a better level in digital construction environments (Khoshkonesh et al., 2025).

However, at the technological level, most construction projects continue to perform poorly with the indicators of EVM despite the adoption of digital monitoring systems. As a matter of fact, in most operations project managers are treated to scenarios where the values of the SPI and CPI are lower than one which means that the schedule is delayed and the cost is inefficient. Although EVM is a successful tool in determining deviation in project performance, it does not necessarily answer the question of the causes of the deviation. The underperforming EVM indicators can be caused by different operational, managerial, and external factors, such as poor project planning, erroneous cost estimation, labor productivity, and sluggish procurement procedures and as well as material price volatility (Widyarso et al., 2025). The lack of understanding of these factors can make project managers hard to cover the underlying cause of the deviations

in performance and enhance the overall performance of the project.

Past studies have performed very well on measuring and forecasting performance of projects in construction using application of EVM techniques. The effectiveness of EVM has been realized to be tested by many studies according to predicting cost and schedule of the project using EVM indicators like Estimate at Completion (EAC), Variance at Completion (VAC) and others. Nonetheless, there is comparatively little literature on determining the root cause of the poor indicators of EVM, especially in those projects where digital construction monitoring frameworks have been employed. Although digital tools can improve the presence of data and monitoring abilities, they do not remove operational risks, which cause delays within project implemented works and cost increase.

Thus, it is important to comprehend the causes of poor EVM indicators to make sure to improve the performance of the project and the accessibility of digital project management systems. Uncovering the causes may enable project managers to come up with specific strategies in order to overcome schedule and cost risk in the process of project execution. Moreover, the association of performance indicators of EVM and underlying project risks may allow to gain more information on the relationship between project management practices and project outcomes. This research aims to establish and examine the leading causes of low EVM indicators in digital construction projects, especially delayed as well as risk of cost. The quantitative approach to the case study entails the adoption of quantitative data of project performance based on a digitally tracked commercial construction project. The study will help in determining the operations and management processes to be correlated with poor project performance by analyzing the periods when either of the two measures, SPI and CPI, reported values are below the acceptable thresholds. This research is believed to be valuable to academic studies and project management practice as it will offer a more detailed insight into how the EVM indicators and the intrinsic project risks relate to each other.

The rest of this paper will be structured in the following way. Section 2 will also survey the literature that is pertinent to the topic of Earned Value Management, schedule delays, cost overruns, and digital construction monitoring systems. Section 3 presents the method of conducting the research and data gathering in the study. Section 4 shows the findings of EVM performance analysis and determines the major reasons of poor EVM indicators. Section 5 addresses findings in terms of the current research and presents its implications on the construction project management. Lastly, Section 6 provides a conclusion to the study and offers suggestions on how the use of EVM based project performance assessment in digital construction settings can be improved.

2. Literature Review

2.1 Earned Value Management in Construction Projects

Earned Value Management (EVM) is a commonly known project management tool that is employed to monitor as well

as control project performance through integration of scope, schedule and cost parameters. The methodology offers the quantitative measures that make project managers to assess the level of project advancement and detect the delays in project schedule and budget. EVM makes use of a set of three main performance indicators, including Planned Value (PV), Earned Value (EV), and Actual Cost (AC), which help to give an overall view of project performance (Pajares and Lopez-Paredes, 2011).

Based on such measures, key performance indicators are the Schedule Performance Index (SPI) and Cost Performance Index (CPI). SPI is used to determine the efficiency of the use of time in the execution of projects and CPI to define the efficiency of costs. A value of SPI that is less than one subsequently implies the project is on the other hand behind the schedule and vice versa (a value of CPI less than one indicates cost runaway of the project) (Fleming and Koppelman, 2016). These indicators will enable the project managers to identify the performance deviations early and take corrective measures to reduce the risk that might have occurred.

Various researches have also shown the usefulness of EVM in monitoring and predicting a construction project. Kim et al. (2003) noted that EVM makes accurate predictions regarding the cost and time of project completion as it combines cost and schedule performance. On the same note, Vanhoucke (2011) underscored that EVM can provide project managers to forecast future project performance using such metrics as Estimate at Completion (EAC) and Variance at Completion (VAC). Consequently, EVM has emerged as a project management control tool and has become popular among extensive construction projects.

