Comparative Analysis of Hybrid Approaches in Earned Value Management and Proposing an Extended Framework as an Integrated Future Model for Project Control

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Abstract

This study aimed to analyze and synthesize recent hybrid approaches in earned value management (EVM) to develop an extended, integrated framework (EVM-X) capable of addressing the complexity and uncertainty of modern project environments. A qualitative, exploratory research design was adopted, relying exclusively on the systematic review and analysis of scientific literature. A purposive selection process identified 22 peer-reviewed articles published within the last decade, focusing on the integration of EVM with methods such as agile project management, critical chain management (CCM), lean construction, and building information modeling (BIM). Data were collected from international academic databases and evaluated for methodological rigor, relevance, and credibility. NVivo 14 software was used to conduct open, axial, and selective coding, allowing thematic synthesis and ensuring theoretical saturation. The resulting analysis informed the design of the EVM-X model by integrating cost and schedule performance with risk management, adaptability, governance, and digital visualization. The analysis revealed five dominant thematic categories: agile adaptability for dynamic environments, risk integration through critical chain and predictive analytics, waste reduction and continuous improvement from lean principles, transparency and data-driven visualization via BIM, and enhanced cost-time forecasting grounded in EVM standards. Combining these elements strengthens EVM's predictive accuracy, improves early deviation detection, and aligns performance reporting with governance and ethical oversight. The EVM-X model was found to overcome the rigidity of traditional EVM and provide a flexible yet standardized approach for complex and high-risk projects. EVM-X offers a future-oriented, multidimensional project control model by unifying quantitative rigor with adaptability, risk awareness, and ethical governance, enabling improved decision-making and accountability.

Keywords: *Earned Value Management; Project Control; Hybrid Approaches; Risk Integration; Agile Project Management; Building Information Modeling; Lean Construction; Governance.*

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1. Introduction

The increasing complexity and dynamism of today's projects require control systems that go beyond traditional cost and schedule monitoring. Among the widely adopted tools, Earned Value Management (EVM) has long provided an integrated measure of cost and time performance by comparing actual progress against planned baselines [1]. Yet, despite its proven effectiveness in tracking financial and scheduling indicators, conventional EVM often struggles to respond to uncertain environments, evolving risks, and non-financial factors influencing project outcomes [2, 3]. This has prompted researchers and practitioners to search for ways to extend and adapt EVM to modern project demands, exploring advanced cost–time analytics, risk integration, and governance-informed approaches [4, 5].

The reliability of project control systems is increasingly tied to the quality of reported performance and underlying managerial behavior. Earnings management—deliberate manipulation of reported performance metrics—can distort the information used for oversight and decision-making, undermining the credibility of both financial reporting and project control frameworks [6, 7]. Cultural and ethical contexts also shape how managers exercise discretion and how stakeholders interpret reported value [8, 9]. Governance mechanisms such as board oversight and institutional investor involvement influence transparency and accountability, reinforcing the call for project control models that are not only technically precise but also ethically resilient [10, 11].

Within the project management discipline, the need to integrate risk awareness into EVM has become clear. Incorporating risk metrics into earned value calculations strengthens the predictive ability of control systems and enables earlier identification of cost and schedule threats [2]. Such advancements align with agile and adaptive management principles, where iterative planning and rapid response capabilities help project teams remain resilient under uncertainty [5]. Pedagogical work has also emphasized preparing practitioners to interpret and react to EVM data in dynamic contexts, fostering a deeper, more proactive use of earned value information [4].

Beyond risk and adaptability, contextual and sustainability-driven insights are shaping the evolution of control models. Environmental, social, and governance (ESG) criteria have been shown to moderate the negative effects of earnings manipulation and enhance the perceived reliability of financial and operational data [6]. Board composition and shareholder activism further influence the credibility of reported project performance [10, 11], while cultural diversity and ethical business practices can alter how performance metrics are understood and acted upon [7, 8]. These findings indicate that future project control frameworks should embed governance and ethical safeguards alongside technical and predictive elements [9, 12].

