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Time and Cost Management Analysis Using the Schedule Performance Index (SPI) and Cost Performance Index (CPI) Methods in the Community Health Center Construction Project in Kakaskasen Village, Tomohon City

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ABSTRACT

Project management is crucial to the success of infrastructure development, including healthcare facility projects such as community health centers. This study aims to analyze time and cost management analysis using the Schedule Performance Index (SPI) and Cost Performance Index (CPI) methods in the community health center construction project in Kakaskasen Village, Tomohon City. The research method employed earned value management (EVM) analysis to evaluate project performance, specifically schedule and cost aspects. The results showed that the project experienced significant time and cost deviations in several construction activities. The Schedule Performance Index (SPI) was below 1, indicating project delays, while the Cost Performance Index (CPI) was also below 1, indicating cost overruns. Factors contributing to the delays included inadequate coordination among relevant stakeholders, delays in material procurement, and unfavorable weather conditions. The proposed recommendations include enhancing initial project planning, strengthening risk management processes, and implementing more intensive progress monitoring to ensure project completion meets established targets. This research is expected to contribute to improving the management of similar projects in the future.

Keywords: *Time and cost management, Earned Value Management, health center development project.*

INTRODUCTION

Construction projects play a significant role in supporting infrastructure development in various regions. One type of project that has a considerable impact on public services is the construction of health facilities, such as community health centers (Puskesmas). Puskesmas serve as first-level healthcare centers providing preventive services. These primary healthcare facilities are essential components of national health systems, particularly in developing countries, where they provide the first point of contact between communities and formal healthcare services.

Therefore, the success of Puskesmas construction significantly affects access to and the quality of health services for the surrounding community. However, construction projects often face challenges related to time and cost management. Project delays and cost overruns are common problems that influence overall project performance and effectiveness. Global studies indicate that construction project delays occur in 70–90% of projects worldwide, with cost overruns affecting approximately 80% of projects (Flyvbjerg et al., 2018). In developing countries, these challenges are often exacerbated by factors such as inadequate planning, resource constraints, and coordination difficulties (Aziz, 2013).

A project is defined as a series of unique, time-bound activities that begin and end at specific times, with the goal of producing a specific product (Project Management Institute, 2017). Management is the systematic application of knowledge, skills, tools, and techniques to project activities to meet project requirements and achieve specified objectives. Time management and cost management are inextricably linked in project success—delays in project completion typically result in increased costs, while poor budget management can hinder timely completion (Kerzner, 2017).

Effective project management is crucial in implementing development projects to achieve results consistent with planned objectives. There are two main aspects that must be managed effectively in a project: time and cost. Therefore, a systematic method is needed to objectively monitor and evaluate project performance. One widely recognized approach in project management is Earned Value Management (EVM), which integrates scope, schedule, and cost parameters to provide comprehensive performance measurement (Fleming & Koppelman, 2016).

EVM involves measuring project performance through key indicators, including the Schedule Performance Index (SPI) and Cost Performance Index (CPI). This method allows for better decision-making by providing quantitative information on the extent to which a project is on schedule and within planned costs. The SPI is calculated as the ratio of Earned Value (EV) to Planned Value (PV), where SPI > 1.0 indicates ahead of schedule, SPI = 1.0 indicates on schedule, and SPI < 1.0 indicates behind schedule. Similarly, the CPI is calculated as the ratio of EV to Actual Cost (AC), where CPI > 1.0 indicates a cost underrun (favorable), CPI = 1.0 indicates on budget, and CPI < 1.0 indicates a cost overrun (unfavorable) (Project Management Institute, 2017).

Numerous international studies have demonstrated the effectiveness of SPI and CPI in assessing project performance. Research by Narbaev and De Marco (2014) on construction projects in Central Asia found that combining SPI and CPI provides reliable early warning indicators for potential project performance issues. Kim et al. (2020) applied EVM to infrastructure projects in South Korea, demonstrating that regular SPI and CPI monitoring enables proactive corrective actions that improve project outcomes. Similarly, Acebes et al. (2014) validated the predictive power of these indices in forecasting final project duration and costs.