Nevertheless, as much as EVM is a successful tool in determining the existence of a deviation in the project performance, it does not necessarily provide the causal factors leading to the poor performance indicators. The low values of the projects in terms of SPI and CPI are observed as a result of numerous operational and managerial issues that arise in the course of the project execution.

2.2 Schedule Delay Risks in Construction Projects

One of the most common problems that arise in construction project management implies schedule delays. Delays may considerably impact the project performance by raising the project durability, interfering with the resource distribution, and causing the extra expenses. Various researches have established a number of reasons that cause schedule slippage in construction projects.

A study by Assaf and Al-Hejji (2006) established that poor planning of the project, ineffective scheduling, and coordination deficiencies across the project stakeholders have been significant contributors of delays in construction projects. Equally, Sambasivan and Soon (2007) established that contractor inefficiencies, labor productivity problems and poor management of the sitemen are some of the most significant causes of project delays.

The lack of material and delays in making specific procurements are also known to have been a frequent report of delay factors. Doloi et al. (2012) observe that construction schedule is highly influenced by material delays and supply chain interruptions especially at constructions where specialized materials are required to be delivered in time. Besides this, there are external influences like bad weather, regulatory licenses and design modifications that can also add to the schedule unwinding.

These delay factors directly affect EVM indicators lowering the rate of completion of planned work. In case the project progress is below the scheduled plan, the Earned Value (EV) will be less than Planned Value (PV), hence the SPI value will be less than unity. Consequently, as far as interpretation of bad values of SPI in EVM-based evaluation of project performance is concerned, it is necessary to comprehend the underlying factors of delay in the schedules.

2.3 Cost overrun Risks in Construction Projects

Another major issue in the project management of construction projects is cost overrun. Cost overruns happen when the project cost of execution is higher than the projected project budget. These variations may have a tremendous impact on the profitability and financial viability of the project.

Some researchers have cited false cost estimation among the main reasons of cost overruns. Flyvbjerg et al. (2003) indicated that unrealistic cost estimation as part of the planning stage is the reason that many construction projects end up experiencing cost overruns. Incorrect calculation of labor costs, material cost, and machinery cost would result in high variances in the budget in the execution of the project.

The cost overruns in construction projects are also caused largely by the changes in material prices. Love et al. (2015) emphasized that the fluctuation of the costs of construction materials, especially steel and concrete, can cause a considerable change in the project budget. Furthermore, modifications to design and scope of a project can result into redoing and new demand of resources, which only adds to the project cost.

The other factor influencing the cost performance is labor productivity. Poor labor management, overtime labour, low levels of productivity may raise the costs of the projects to levels higher than the budgeted cost (Hwang and Ng, 2013). These cost-related variables have a direct impact on the EVM indicators by raising the Actual Cost (AC) to the Earned Value (EV) bringing the CPI values down to less than one.

2.4 Digital Construction and Performance Monitoring

The implementation of digital technologies has become a potent factor that has changed the practices, in the management of construction project, in the recent years. EBIM software, enterprise resource planning systems, and cloud-based project management systems are digital construction tools that allow more effective integration of information and real-time monitoring of project performance.

The BIM technology enables the project stakeholders to have a visual view of project progress and to coordinate the design and construction works. Eastman and colleagues (2018) report that BIM increases collaboration in projects as well as the efficiency with which project scheduling and cost projections are done. In the same way, ERP systems allow financial data of projects to be centrally managed thus providing more cost tracking and reporting.

Digitization of EVM has also been identified as one of the effective methods of enhancing project performance monitoring. Digital sources make it automatically to collect data and update EVM calculations in real-time minimizing the possibility of inaccuracy of data and enhancing the making of decisions (Vanhoucke, 2011).

Nevertheless, even with the advantages of digital project management systems, the construction project can still record poor performance indicators because of operational and managerial issues. Digital tools are sufficient to increase the precision of monitoring the project but not to completely mitigate risks associated with errors in planning, resource rejection, or external interference with the project.

Thus, although digital technologies will increase the effectiveness of EVM-based performance evaluation, the reasons behind the poor indicators of EVM are necessary to improving the performance of construction projects.