In construction and infrastructure settings, EVM remains central but has been adapted to local challenges and new analytical tools. Applications in road and civil projects have shown the benefits of customizing cost and schedule metrics to local conditions and regulatory frameworks [13]. Integrating schedule-based techniques such as Earned Schedule (ES) and Earned Duration Management (EDM) with traditional EVM enhances timeline forecasting and provides a richer understanding of project status [5]. These developments underscore the importance of contextualizing EVM to better reflect market realities and risk environments [2].

At the same time, cross-cultural and crisis-oriented evidence points to the vulnerability of control frameworks to external shocks and social expectations. The COVID-19 crisis challenged the consistency of corporate governance and CSR commitments, revealing variations in earnings quality and reporting integrity across different institutional contexts [7, 8]. These insights highlight the importance of designing project control models that are robust under volatility and adaptable to diverse governance and cultural conditions.

Against this backdrop, extending EVM with complementary approaches—such as risk-based analysis, agile adaptability, and governance-informed safeguards—is essential for building future-ready project control systems. Technical innovations must converge with ethical and institutional insights to ensure both accurate forecasting and trustworthy reporting [4, 5, 9, 14].

The aim of this study is to conduct a comparative analysis of hybrid approaches in earned value management and to propose an extended, integrated framework (EVM-X) for more comprehensive and resilient project control.

2. Methodology

This research adopted a qualitative study design with an exploratory and integrative orientation to develop an advanced framework for earned value management (EVM) by synthesizing hybrid approaches in project control. The study relied exclusively on the analysis of scientific publications, focusing on the most recent and high-quality evidence available in the field. The research population consisted of academic and professional literature and subject-matter experts in project management, with an emphasis on innovative control models integrating EVM with complementary methodologies such as agile project management, critical chain project management (CCPM), building information modeling (BIM), lean construction, and machine learning-based predictive control.

To ensure contextual relevance and alignment with regional academic expertise, subject-matter participants were selected from Tehran, including experienced scholars and practitioners in project management and construction engineering. Selection followed a purposive sampling strategy, prioritizing individuals and sources capable of providing in-depth and diverse perspectives on integrating modern control methods with EVM. Sampling continued until theoretical saturation was reached—that is, until no new conceptual themes or methodological innovations emerged from the reviewed literature or expert feedback.

Data were gathered systematically from scientific databases and peer-reviewed journals. A structured search strategy was applied using keywords such as earned value management, agile project management, critical chain, building information modeling, lean construction, risk-based control, predictive analytics in project management, and integrated project control frameworks. The search was limited to the last decade to capture the most recent developments in advanced EVM-based models and hybrid control strategies.

After screening for quality and relevance, 22 articles were selected for in-depth qualitative analysis. Each selected paper was required to demonstrate methodological rigor, present evidence-based findings, and directly address hybridization or integration of EVM with other project management approaches. The credibility of the sources was further validated by journal ranking, citation counts, and methodological transparency.

Data analysis followed an iterative and inductive coding process to synthesize insights into a coherent conceptual model. First, the full texts of the selected articles were imported into NVivo software version 14 for qualitative analysis. A thematic coding framework was developed to categorize data under key dimensions such as cost and time integration, risk analysis, predictive analytics, quality and safety indicators, agile adaptability, and visual data integration.

Coding was conducted in multiple cycles: open coding to capture emerging concepts, axial coding to refine and relate categories, and selective coding to integrate findings into overarching theoretical dimensions. Constant comparison techniques were used throughout to ensure that categories accurately represented the content of the literature and expert perspectives.

Theoretical saturation was confirmed when no new categories or subthemes emerged from successive rounds of coding and conceptual refinement. The resulting analysis formed the basis for synthesizing a comprehensive integrated framework (EVM-X), which unifies the strengths of traditional earned value management with modern control methodologies.

