RICERCA, INTERNATIONAL JOURNAL OF MULTIDISCIPLINARY RESEARCH AND INNOVATION
ISSN: 2583-083X
Peer Reviewed Journal, www.rijmri.com

EVALUATING EARNED VALUE MANAGEMENT FOR MANAGING TIME AND COST OVERRUNS IN INFRASTRUCTURE CONSTRUCTION PROJECTS

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Abstract

Infrastructure construction projects are always faced with time and cost overruns because of their size, uncertainty and multi-stakeholder status. Earned Value Management (EVM) has received a lot of publicity as a unified project control method that is able to concomitantly track cost and schedule performance. This review paper is a critical analysis of the EVM in time and cost overruns management in infrastructure construction projects. The research synthesizes empirical evidence of EVM applications in the transportation, energy, and public infrastructure development projects based on a planned survey of peer-reviewed articles. The review evaluates the efficiency in using EVM to manage costs and schedule, outlines the major issues of implementation, and reviews the recent methodological extensions to overcome the weaknesses of conventional EVM. The results suggest that though EVM gives good early warning measures and enhances predictability of costs, its success in schedule management is limited unless supported by other sophisticated methods like Earned Schedule, risk-adjust models and computerized integration. The paper concludes that EVM can be best applied to the complexities unique to construction as a control mechanism that should be tailored to suit construction complexities instead of being implemented as a control mechanism.

Keywords: Earned Value Management, Infrastructure Projects, Cost Overruns, Time Overruns, Project Control, Construction Management

1. Introduction

The infrastructure construction projects are an important factor in the economic development but are often associated with extreme time wastages and increased costs. Many researchers have found overruns to be systemic as opposed to exceptional in nature due to changes in designs, incorrect planning, scarcity of resources, and external vagaries. The traditional methods of project monitoring normally do not give timely and combined feedback on the deviations of performance and thus have a reactive instead of a proactive management.

To determine this gap Earned Value Management has been created which incorporates cost, schedule, and scope within one performance measurement framework. EVM was originally used in defense and aerospace, but has also found increased application in infrastructure construction projects in which financial responsibility and timeline conformity are paramount [1]. Although its use is increasing, the construction industry is still divided about the practical usefulness of EVM because of dynamic and uncertain conditions of construction environments.

The purpose of this review paper is to assess the efficiency of EVM in time and cost overrun management of infrastructure construction projects through the critical synthesis of available literature and the identification of the strengths, limitations, and trends.

1.1 Background of the Study

Cost overruns and time delays are one of the most endemic issues in infrastructure construction projects the world over. The past studies show that overruns are not a lone event but a systemic problem due to the factors considered inaccurate initial estimates, constant design changes, poor resource allocation, market volatility, regulatory delays, and unexpected site conditions. The conventional project monitoring methods which regularly monitor both cost and schedule separately have demonstrated little success in identifying early warning sensations of performance variations. Consequently, corrective measures are often taken at a very late stage when recovery is a hard task or even non-economical [2].

The issue of cost overruns in infrastructure building projects is a problem that can be explained in various aspects, which depend on each other. These influences work jointly and usually compound each other and hence early detection and effective control is difficult especially when traditional methods of monitoring the project are employed.