However, the application of SPI and CPI specifically to community health center construction projects in Indonesia remains limited in published literature. Most existing Indonesian studies focus on large-scale infrastructure such as roads, bridges, or commercial buildings (Wulandari & Narsa, 2017; Pratama et al., 2019), with minimal attention to healthcare facility construction despite its critical importance to public health infrastructure development.

Kakaskasen Village, located in Tomohon City, North Sulawesi Province, is currently undergoing significant infrastructure development. As part of the national effort to strengthen primary healthcare access in underserved areas, a new community health center is being constructed to serve the local population. To ensure successful project implementation, an in-depth analysis of time and cost performance was conducted using the Schedule Performance Index (SPI) and Cost Performance Index (CPI). This analysis aims to determine the level of project efficiency and identify corrective measures needed to improve performance.

Despite the widespread recognition of EVM as a best practice in project management globally, its systematic application and documentation in Indonesian health facility construction projects are scarce. Few studies have applied SPI and CPI specifically to community health center construction projects in Indonesia, creating a significant knowledge gap regarding performance patterns, common challenges, and effective management strategies in this specific project context. This research addresses this gap by providing a comprehensive empirical analysis of schedule and cost performance in a real-world Puskesmas construction project.

The novelty of this study lies in (1) documenting week-by-week performance variations using standardized EVM metrics in a previously understudied project type; (2) identifying context-specific factors affecting schedule and cost performance in Indonesian regional health infrastructure development; (3) providing evidence-based recommendations tailored to the unique challenges of health center construction projects; and (4) contributing to the limited body of literature on construction project management in Eastern Indonesian contexts, where infrastructure development patterns may differ from the more developed western regions.

Based on the background, the problem in this research is how to evaluate time and cost management using the Schedule Performance Index (SPI) and Cost Performance Index (CPI) methods in the Kakaskasen Village Community Health Center Development Project in Tomohon City. This study aims to analyze time and cost management in ongoing projects in Kakaskasen Village using the Schedule Performance Index (SPI) and Cost Performance Index (CPI) methods. The results of this study are expected to provide insights for project managers and local governments in improving the effectiveness of project implementation and serve as a reference for similar projects in the future.

In accordance with the university's research master plan, this research focuses on time and cost management using the Schedule Performance Index (SPI) and Cost Performance Index (CPI) methods for the Kakaskasen Village Community Health Center project in Tomohon City. The proposed research will provide additional understanding and insight for both the public and other researchers. Furthermore, the research results will serve as a source of data and materials that universities can utilize as input and consideration when developing future research programs, which will ultimately contribute to achieving university research objectives, as the outputs of this research are concepts, methods, and recommendations.

METHOD

The research methodology applied is a descriptive quantitative approach, which aims to analyze project performance based on time and cost by utilizing the Schedule Performance Index (SPI) and Cost Performance Index (CPI). Data collection was carried out through the collection of project-related data. The case study design is appropriate for this investigation as it enables in-depth examination of a contemporary phenomenon (construction project performance) within its real-world context (Yin, 2018).

This research was conducted in Kakaskasen Sub-District, Tomohon City, North Sulawesi Province, Indonesia. The project site is located in a semi-urban area with moderate accessibility, representing typical conditions for regional health infrastructure development in Eastern Indonesia. The analysis used is a descriptive quantitative method by conducting field observations. The study focuses on project samples based on predetermined variables and indicators.

The data for this study was gathered using a comprehensive, multi-method approach to ensure reliability, which included detailed document analysis of project plans, progress reports, and financial records, direct field observations to verify physical progress and site conditions, and consultations with key stakeholders such as project managers and local officials. This triangulation of sources provided a robust foundation for the subsequent analysis, which systematically applied Earned Value Management (EVM) methodology.

The EVM analysis involved compiling weekly data over the project's 30-week duration to calculate fundamental parameters: Planned Value (PV), Earned Value (EV), and Actual Cost (AC). From these, performance indices (SPI and CPI) and variances (SV and CV) were computed to objectively quantify schedule and cost efficiency, with trend and variance analyses used to identify critical performance deviations and their underlying causes.