3. Findings and Results

The qualitative analysis of 22 selected scientific sources, combined with expert insights from Tehran, led to the identification of a comprehensive set of themes and subthemes that underpin the proposed EVM-X Integrated Model. Using an inductive approach supported by NVivo 14, the data were coded and refined until theoretical saturation was reached, ensuring that the final framework captures the full range of concepts reported in the literature and confirmed by domain specialists. The findings reveal five main thematic categories—Agile Project Management, Critical Chain Management, Lean Construction, Building Information Modeling (BIM), and Earned Value Management (EVM)—each contributing distinct but complementary capabilities to advanced project control. Within these categories, multiple subthemes and associated concepts emerged, demonstrating how integrating iterative and flexible practices, robust resource and risk management, lean waste reduction, digital modeling and visualization, and rigorous cost-schedule tracking can produce a unified and future-ready model for managing complex projects. This section presents these themes in detail, highlighting their specific elements and the way they interconnect to form the extended earned value management framework (EVM-X).

Table 1. Thematic Table for EVM-X Integrated Model

Category (Theme)	Subcategory	Concepts (Open Codes)
Agile Project Management	Iterative Planning	Sprint cycles, Backlog refinement, Adaptive scheduling, Short-term milestones
	Stakeholder Collaboration	Customer feedback loops, Daily stand-ups, Co-creation with end-users, Transparency, Stakeholder mapping
	Flexibility & Adaptability	Scope adjustment, Change responsiveness, Iterative release, Minimal documentation
	Performance Metrics	Velocity, Burndown charts, Earned story points
	Risk Management in Agile	Rapid risk identification, Continuous monitoring, Prioritization of critical tasks
Critical Chain Management	Buffer Management	Time buffers, Resource buffers, Feeding buffers, Dynamic buffer control
	Resource Optimization	Constraint focus, Multi-project resource allocation, Critical resource scheduling
	Schedule Reliability	On-time delivery, Chain monitoring, Bottleneck analysis
	Risk Control	Variability management, Contingency planning, Monitoring uncertainty
	Decision Support	Real-time adjustments, Proactive interventions, Performance thresholds
Lean Construction	Waste Reduction	Eliminating rework, Minimizing delays, Reducing overproduction
	Continuous Improvement	Kaizen, Value stream mapping, Benchmarking

	Flow Optimization	Pull systems, Just-in-time delivery, Work-in-progress limits
	Quality Integration	First-time-right approach, Standardized procedures, Error-proofing
	Stakeholder Value	End-user value focus, Collaboration contracts, Shared responsibilities
	Cultural Adoption	Training teams, Management commitment, Worker empowerment
Building Information Modeling (BIM)	Data Integration	3D/4D/5D modeling, Centralized data hub, Digital twin
	Visualization & Transparency	Graphical dashboards, Visual progress tracking, Clash detection
	Cost & Time Control	Model-linked scheduling, Cost simulation, Real-time updates
	Collaboration Platform	Shared digital environment, Cloud-based models, Cross-discipline integration
	Risk & Quality Analysis	Simulation of scenarios, Early error detection, Quality compliance
Earned Value Management (EVM)	Cost & Schedule Tracking	Cost variance (CV), Schedule variance (SV), Performance indices (CPI, SPI)
	Forecasting	Estimate at Completion (EAC), Estimate to Complete (ETC), Predictive modeling
	Performance Monitoring	Baseline comparison, Progress reports, Early warnings
	Integration with Other Methods	Agile metrics alignment, Buffer integration, BIM-linked indicators
	Decision-Making Support	Corrective actions, Trend analysis, Scenario planning
	Standardization	PMBOK alignment, IPMDAR compliance, EIA-748 standards

Agile Project Management: Agile project management emphasizes flexibility and continuous value delivery by structuring work into short, adaptive cycles. Its iterative planning allows projects to adjust to change through sprint cycles, backlog refinement, and adaptive scheduling with short-term milestones. Stakeholder collaboration is central, relying on constant feedback loops, daily stand-ups, co-creation with end-users, and transparent communication channels. Agile also promotes flexibility and adaptability, enabling scope adjustments, rapid response to evolving requirements, and iterative releases with minimal documentation. To measure progress, teams use performance metrics such as velocity, burndown charts, and earned story points. Importantly, Agile integrates risk management early, identifying threats quickly, prioritizing critical tasks, and continuously monitoring to minimize project uncertainty.