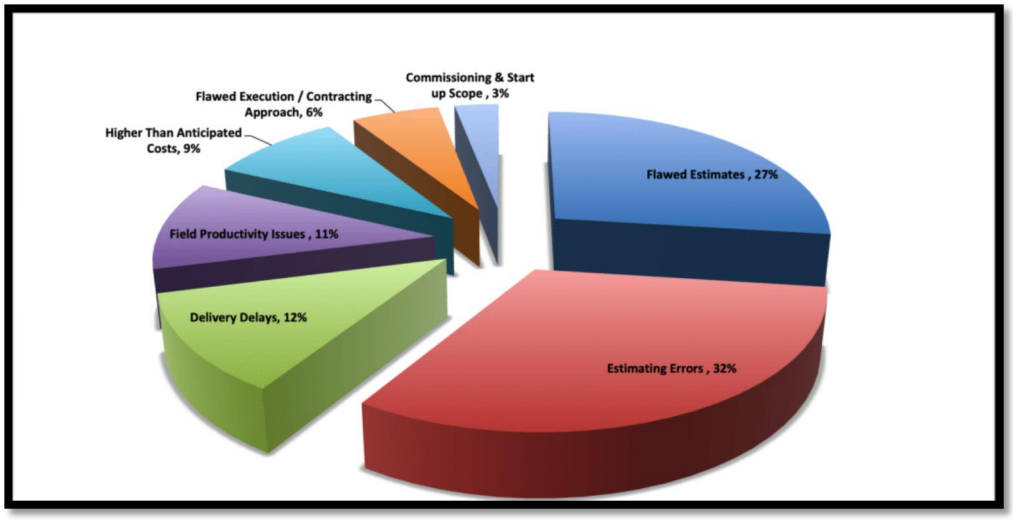

Figure 1: Major Factors Contributing to Cost Overruns in Large Infrastructure Construction Projects

As Figure 1 shows, miscalculation of estimates, estimating errors, problems related to the delivery and productivity are the leading causes of cost overruns in large construction projects. These causes are spread out, and this indicates the weakness of isolated cost or schedule tracking mechanisms and the necessity of integrated performance measurement systems that can offer early warning mechanisms in all three dimensions of cost, time, and scope. This environment offers a good reason as to why the Earned Value Management should be implemented as a complex project control model in infrastructure development.

To address these shortcomings, Earned Value Management (EVM) was created as a combined project control methodology that integrates scope, time and cost into one performance measurement system. The comparison between the planned progress and the actual performance, as well as the cost incurred allows the objective evaluation of project health by using EVM and helps project the final outcomes [3]. Whereas EVM was originally developed within the context of defense and aerospace projects, the fact that it is both structured and quantitative has resulted in its growing use in the context of infrastructure construction projects (especially when it involves a source of public funding, and where accountability is a mandatory consideration). Although it has theoretical benefits, the implementation of EVM in construction has produced mixed outcomes. The dynamic nature of infrastructure projects, their areas of uncertainty, and their disjointed implementation make the projects susceptible to the assumptions of classical EVM. Consequently, some questions still remain on how effective EVM would be in addressing the time and cost overruns in the actual infrastructure projects.

1.2 Earned Value Management in Managing Time and Cost Overruns

Earned Value Management has been popularly marketed as a proactive project management instrument to manage the performance of projects through offering early warnings on cost and schedule variances. EVM-based cost performance indicators have been shown to have a great potential in detecting budget overruns early enough enabling the project managers to take corrective actions. Its efficiency in schedule control has however been more questionable especially in long term infrastructure projects where schedule indicators used traditionally might not be as reliable.

In order to demonstrate the combined character of Earned Value Management in tracking the performance of a project, Figure 1 provides a conceptual model reflecting the relationship between Planned Value, Earned Value and Actual Cost with time. The figure shows that EVM can at the same time record the progress of schedules and cost spendings, which make project managers detect variations in baseline plans at a tender point in the execution of projects.