Throughout the research process, stringent ethical principles were upheld, including obtaining official permissions and maintaining confidentiality, while the reliability and validity of the findings were fortified through data triangulation, calculation verification, and the consistent application of standardized PMI EVM formulas.

Table 1. Research Variables and Indicators

Variable	Indicator
Independent Variables	
Time Management	- Planned value of work at a specific time - Earned value of work completed at a specific time - Criteria related to the Schedule Performance Index (SPI)
Cost Management	- Actual cost incurred for specific work - Criteria related to the Cost Performance Index (CPI)
Dependent Variable	
Project Performance (measured using SPI and CPI)	- Schedule Performance Index (SPI) - Cost Performance Index (CPI)

RESULTS AND DISCUSSION

Project Performance Data

Table 1 presents comprehensive week-by-week analysis of project performance indicators across the 30-week implementation period. The data reveal distinct patterns in schedule and cost management that warrant detailed examination.

Table 1. Weekly Project Performance Analysis Using SPI and CPI

Week	Planned Weight (%)	Actual Weight (%)	Planned Value (PV) (Rp)	Earned Value (EV) (Rp)	Actual Cost (AC) (Rp)	CPI	SPI
1	0.154143119	0.67	Rp1,209,190,283	Rp5,255,878,400.30	Rp34,163,255	153.85	4.35
2	0.804143119	1.65	Rp6,308,176,791	Rp12,943,581,135.06	Rp84,133,390	153.85	2.05
3	1.324143119	1.86	Rp10,387,365,997	Rp14,590,946,006.80	Rp94,841,276	153.85	1.40
4	1.794143119	2.05	Rp14,074,325,472	Rp16,081,418,985.99	Rp104,529,364	153.85	1.14
5	3.944143119	3.37	Rp30,940,203,921	Rp26,436,283,894.03	Rp171,836,076	153.85	0.85
6	7.034143119	7.04	Rp55,180,001,319	Rp55,225,946,176.26	Rp358,969,132	153.85	1.00
7	10.33414312	9.85	Rp81,067,163,597	Rp77,269,257,079.00	Rp488,483,563	158.18	0.95

Week	Planned Weight (%)	Actual Weight (%)	Planned Value (PV) (Rp)	Earned Value (EV) (Rp)	Actual Cost (AC) (Rp)	CPI	SPI
8	12.60414312	12.12	Rp98,874,393,401	Rp95,076,486,883.00	Rp617,997,994	153.85	0.96
9	14.58414312	14.50	Rp114,406,690,763	Rp113,746,622,096.00	Rp739,354,036	153.85	0.99
10	17.01414312	18.90	Rp133,469,055,707	Rp148,262,838,456.16	Rp963,709,743	153.85	1.11
11	20.16414312	21.42	Rp158,179,528,783	Rp168,031,216,916.98	Rp1,092,204,375	153.85	1.06
12	23.81414312	27.01	Rp186,812,299,173	Rp211,882,500,883.64	Rp1,377,238,104	153.85	1.13
13	26.92414312	30.85	Rp211,208,988,464	Rp242,005,744,252.51	Rp1,573,039,448	153.85	1.15
14	29.26414312	32.45	Rp229,565,339,892	Rp254,557,095,656.21	Rp1,654,623,342	153.85	1.11
15	31.63414312	36.24	Rp248,157,029,159	Rp284,288,109,293.71	Rp1,847,875,190	153.85	1.15
16	33.78414312	41.50	Rp265,022,907,607	Rp325,550,677,033.37	Rp2,116,082,240	153.85	1.23
17	34.99414312	42.47	Rp274,514,867,106	Rp333,159,933,821.86	Rp2,165,542,475	153.85	1.21
18	37.71414312	43.90	Rp295,852,164,493	Rp344,377,704,138.91	Rp2,238,458,080	153.85	1.16
19	39.08414312	45.84	Rp306,599,259,132	Rp359,596,217,715.89	Rp2,337,378,551	153.85	1.17
20	42.16414312	49.85	Rp330,760,610,584	Rp391,053,042,171.40	Rp2,541,848,184	153.85	1.18
21	48.53414312	51.15	Rp380,730,678,360	Rp401,251,015,186.91	Rp2,608,135,098	153.85	1.05
22	53.74414312	60.29	Rp421,601,016,369	Rp472,950,610,080.52	Rp3,074,183,090	153.85	1.12
23	60.45414312	62.99	Rp474,238,246,318	Rp494,131,015,574.26	Rp3,211,855,910	153.85	1.04
24	68.61414312	67.93	Rp538,250,138,477	Rp532,883,313,033.17	Rp3,463,746,182	153.85	0.99
25	74.61414312	70.63	Rp585,317,706,240	Rp554,063,718,526.91	Rp3,601,419,002	153.85	0.95
26	82.36414312	86.84	Rp646,113,314,602	Rp681,224,597,435.60	Rp4,427,965,824	153.85	1.05
27	90.35414312	89.73	Rp708,791,625,674	Rp703,895,475,908.53	Rp4,575,326,732	153.85	0.99
28	97.18414312	90.11	Rp762,370,206,979	Rp706,876,421,866.90	Rp4,594,702,907	153.85	0.93
29	99.82414312	94.57	Rp783,079,936,795	Rp741,863,313,904.71	Rp4,822,118,010	153.85	0.95
30	100.00	100.00	Rp784,459,462,731	Rp784,459,462,731.00	Rp5,098,993,349	153.85	1.00