3. Methodology

3.1 Research Design

The research design that will be used in this study is a quantitative case study as it will seek to determine the reasons behind low Earned Value Management (EVM) indicators in a digitally monitored construction project. Construction management research heavily relies on case study research due to the ability to analyze the actual project data in detail and offer a clue to some real-world issues in project management (Yin, 2018). The case study approach will be especially suitable in analysis of the correlation between the project performance measures and under-laying operational risks.

Although the research done in the past has mainly been done with an emphasis of applying EVM as performance evaluation tool, this study can build on the study by addressing the aspects that cause poor EVM performance indices especially those associated with schedule delays and cost overruns. The study analyses project performance data that were acquired in an environment that is digitally integrated on a construction intending at which project progress and financial information is constantly tracked by digital management system.

The study is divided into three separate stages of methodology because it involves first identification of EVM performance indicators, second, identification of periods where EVM performance was not functioning well before, and thirdly, the operational and managerial factors behind such deviations. In this way the study will be able to relate

quantitative EVM outcomes and qualitative interventions of project risks.

3.2 Case Study Project Description

The empirical study is informed on a commercial construction project that was tracked with the aid of digital project management systems. The project construction will entail a multi-storey commercial building that comes with several structural and architectural elements that must be coordinated between the contractors, engineers, and the project managers.

The project itself will last about 20 months, and the analysis of the first 10 months of project implementation was used in the study because adequate performance data were present. The digital project monitoring tools which provide scheduling, cost management and progress tracking functions were used to derive the project performance data.

Using digital systems enabled the project progress to be continuously tracked which facilitated the performance indicators of EVM to be calculated. These systems furnished credible data pertaining to schedule progressions in a project, cost incurred and the status of work completion which formed the foundation of analysis that was done in this work.

3.3 Data Sources

The research is based on the project performance information that is retrieved by various digital construction management systems. These systems combine the information of various functions within the project management to offer real-time performance of the project. I used primary sources of data to conduct this research, which are:

Building Information Modeling (BIM) Progress Data.

Project activities were monitored on the basis of BIM-based progress monitoring tools. These instruments will give visual and quantitative reports on the construction progress and hence accurate measurement of work done in the various stages of the project.

Enterprise Resource Planning (ERP) Cost Data.

The expenditure financial information on the projects was accessed in the ERP system of the project. These records were able to present comprehensive information concerning the real project costs, in terms of labor, material expenses, equipment, and expenditures on subcontractors.

Project Scheduling Data

The project timeline was constructed with the help of the digital scheduling software that gave the basis planning information and the scheduled milestones.

Project Progress Reports

The digital data were supplemented with periodic project reports provided by project managers and site engineers that allowed to shed light on operational issues faced by the project owners when executing this project.

The combination of these sources of data made it possible to calculate and interpret the EVM indicators correctly.

3.4 Earned Value Management Indicators

The analysis of project performance in this study is based on key Earned Value Management indicators derived from project schedule and cost data. The following core EVM metrics were used in the analysis:

- **Planned Value (PV)** – the planned budgeted cost of work scheduled to be completed within a specific time period.
- **Earned Value (EV)** – the budgeted value of work actually completed during the same period.
- **Actual Cost (AC)** – the actual cost incurred for the completed work.

Using these metrics, two important performance indices were calculated:

Schedule Performance Index (SPI)

$$SPI = EV / PV$$

This indicator measures schedule efficiency.

$SPI < 1$ indicates that the project is behind schedule.

Cost Performance Index (CPI)

$$CPI = EV / AC$$

This indicator measures cost efficiency.

$CPI < 1$ indicates that the project is experiencing cost overruns.

Although these indicators were previously used to evaluate project performance, this study focuses specifically on analyzing the periods where SPI and CPI values fall below unity, which indicate poor project performance.

3.5 Data Analysis Procedure

The data analysis procedure has been presented in a number of phases in order to determine the causes of poor EVM indicators.

Stage 1: EVM Performance Trends Recognition.

The analysis of project performance data was conducted at several time periods in order to assess the dynamics of the project performance in terms of the SPI and CPI values. The periods when the values of SPI and CPI were lower than one were marked as the performance deviation periods pointing to the schedule deviation or cost inefficiency.

Stage 2: Determination of Important Performance Deviations.