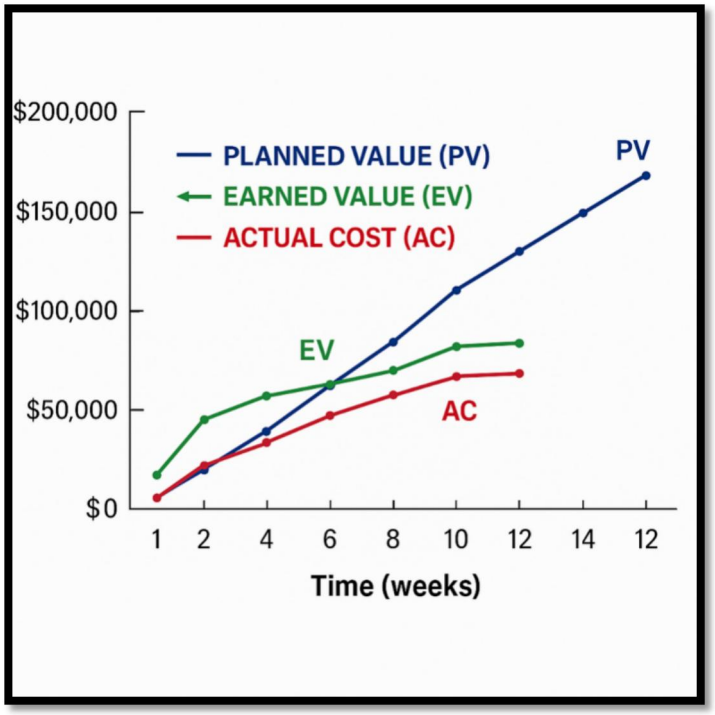

Figure 2: Graphical representation of Earned Value Management showing the relationship between Planned Value (PV), Earned Value (EV), and Actual Cost (AC) over time in a construction project.

Figure 2 demonstrates that the inconsistencies between Planned Value and Earned Value are a sign of schedule performance problems, whereas the discrepancies between Earned Value and the Actual Cost are a sign of cost efficiency. Earned Value that lowers the planned value indicates that the project is lagging behind schedule whereas an actual cost that is greater than the earned value indicates cost overruns [4].

Recent studies have attempted to overcome these shortcomings by extending the methodologies, including the Earned Schedule, risk-adjusted EVM models, and combination with the digital construction management tools. Such developments imply that EVM is a useful framework, but its success is conditional on the situational adaptation, the accuracy of data, and the maturity of the organization. The synthesis of available literature is, therefore, required to evaluate the use of EVM, its successes, and failures in managing time and cost increase in the construction of infrastructure developments.

1.3 Objectives of the Study

The objectives of this review study were

- To critically evaluate the role of Earned Value Management in controlling time and cost overruns in infrastructure construction projects.
- To synthesize empirical evidence on its effectiveness in cost and schedule performance management.
- To identify key challenges and limitations associated with its implementation in construction environments.
- To examine recent methodological advancements and extensions of EVM proposed in the literature.
- To highlight research gaps and practical implications for improving project control practices in infrastructure construction.

2. Conceptual Basis and Review Methodology

The concept of Earned Value Management has been well known as a combined project control model that connects together cost performance, schedule performance and scope performance into a single unit. Before deciding on its effectiveness in dealing with time and cost overruns in construction projects of infrastructure one needs to understand its conceptual underpinnings. In this section, the theoretical background of EVM is discussed at the beginning followed by the methodology used to conduct the literature review.

2.1 Conceptual Framework of Earned Value Management

The concept called Earned Value Management is based on the idea that the performance of the project should be evaluated using the value of the work which was completed instead of just looking at the amount of money used or time passed. The framework is based on three basic parameters Planned Value that is the approved budget of the planned work, Earned Value that is the planned value of the work done, and Actual Cost that is the actual amount of the work performed [5]. Through the systematic comparison of these parameters, EVM comes up with key performance indicators which include cost variance, schedule variance, cost performance index, and schedule performance index.

These indicators are quantitative ways of knowing whether a project is performing above or below schedule and below or above budget. Among the major advantages of EVM, it allows predicting the final results of the project cost at the end and the expected time of completion, depending on the current trends in project performance. This attribute of prediction makes EVM a forward-looking managerial tool and not a backward reporting system. The framework however makes some assumptions of stable baselines, objective measurement of progress, and reliable cost information- assumptions which are regularly refuted in infrastructure construction settings, which are uncertain and subject to frequent changes.