Critical Chain Management (CCM): Critical Chain Management focuses on optimizing time and resources while reducing uncertainty in schedules. Its foundation is buffer management, using time and resource buffers such as feeding and dynamic buffers to protect the project schedule against variability. Resource optimization ensures efficient use of critical resources across multiple projects through constraint-focused scheduling. By improving schedule reliability, teams can monitor chains, analyze bottlenecks, and maintain on-time delivery. CCM also supports risk control by managing variability, using contingency planning, and continuously tracking uncertainties. Additionally, decision support is strengthened by real-time adjustments and proactive interventions based on performance thresholds, giving managers timely alerts for corrective action.

Lean Construction: Lean construction aims to maximize project value and eliminate inefficiencies. Waste reduction targets rework, delays, and overproduction to increase productivity. Through continuous improvement, tools like Kaizen, value stream mapping, and benchmarking foster an environment of constant process refinement. Flow optimization enhances efficiency using pull systems, just-in-time delivery, and strict work-in-progress limits. Lean also promotes quality integration, encouraging standardized procedures, first-time-right practices, and error-proofing. Another key subtheme is stakeholder value, which prioritizes end-user needs, shared responsibilities, and collaborative contracts to align all parties. Finally, cultural adoption ensures the lean mindset spreads across teams by providing training, gaining management commitment, and empowering workers.

Building Information Modeling (BIM): Building Information Modeling enhances project control by integrating digital data with visual and analytical tools. Data integration combines 3D, 4D, and 5D modeling into a centralized digital hub or digital twin for real-time tracking. Visualization and transparency improve communication through dashboards, progress tracking, and clash detection, allowing teams to see issues before they escalate. BIM supports cost and time control with model-linked scheduling, cost simulation, and live updates to maintain alignment with budgets and timelines. It also provides a collaboration platform, where teams across disciplines work within shared cloud-based models, promoting consistency and coordination. Additionally, risk and quality analysis benefits from BIM's ability to simulate scenarios, detect errors early, and ensure compliance with quality standards.

Earned Value Management (EVM): Earned Value Management remains the core analytical tool, now enhanced for modern project environments. Its cost and schedule tracking leverages indicators like cost variance (CV), schedule variance (SV), and performance indices (CPI, SPI) to evaluate progress accurately. Forecasting techniques such as Estimate at Completion (EAC) and Estimate to Complete (ETC) support predictive decision-making and proactive adjustments. Performance monitoring compares actual performance to baselines, generates progress reports, and provides early warnings when deviations occur. The ability to integrate with other methods—aligning agile metrics, linking to buffer analysis, and connecting with BIM dashboards—makes EVM adaptable to hybrid environments. Furthermore, decision-making support is strengthened through trend analysis and scenario planning. Finally, standardization ensures alignment with recognized frameworks like PMBOK, IPMDAR, and EIA-748, providing a reliable foundation for reporting and compliance.