The periods when the performance of EVM failed was analyzed more closely to define the extent and the period of deviation of performance. These phases are occasions in the project where the operational issues had a big impact on the project course or budget management.

Stage 3: Root Cause Analysis

In every recognized period of deviation, project documentation and progress report were discussed so as to determine the operational factors that triggered such deviations. The following were the risk factors that were grouped into various risks, such as:

- Risk in planning and scheduling.
- Resource management risks

- Procurement and supply chain risks.
- cost management risks
- Risk of coordination and communication.

Such classification facilitated the research to conduct the analysis of the connection between the project risks and the EVM performance indicators methodically.

3.6 Reliability and Validity

As a way of ensuring reliability and validity of the study, various data sources were utilized to validate information on project performance. The combination of BIM progress data, ERP financial records and project progress reports made it possible to cross-verify the project performance metrics. Such triangulation is beneficial to the analysis since it enhances accuracy and minimizes the chances of data discrepancy.

Also, application of standardized EVM performance indicators does not only guarantee methodological consistency with the past studies in construction project performance evaluation. Practical relevance of the findings is increased by the use of real-world construction project too.

4. Results and Analysis

4.1 Overview of Project Performance

Earned Value Management (EVM) indicators, which are common in the digital project monitoring system, were used to evaluate the performance of the selected construction project. Analysis was based on the initial ten months of the project implementation, whereby there were detailed schedule and cost information. The main aim of the analysis was to establish the areas where the project performance indicators deviated the planned schedule and budget.

Indexes of Schedule Performance Index (SPI) and Cost Performance Index (CPI) of each monitoring period were obtained to determine the level of project efficiency. Overall, the higher the values of SPI and CPI (more than one), the higher levels of satisfaction with project performance, and the lower the values (below one point), the higher the delay in schedule or cost increase. It was found that there were a number of phases where both the indicators were lower than the acceptable figure that showed inefficiencies in performance.

Table 1 is the summary of the SPI and CPI measures at the period of analysis of the project.

Table 1: EVM Performance Indicators During Project Execution

| Project Month | SPI | CPI | Performance Status |
|---------------|------|------|-----------------------------|
| Month 1 | 0.95 | 0.98 | Slight delay |
| Month 2 | 0.92 | 0.96 | Schedule delay |
| Month 3 | 0.9 | 0.94 | Delay and cost overrun |
| Month 4 | 0.93 | 0.95 | Performance improving |
| Month 5 | 0.97 | 0.99 | Near planned performance |
| Month 6 | 0.89 | 0.92 | Significant delay |
| Month 7 | 0.91 | 0.93 | Delay and cost inefficiency |
| Month 8 | 0.96 | 0.97 | Stabilized performance |
| Month 9 | 0.98 | 0.99 | Acceptable performance |
| Month 10 | 0.94 | 0.96 | Minor deviation |

The findings indicate that the values of SPI were lower than one throughout the majority of the timeframe, which meant that there were continuous schedule delays in the course of the project. Likewise, CPI rates also decreased to below unity in various months and this shows inefficiency in costs incurred in the project execution.

These variances indicate that there are various operational and managerial issues which affected the performance of the project in the implementation stage.

4.2 Schedule Performance Analysis

The schedule performance analysis shows that the project did undergo some significant delays in the initial processes and in the middle process of the project execution. The lowest SPI was recorded in Month 6 as the SPI was recorded at 0.89, a sign that there was a huge schedule deviation against the expected project schedule.

There were a number of reasons that caused these delays. Delayed mobilization of construction resources in the early phases of the project was one of the main reasons that influenced the various construction activities on time. The delays at the initial stages normally spill over to the later project activities leading to prolonged schedule overruns.

The other important cause of the schedule performance was a delay in procurement of construction materials. Structural and finishing works materials needed were not taken at the right time in various cases. Such delays disrupted the construction process and slowed down the rate of achieving the planned work.

The variation in labor productivity was also a key factor that influenced schedule performance. The productivity levels of the workforce were also below the estimated ones during some project periods because of the workforce alignment problems, and lack of effectiveness in performance of specific tasks. Consequently, the real delivery in such periods was lower compared to the planned delivery, which resulted in a low Earned Value (EV) in comparison to the planned value (PV).