2.2 Review Design and Literature Identification

In order to assess the application and evaluation of EVM in infrastructure construction projects, this research chose a qualitative systematic literature review methodology. The criteria used in the review were peer-reviewed journal articles, conference papers, and credible sources on the topic of project management and construction engineering. Relevant studies were identified through academic databases like Google scholar, journals indexed by Scopus and other big publishers.

The search in the literature entailed the use of keywords that linked to earned value management, management in construction projects, infrastructure projects, cost overruns, and schedule delays. Peer-reviewed articles published mainly within the past 20 years were given priority to both historic research and latest methodological developments. Special attention was paid to empirical research on the practical implementation of EVM in such infrastructure areas as highways, railroads, bridges, energy projects, and mega projects.

2.3 Inclusion Criteria and Scope of Review

The studies were filtered to include only those that specifically dealt with the use, assessment, or expansion of EVM in construction or infrastructure setting. Such studies which were purely manufacturing, software development or defence without construction relevance were ruled out. The reviews were conducted in both quantitative and qualitative studies to have a comprehensive understanding of the practical performance, limitations and contextual issues of EVM.

It was ensured that the review was limited to large-scale infrastructure projects, as infrastructure projects generally encounter elevated amounts of complexity, uncertainty, and risk exposure than small or short-duration construction projects. Such attention provided the correspondence with the goals of the research and increased the topicality of the results.

2.4 Data Analysis and Synthesis Approach

Approach to thematic synthesis was used to analyse the selected literature. Research publications were reviewed to determine some of the themes that kept on reappearing in terms of the achievement of the EVM in controlling cost overruns and its success in schedule management, the general implementation difficulties, and offered methodological improvements. The review instead of statistical aggregation of results focused on comparative interpretation and critical critique of findings reported [6].

This method allowed revealing the common patterns, inconsistency, and gaps in research in the context of various infrastructures. The synthesising findings thematically, the review conducts a systematic and critical analysis of the current state of knowledge on EVM in infrastructural construction projects, which constitutes one of the solid grounds on which further analysis and discussion may be made.

3. Effectiveness of Earned Value Management in Infrastructure Projects

The application of the Earned Value Management in the construction projects of infrastructure facilities has become a widely studied area within the literature especially in the use of this management tool in controlling cost overruns and schedule performance. On the whole, the results of research indicate that EVM has much more

advantages as compared to traditional approaches to project control but its effectiveness varies in terms of project features, the way it is implemented, and external conditions. This part collects empirical data on the performance of EVM, and specifically looks at the issue of cost control and schedule control in grand scale infrastructure projects.

3.1 Effectiveness of EVM in Managing Cost Overruns

The articles that have been reviewed show that EVM is very efficient in identifying and controlling cost overruns in construction projects in the infrastructure sector. Cost performance indices like cost variance and cost performance index help project managers to identify variances between planned and actual spending at a tender age during project implementation. This early warning methodology makes it possible to respond with corrective responses in time such as budget reallocation, scope modification, and optimization of resources, which will minimize the chances of a drastic increase in costs.

It has been empirically found that infrastructure project using the EVM in the planning and early implementation stages enjoy a higher degree of predictability of costs and better financial discipline as compared to projects which use the traditional methods of cost monitoring. Combination of cost and progress information into the EVM system is a more accurate evaluation of financial performance as compared to mere expenditure tracking which usually does not consider the value of work done. Consequently, it has been demonstrated that EVM-based cost forecasting is more effective in providing sound forecasting of the eventual project cost to aid informed decision-making by the project stakeholders.

The literature however does not fail to note the limitations in terms of the reliability of cost data despite these advantages. EVM can be undermined by inaccurate or late reporting of costs in infrastructure projects that are typified by large subcontracting, high number of change orders, and claim. Furthermore, classical EVM does not consider the risks of external costs including inflation, changes in material prices, or legal disputes in contracts explicitly, unless they are combined with risk management mechanisms.