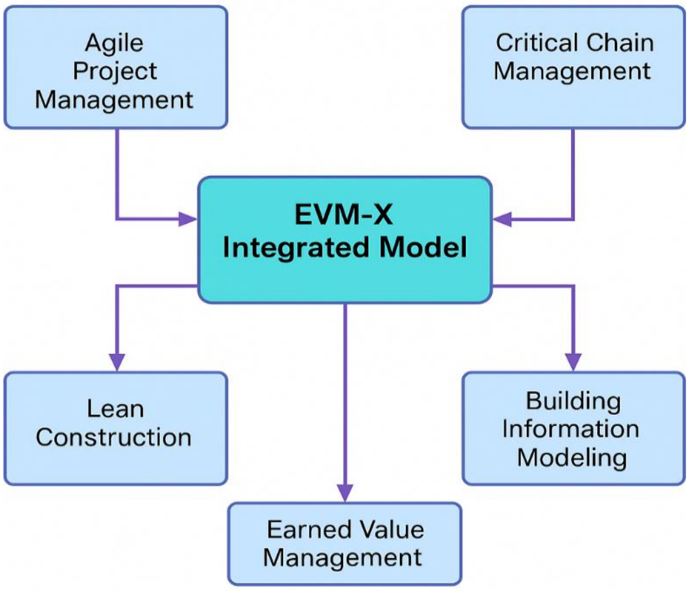

Figure 1. The Integrated EVM-X Framework

4. Discussion and Conclusion

The findings of this study revealed that the EVM-X integrated model successfully addresses long-standing limitations of traditional Earned Value Management (EVM) by incorporating adaptive, risk-aware, and ethically grounded practices identified in contemporary research. Through a rigorous qualitative analysis of 22 high-quality scientific sources, five thematic categories emerged—Agile Project Management, Critical Chain Management, Lean Construction, Building Information Modeling (BIM), and enhanced EVM—which together form a multidimensional control framework capable of responding to the complexities of modern projects. The integration of these elements highlights that the future of project control lies not in the isolated application of EVM but in combining it with flexible planning, predictive risk modeling, and governance-sensitive decision support [1, 4].

A key result of the study is the confirmation that adaptability and iterative control mechanisms can strengthen EVM's predictive capacity. Agile practices, such as short iterative cycles, continuous stakeholder involvement, and responsive planning, directly address EVM's rigidity when faced with volatile scopes or fast-changing requirements [4, 5]. Prior work has shown that EVM alone struggles with scope volatility and frequent replanning because its reliance on a fixed baseline makes it sensitive to early inaccuracies [2]. By embedding agile features like sprint-based progress measurement and customer-centric feedback, EVM-X transforms static cost and schedule tracking into a dynamic, learning-oriented process. This aligns with educational approaches that teach EVM in practical, interactive ways to promote understanding and timely adjustments [4].

Another significant outcome is the reinforcement of risk integration as a core component of project control. Classical EVM lacks a systematic way to incorporate probabilistic risk or uncertainty into its variance indices [2]. Our model fills this gap by integrating risk buffers and predictive analytics similar to those used in critical chain management. Prior studies suggest that combining EVM with risk-based scheduling improves early deviation detection and allows for more proactive corrective actions [2, 5]. This enhancement resonates with efforts to modernize EVM for construction and infrastructure projects, where uncertainty and complex dependencies frequently disrupt schedules [13]. By embedding risk-awareness at both strategic and operational levels, EVM-X offers a more resilient structure for large and uncertain projects.

The findings also underscore the importance of digital integration and visualization to increase the transparency and decision value of EVM outputs. Traditional reporting often fails to communicate performance data effectively to diverse stakeholders, limiting the practical impact of control systems [1]. Studies on Building Information Modeling (BIM) and digital dashboards demonstrate that visually integrated performance indicators allow managers to detect schedule slippage and cost overruns faster and with greater clarity [5]. By incorporating BIM-inspired data visualization and integrated dashboards, EVM-X ensures that cost and schedule data are not just computed but communicated meaningfully, improving cross-functional coordination and informed decision-making [4].

A particularly novel contribution of this study is the explicit alignment between project control and corporate governance and ethics. Our thematic analysis highlighted that financial reporting reliability and earnings quality have direct implications for the trustworthiness of project performance metrics [6, 7]. Previous research shows that managerial opportunism and earnings manipulation can distort financial indicators and undermine long-term value [14, 15]. Furthermore, corporate governance mechanisms, such as board oversight and institutional shareholder involvement, can moderate these behaviors and improve the interpretability of performance data [10, 11]. By embedding governance safeguards and ethical performance considerations, EVM-X ensures that project control outputs remain credible and useful not only to technical managers but also to financial stakeholders and regulators [12].