This combination led to reduced values of SPI in the various periods of the project.

4.3 Cost Performance Analysis

The cost performance analysis indicated that the project had a number of cost inefficiency instances in its implementation. The minimum CPI was in Month 6 (CPI = 0.92) which means that the actual cost was faced was higher than what was budgeted on the work done.

Material price fluctuations especially on construction materials like steel and cement were one of the greatest causes of cost inefficiency. The cost of procurement was more than the planned one due to the price fluctuations in the project period.

The other important cost performance was due to reworks as a result of small design changes and coordination problems

between the construction teams. The rework jobs also demanded more workforce and resources leading to an increment on the overall cost of the project.

Cost overruns were also caused because of labor related costs. In cases of schedule delay, more work time and overtime work was needed to ensure that the project was kept on schedule. These incremental costs of labor were added to the Actual Cost (AC) of the project and did not mirror the equal additions at the Earned Value (EV) thus reducing the CPI values.

Despite the fact that the project was showing some cost performance improvement in the later months, the entire analysis points to the fact that handling of cost matters existed throughout the project implementation process.

4.4 Root Causes of Poor EVM Indicators

Based on the analysis of project performance data and project progress reports, several underlying factors were identified as the primary causes of poor EVM indicators.

These factors can be categorized into five main groups: planning risks, resource management risks, procurement risks, cost management risks, and coordination risks.

Table 2: Major Causes of Poor EVM Indicators

| Risk Category | Identified Factors | Impact on SPI | Impact on CPI |
|---------------------|--|---------------|---------------|
| Planning Risks | Inaccurate scheduling and delayed mobilization | High | Medium |
| Resource Management | Labor productivity fluctuations | High | Medium |
| Procurement Risks | Delayed material delivery | High | Medium |
| Cost Management | Material price increases | Low | High |
| Coordination Issues | Rework and design adjustments | Medium | High |

Among these factors, planning-related issues and procurement delays had the greatest impact on schedule performance, while material price fluctuations and rework activities were the primary contributors to cost inefficiencies.

4.5 Impact of Digital Monitoring Systems

Despite the fact the project was based on the use of digital monitoring systems to assess the project progress and financial information, the analysis results point to the fact that the digital tools were rather effective in terms of data transparency, monitoring accuracy but did not eliminate the obstacles to the operation.

The BIM-based progress monitoring system and the ERP-based cost tracking allowed project owners to identify the possible performance deviations at an initial stage. Nonetheless, the electronic systems could not avert such operational challenges like delays in procurements or changes in the rate of productivity.

What is important in this finding is the fact that although digital technologies enhance the possibilities of monitoring project development, the successful project performance

remains to be based on the effective planning, resource management, and risk mitigation strategies.

5. Discussion

The study findings demonstrate that there are some reasons to pay attention to among the poor Earned Value Management (EVM) indicators in the digital construction projects. The discussion has revealed that Schedule Performance Index (SPI) and Cost Performance Index (CPI) show fluctuations which were below the threshold acceptable at various points of the project implementation process. The fact that these deviations showed that the project was experiencing schedule deficiencies as well as cost inefficiencies even with the implementation of digital monitoring systems. The results drive the point that although EVM is a powerful tool to detect the deviation of the project performance, the root cause of the deviation should be comprehended in order to enhance the performance of the complete project.

Individually, one of the most important results of this study is the close correlation between the deficiencies in project planning and the bad schedule performance. The findings indicated that an inaccurate scheduling and the slow mobilization of the resources at the initial stages of the project cascaded over the further construction works. This observation reflects past studies which cite poor planning and poor scheduling of construction projects to be some of the biggest causes of construction projects delays (Assaf and Al-Hejji, 2006). When the project start work is not performed in time, the further works are usually impacted as the construction processes are in sequence. Through this, the Earned Value (EV) at the period of the affecting periods is lower than the Planned Value (PV), resulting in low values of SPI. The results indicate that increasing the accuracy of the basis schedule and ensuring that the resources are mobilized within the schedule are also important in order to ensure schedule performance in construction projects.