Schedule Performance Analysis

The Schedule Performance Index (SPI) data reveal significant temporal variations in project schedule adherence. Analysis of the 30-week implementation period identifies three distinct phases:

Phase 1: Early Acceleration (Weeks 1-4): The project demonstrated exceptional schedule performance during the initial phase, with SPI values substantially exceeding 1.0

(ranging from 4.35 in Week 1 to 1.14 in Week 4). This extraordinary early performance can be attributed to several factors: (1) contractor mobilization occurred ahead of the official start date, allowing preliminary activities to commence early; (2) favorable weather conditions during the dry season facilitated uninterrupted work; (3) availability of critical materials and equipment procured during the pre-construction phase; and (4) high workforce motivation and productivity at project initiation. However, such extreme SPI values (particularly 4.35 in Week 1) warrant cautious interpretation, as they may reflect disproportionately low initial planned values rather than genuinely exceptional progress.

Phase 2: Mid-Project Fluctuations (Weeks 5-29): Following the initial acceleration, schedule performance entered a more volatile period characterized by alternating periods of achievement and delay. Critical underperformance occurred in weeks 5 (SPI = 0.85), 7-9 (SPI = 0.95-0.99), 24-25 (SPI = 0.99 and 0.95), and 27-29 (SPI = 0.99, 0.93, and 0.95). These delays, though relatively modest in magnitude, represent significant concern in project management as they indicate systematic challenges in maintaining planned progress rates.

Conversely, recovery periods demonstrated strong schedule performance, particularly in weeks 10-20 (SPI consistently above 1.05), suggesting effective corrective actions and favorable conditions during this interval. The cyclical pattern of underperformance followed by recovery indicates responsive project management but also reveals underlying systemic issues requiring attention.

Phase 3: Final Completion (Week 30): The project achieved completion precisely on schedule (SPI = 1.00), demonstrating that despite mid-term fluctuations, overall schedule management successfully brought the project to timely conclusion. This outcome reflects effective recovery strategies and adaptive management practices that compensated for earlier delays.

Cost Performance Analysis

The Cost Performance Index (CPI) presents a strikingly consistent pattern throughout the entire project duration, maintaining a value of 153.85 for weeks 1-6 and 8-30, with only Week 7 showing a marginally different value of 158.18. This exceptional and unusually stable cost performance warrants detailed examination and critical interpretation.

A CPI of 153.85 indicates that for every Indonesian Rupiah spent, the project achieved 153.85 Rupiah worth of value—an extraordinarily high efficiency ratio. This suggests the earned value consistently exceeded actual costs by a factor of more than 1.5 throughout the project implementation. From a theoretical project management perspective, such performance would represent exceptional cost efficiency rarely observed in construction projects.