3.2 Effectiveness of EVM in Managing Schedule Performance

The EVM effectiveness of schedule performance has been subjected to greater criticism in comparison to cost control. Although schedule variance and schedule performance index are useful in identifying schedule slippage in the initial stages, various researchers have established that the indicators lose their value over long-term infrastructure projects. It is common to see near the end of a project that traditional EVM schedule metrics tend to take on neutral values, despite the presence of large delays, and thus be of lower value in giving accurate time predictions.

To overcome this shortcoming, scholars have suggested an extension like Earned Schedule, which instead of using cost-based time measurement, time-based indicators are used. The empirical use of Earned Schedule in infrastructure construction projects has been shown to be more accurate in estimating the completion dates and are also sensitive to schedule deviations. These results indicate that despite the positive insights that can be gained using traditional EVM, there is a need to improve its methodological value to be used over the entire life cycle of the project.

The literature also recommends that the quality of baseline schedules and objectivity of progress measurement have a strong effect on schedule control effectiveness. Poor baseline planning, improper sequence of activities, and subjective evaluation of the work completion may cause distortion of EVM schedule indicators and thus false conclusions. Therefore, the most effective schedule management using EVM is applicable in projects with a well-developed system of planning and standardized procedures of measuring progress.

3.3 Influencing Factors and Contextual Dependence

In most of the studied literature, there is a common theme that the efficacy of EVM on infrastructure projects is extremely contextual. Organizational maturity, staff competency, data accuracy and management commitment are some of the factors that are conclusive in determining outcomes. Projects that are undertaken in organisations with a well-established project management system and performance measurement culture are always recorded as reporting improved results after implementing the EVM.

On the other hand, in a situation where there is weak governance, disjointed responsibilities, and lack of technical skills, EVM tends to degenerate into a reporting routine, as opposed to decision-supporting tool. These results demonstrate that the technical framework of EVM is not the only important factor to consider whether it will be effective or not but rather the general project and organizational background where it will be used.

In order to offer a systematic review of empirical findings, the most important researches that assessed the effectiveness of Earned Value Management towards infrastructure construction projects are summarized in Table 1.

Table 1: Summary of Key Empirical Studies on the Effectiveness of Earned Value Management in Infrastructure Projects

Author(s)	Study Focus	Methodology	Key Findings on EVM Effectiveness
Proaño-Narváez et al. (2022) [7]	Evaluation of EVM application and performance outcomes	Systematic literature review and comparative analysis	EVM was effective in early detection of cost overruns and improving cost predictability; schedule control effectiveness was limited in long-duration projects without methodological extensions.
Reda et al. (2025) [8]	Performance evaluation using EVM	Case study with EVM indicators (CPI, SPI)	Implementation of EVM improved cost control and enabled early identification of schedule delays; effectiveness depended on accuracy of baseline planning and reporting discipline.
Ateş & Eirgash (2025) [9]	Data-driven decision-making using EVM	Empirical analysis using earned value indicators	EVM supported proactive management decisions and improved performance transparency; integration with digital tools enhanced forecasting reliability.
Widyarso et al. (2025) [10]	Analysis of time and cost performance	Quantitative performance assessment using EVM metrics	EVM proved more reliable for cost performance monitoring than schedule forecasting; schedule indicators showed declining accuracy toward project completion.
Ngo et al. (2022) [11]	Continuous EVM and forecasting improvement	Analytical modeling and performance simulation	Traditional EVM forecasting had limitations in complex projects; continuous and enhanced EVM models improved time and cost performance prediction accuracy.

As it can be summarized in Table 1, the analyzed literature shows a consistent pattern that Earned Value Management, specifically, proves effective in the management of cost overruns and the increase of financial predictability in infrastructure projects. Nevertheless, the results also indicate the presence of re-occurring limitations in making schedule forecasts, particularly in the long-term and complicated projects, where the conventional EVM indicators are likely to lose use. The results also show that the accuracy of the baseline, data quality and organizational maturity are highly affecting the effectiveness of EVM, which supports the necessity to extend the methodology and adjust it to the context of infrastructure construction works.