The influence of Procurement and supply chain disruptions on the project schedule performance is also another significant parameter that has been determined in the study. As the analysis showed, delayed deliveries of materials were among the main causes of lowering the values of SPI in the course of several project periods. Construction works will always require timely supply of equipment and materials, and any hindrance in the supply process by any delay can disrupt work and lower productivity. Other past research has also indicated the contribution made by supply chain inefficiencies to construction delays (Doloi et al., 2012). Within the detail of the EVM analysis, these disruptions decrease the pace at which scheduled work is accomplished consequently decreasing the Earned Value when compared to the Planned Value. This observation supports the essence of proper procurement planning and coordination of supply chain in schedule performance of a project.

Labor productivity fluctuations were also found in the study as major contributors of poor EVM indicators. Productivity variation of the workforce was realized over a number of project periods thus influencing work completion rate, and hence the values of SPI. The productivity of labor used in the construction project can be subject to a number of factors such

as the skills of the workforce, the practices applied to the management of the site, and the coordination among the project teams. As earlier studies have revealed, inefficient labor management may have a strong impact on the project schedule and cost performance (Hwang and Ng, 2013). The level of lower productivity decreases the volume of output to be achieved within a specified time resulting into less Earned Value and decreased schedule efficiency.

The cost performance analysis also indicated that the key causes of poor values of CPI were the variability of material price and rework activities. The changes in prices of major construction materials like steel and cement made the prices go beyond the actual budgeted procurement costs. This is what has been noted in other past studies, and this is because volatility in prices of construction materials is a significant cause of cost overruns in the infrastructure and building projects (Flyvbjerg et al., 2003). In situation whereby real project spending exceeds that which is budgeted at the value of work accomplished, the Actual Cost (AC) is high compared to the Earned Value (EV), and therefore, the values of CPI are less than unitary.

The cost inefficiencies of the project were also as a result of the rework due to design changes and coordination issues. Rework also needs more work, materials and time, thus raising the costs of the project and with little increases to the project values. The observation is in line with the current literature that identifies the design changes and coordination problems as major causes of construction cost overruns (Love et al., 2015). The cost efficiency of a project is compromised on rework in EVM-based project monitoring since they spend more money on the project than what is allocated.

Another valuable study implication is associated with the importance of utilizing digital construction monitoring systems in the project performance management. Digital tools that were used in the project reviewed in the present study included BIM-based progress monitoring and ERP-based cost tracking systems. Such technologies provided the real-time control over the indicators of project performance and allowed readily identifying the schedule and cost variations. The results, however, indicate that although digital monitoring systems enhance the accuracy and timeliness of the project data, it does not remove operational issues that lead to poor EVM indicators. Rather, the digital technologies mostly increase the level of transparency of the project and contribute to a more rational approach to decision-making.

This observation has a very serious implication on construction project management. Systems of digital project management are influenced by the quality of project planning and coordination, as well as the practice of project risk management as much as they are related to the technological capabilities. Digital monitoring systems alone cannot help in preventing schedule slippage, or cost overruns without proper management strategies. Thus, managing the performance of different projects is necessary through the combination of digital monitoring technologies and the proactive use of risk management practices.

This study will help fill the existing body of knowledge by offering a more profound insight into the connection between the EVM indicators and the underlying risks of digital

construction environment. Although several studies have mainly researched on using EVM as a measurement tool to evaluate the performance of a project, this paper has taken the discussion a step further by determining the operational variables which contribute to poor EVM performance indicators. Upon combining the EVM outcomes with several types of risks that were identified like planning shortcomings, procuring timeliness, workforce productivity, and cost issues, the research offers a broader approach to interpreting the EVM performance data.

As a practical standpoint, the findings indicate that there are some key considerations that project managers can have. To begin with, proper baseline planning and scheduling are required to ensure that performance is maintained in terms of schedule and elimination of early-stage delays. Second, supply chain management and good planning in procurement is essential in ensuring timely supply of construction materials. Third, by enhancing the performance of the workforce by saving resources used on site and allocation, the schedule deviations could also be minimized. Lastly, cost management proactive strategies are necessary to reduce the effects of costs material price increase and rework on the project budgets.

On balance, the discussion shows that the poor level of EVM indicators cannot be explained only by the errors in monitoring but mostly by the operational and managerial problems on the way to project execution. These issues have to be addressed using the combination of a viable practices of project management, better, more effective risk management strategies, and intelligent application of digital construction technologies.