The integration of contextual and cultural dimensions also emerged as crucial. Research shows that cultural diversity and institutional frameworks affect both corporate reporting and project execution [8]. For instance, the moderating role of culture on the link between CSR practices and earnings quality suggests that value-based project control cannot be fully universal [8]. Our model accounts for these differences by allowing flexibility in governance and reporting structures while maintaining global standards like PMBOK and EIA-748 [1]. This adaptability is essential for multinational or cross-border projects that operate under varying ethical, regulatory, and cultural expectations.

Additionally, the study confirms the need for integrated forecasting capabilities that move beyond static estimates. Techniques such as Estimate at Completion (EAC) and Estimate to Complete (ETC), while well established in EVM, can be enhanced by incorporating real-time analytics and scenario planning to anticipate different cost and schedule outcomes [1, 5]. Our findings resonate with studies emphasizing that incorporating advanced forecasting and dynamic rescheduling significantly improves project responsiveness and decision quality [4]. This predictive capability is particularly relevant for industries facing volatile resource markets or rapid technological changes, where static baselines quickly lose relevance.

Finally, the research highlights that standardization and methodological rigor remain essential even when pursuing integration and adaptability. While hybridization adds flexibility, adherence to recognized standards and structured reporting frameworks provides comparability and accountability [1, 3]. Prior literature warns that without strong methodological anchors, integrated approaches risk becoming fragmented and inconsistent [16]. EVM-X explicitly aligns with international standards while allowing extensions through digital and agile elements, balancing innovation with reliability.

In sum, the results show that the EVM-X integrated model advances project control by combining the quantitative strength of EVM with risk integration, agile responsiveness, digital visualization, and ethical oversight. This combination addresses gaps noted across different streams of literature—from project management to corporate governance and ethics [6, 7, 9]. It contributes a comprehensive and future-oriented perspective capable of supporting both technical performance monitoring and organizational accountability.

While this study provides a robust conceptual model, it has several limitations. First, the analysis relied exclusively on secondary data from scholarly sources, which means no direct field data or live project performance metrics were tested. Although the use of theoretical saturation enhances credibility, the absence of empirical validation may limit the generalizability of the findings across diverse industries and project sizes. Second, the literature analyzed spans various cultural and economic contexts, and while the model incorporates flexibility, its direct applicability to highly regulated or resource-constrained environments needs empirical testing. Third, the qualitative coding and thematic synthesis, while rigorous, remain subject to interpretive bias inherent in any researcher-driven analysis. Finally, although the model integrates governance and ethics, it does not provide explicit operational tools or measurement indices to assess ethical risk or cultural variation within project control systems.

Future studies could focus on empirical validation and performance measurement of the EVM-X model across different industries such as construction, IT, and energy. Large-scale field testing using real-time project data would help refine the predictive elements and confirm the practical value of integrating risk buffers and agile responsiveness. Researchers should also explore how emerging technologies—such as artificial intelligence and machine learning—can automate aspects of forecasting and risk analysis to support EVM-X. Cross-cultural investigations would be valuable to test how governance and ethical dimensions affect project outcomes under varying legal and institutional settings. Additionally, developing standardized metrics or diagnostic tools for assessing the ethical and sustainability dimensions embedded in EVM-X would strengthen its strategic use for boards and regulators.

Practitioners seeking to adopt the EVM-X model should begin by gradually expanding traditional EVM systems rather than replacing them abruptly. Incorporating agile reporting cycles and digital dashboards can provide quick wins while building familiarity with more adaptive practices. Organizations should invest in training project teams and stakeholders to interpret integrated risk and performance indicators effectively, improving responsiveness to early warning signs. Governance and ethics integration requires aligning project reporting with broader corporate controls; therefore, close collaboration between project management offices and corporate compliance or audit teams is essential. Finally, managers should customize the EVM-X framework to their organizational culture and industry regulations, ensuring alignment with local norms while maintaining international standards for transparency and comparability.

Authors' Contributions

Authors equally contributed to this article.

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Declaration of Interest

The authors report no conflict of interest.

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Ethical Considerations

All procedures performed in this study were under the ethical standards.

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