4. Implementation Challenges and Emerging Extensions

Even with all its theoretical strengths, the implementation of the Earned Value Management in the infrastructure construction project is plagued with challenges. The literature review shows that a significant proportion of EVM implementations do not result in the assumed benefits because of the discrepancy between the assumptions of the framework and the realities of construction settings. This part scrutinizes critically the main challenges in implementation and generalizes some of the proposed extensions of methodology and technology to overcome the shortcomings.

4.1 Implementation Challenges of EVM in Infrastructure Construction

The difficulty of setting realistic and stable baselines has been listed as one of the most commonly mentioned challenges in the application of EVM to infrastructure projects. The infrastructure projects are known to be started with incomplete designs and re-defined scopes thus making it hard to establish the proper schedules and the cost baseline at the initial stages [12]. The high frequency of design adjustments and scope modifications in the implementation of the designs deter the validity of original baselines thus skewing the performance indicators of EVM.

The other major limitation can be associated with progress measurement. Compared to manufacturing or software development, construction activities are site-specific and nonhomogeneous, and it is hard to measure objectively

the completion of work. Numerous reports indicate that progress is estimated in subjective way and thus creating errors in earned value computations. Such subjectivity undermines the credibility of EVM indicators and the ability to rely on them as predictors.

EVM further is complicated by fragmented project structures. Infrastructure projects normally have various contractors, subcontractors and suppliers who are working under various contractual agreements. Timely and accurate data collection in such environments is not easy and therefore leads to delays in reporting and to less responsiveness of EVM based control systems. Bureaucratic approval procedures and fixed reporting lines in the public infrastructure projects make these problems worse and project managers are unable to take action on the early warning signals.

The opposition of project staff also becomes one of the frequent obstacles. Some of the studies point out that, EVM has been perceived as an administrative burden instead of a decision support tool especially those organizations that lack project management maturity. Poor training, inadequate knowledge of the concept of EVM, and a missing management commitment are among the factors that make EVM to be superficial, as its implementation is not meant to improve performance, but to act as a compliance measure [13].

4.2 Emerging Methodological and Technological Extensions

To address these difficulties, recent studies have been concerned with the extension and adjustment of the conventional EVM model to the infrastructure building complexities. Among them is the use of risk and uncertainty in EVM via probabilistic and risk-adjusted models. These methods combine risk analysis methods, with Monte Carlo simulation, to enhance the accuracy of the forecast provided in uncertain conditions and to consider the fluctuations of costs and schedule performances [14].

The other major development is the development of integration of EVM and digital construction management tools. It has been demonstrated that the integration of EVM with Building Information Modeling bring more precision to data as well as less subjectivity in the measurement of progress. The combination of work breakdown structures and the three-dimensional representation and real-time project data, BIM-enabled EVM provides the automated tracking of the progress, the visual monitoring of performances, and expedited decision-making.

Other extensions are that EVM has been integrated with lean construction principles and the use of advanced project management information systems. These hybrid systems are designed to enhance reliability in workflow, minimize waste and even the coordination among the project participants [15]. Taken together, these changes bear indications of a shift of the traditional, deterministic models of EVM towards more flexible and data-intensive, structure-specific performance management systems.

Conclusion And Research Implications

This review finds that the concept of Earned Value Management is a helpful tool in managing the overruns in time and costs during the construction of infrastructure based projects with the need to manage costs and early detect performance disorders. Nonetheless, its conventional version does not provide enough stable schedule control in complicated and unpredictable construction conditions. EVM is not only effective because of its technical indicators, but organizational preparedness, accuracy of data, and contextual suitability.

Future studies are required in empirical validation of integrated EVM models in entire project life cycles and in a variety of geographical settings, especially in the developing economies. To practitioners, EVM ought to be implemented as an adaptable decision-support mechanism and not as a strict compliance mechanism with the assistance of digital technologies and risk-based planning practices.

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