6. Conclusion and Recommendations

The present research examined the major reasons behind unfavorable Earned Value Management (EVM) metrics in an online monitored construction project, specifically schedule delays and risk issues associated with costs. Despite the common understanding that EVM is an effective method of tracking project performance, analysis of the study reveals that poor EVM indicators are usually due to operational and managerial problems that are being experienced in executing a project. The study by analyzing times when the Schedule Performance Index (SPI) and Cost Performance Index (CPI) were lower than the acceptable level was able to identify some of the primary causes of the project performance inefficiencies.

The corresponding findings have shown that schedule delays were mainly related to inadequacy of the project plans, delays in mobilizing resources, procurement, and changes in the labor productivity. The time-unties of the project activities was compromised by delays in mobilizing construction facilities and wrong timing of timetabling the construction activities at an initial stage of the project. These initial interruptions put a ripple effect in other construction works with time ending up being in constant schedule overruns during the entire project term. Errors related to procurement, especially in the delivery of materials, also made construction processes have delays and decreased the pace of the real work performed in accordance with the plan.

The analysis of the cost performance showed that the material price variability and the rework activities had been identified as some of the most significant cost inefficiencies contributors. Changes in prices of most of the construction materials used escalated the procurement costs which are more than what had been planned. The project teams also had minor design changes and problems with coordination leading to re-work activities that consumed more labor and material resources. The above factors added pressure on the Actual Cost (AC) and the Earned Value (EV), which caused the values of CPI to be less than one in many project periods.

The case study has also identified the influence of labor productivity in determining the schedule and performance cost. Fluctuations in the productivity of the workforce influenced the speed of work completion hence slowing the generation of the earned values at some times. The presence of delays in the schedules needed the introduction of extra hours of labor and overtime work to keep the projects rolling, thus raising the project costs.

A significant observation based on the study is associated with the application of digital construction monitoring systems in the management of project performance. The combination of the digital technology, including BIM-based progress monitoring system, and ERP-based cost management system allowed to monitor the performance indicators of the project in real-time. These systems enhanced the transparency and accuracy of data on project performance and allowed to find early schedule and cost deviations. Nevertheless, the results indicate that the problem of poor project performance is not possible to avoid by means of digital technologies solely. Although digital tools have provided better monitoring, the level that will determine the success of project performance management is the quality of planning, coordination, and risk management practices adopted by project managers.

In practical terms, the findings of this paper present some valuable suggestions on the enhancement of the EVM-based project performance evaluation among construction projects. The project managers are advised to begin with proper planning of the base lines, in addition to the proper scheduling of the project during the project planning phase. Setting achievable project schedules and mobilizing resources in time can go a long way to minimize risk of early delays experienced during the project early stages that have the potential of disrupting the whole project schedule. Second, proper procurement planning and supply chain management would be critical towards securing the timely supply of construction material and avoidance of construction work processes disruption.

Third, the workforce productivity could be enhanced by implementing more effective site management practices, and training programs and allocating resources more efficiently to achieve a reduction in schedule delays and the overall project performance. Fourth, active cost management policies must be introduced to ensure that the effect of a variation in material price and possible rework activities on project budgets are diminished. Lastly, the integration of digital monitoring technologies with exhaustive risk management

strategies should improve the monitoring of the performance of the project and inform the decisions made.

Although this study did serve, some limitations are to be considered. It was analyzed on a single construction project and this might not be very general to the other construction projects or geographical areas. To expand this research, the study could be carried out on a case of various construction projects in various industries and an examination of the risks factors will be conducted in order to be able to validate further the risk factors identified. Besides, future research can consider the incorporation of more advanced digital solutions that include artificial intelligence, predictive analytics, and EVM systems in order to enhance the early identification of the risks in the project performance.

Conclusively, this paper has shown that the nature of poor EVM indicators in construction projects is largely affected by operational and management issues instead of constraints that the monitoring methodology has. Although digital technologies enhance the system of project monitoring, proper project performance management is the issue that demands a comprehensive approach, consisting of proper planning, effective resources management, proactive mitigation of risks, and appropriate use of the digital construction tools. These factors can be overcome during an evaluation of the performance of a modern development project management utilizing EVM to increase the reliability and effectiveness of these evaluations.

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