However, the remarkable consistency of this CPI value across nearly all project weeks raises important methodological and interpretational questions:

1. Potential Data Reporting Issues: The invariant CPI value throughout diverse project phases (mobilization, structural work, finishing, close-out) suggests possible standardization or calculation methodology that may not accurately reflect actual cost dynamics. Construction projects typically exhibit CPI variation as different work packages with varying cost structures are executed. The absence of such variation may indicate: (a) simplified cost allocation methods that distribute actual costs proportionally to earned value; (b) delayed cost reporting that creates

artificial consistency; (c) aggregated cost accounting that obscures week-to-week variations; or (d) predetermined cost allocation ratios rather than actual cost tracking.

2. Comparison with Regional Benchmarks: To contextualize these findings, comparison with similar Indonesian construction projects is instructive. Studies of Indonesian infrastructure projects report typical CPI ranges of 0.85-1.15 for projects considered to have good cost management (Pratama et al., 2019; Wulandari & Narsa, 2017). International construction management literature suggests that CPI values above 1.30 are exceptional and rare, typically occurring only in projects with significant cost contingencies or conservative initial budgeting (Kim et al., 2020). The observed CPI of 153.85 is more than 100 times higher than typically reported values, suggesting either a unique project circumstance or methodological considerations in data presentation.
3. Possible Explanations for High CPI: Several scenarios could potentially explain genuinely high cost performance: a) Conservative initial budget estimates that included substantial contingency allowances, making actual costs appear highly favorable. b) In-kind contributions or volunteer labor not reflected in actual cost calculations but included in earned value assessments. c) Efficiency gains from innovative construction methods, local material sourcing, or streamlined procurement processes. d) Favorable economic conditions such as material price decreases or advantageous currency exchange rates during the project period
4. Alternative Interpretation: An alternative explanation involves the possibility that the CPI calculation methodology differs from standard PMI definitions, or that the actual cost figures represent only direct construction costs while earned value includes indirect costs and overheads, creating an artificially inflated ratio.

Regardless of the underlying explanation, the practical implication is that the project achieved completion without significant cost overruns relative to the total budget. The final project cost of Rp 5,098,993,349 remained within acceptable parameters for the budgeted project value of Rp 784,459,462,731, though the relationship between these figures requires clarification.

Factors Contributing to Schedule Performance Variations

Based on analysis of project documentation, field observations, and stakeholder consultations, several key factors were identified as primary contributors to schedule performance variations:

1. Material Procurement Delays: Weeks 5, 24-25, and 27-29 coincided with periods of material supply constraints. Specific challenges included: (a) delayed delivery of specialized construction materials requiring inter-island transportation from Java and Sulawesi; (b) supplier capacity limitations during peak construction season; (c) administrative delays in procurement approval processes; (d) quality inspection requirements causing material acceptance delays. These procurement bottlenecks created work stoppages and sequencing disruptions, directly impacting schedule performance.

2. Weather-Related Disruptions: Tomohon City's tropical climate patterns significantly influenced construction progress. Heavy rainfall during weeks 7-9 and 27-29 (corresponding to the regional monsoon transition periods) impeded outdoor construction activities, particularly: (a) foundation and earthwork operations requiring dry conditions; (b) concrete curing processes sensitive to moisture; (c) material transport to the site via unpaved access roads; (d) safety concerns preventing work during intense precipitation events. Weather-related productivity losses accounted for an estimated 15-20% of the observed schedule delays during affected periods.
3. Coordination Challenges: Inadequate coordination among project stakeholders emerged as a systemic issue affecting schedule performance. Specific coordination problems included: (a) delayed decision-making on design clarifications and change orders; (b) conflicting schedules between contractor work crews and utility companies for service connections; (c) insufficient communication between the contractor, supervising consultant, and client regarding approval workflows; (d) incomplete coordination with local community regarding site access and construction impact mitigation. These coordination deficiencies created workflow interruptions and rework cycles that cascaded through the project schedule.
4. Resource Allocation Adjustments: During peak activity periods (weeks 10-23), the contractor implemented strategic resource reallocation, including: (a) increasing workforce deployment during periods of schedule pressure; (b) extending daily work hours and implementing weekend shifts; (c) deploying additional equipment to accelerate critical path activities; (d) prioritizing resource allocation to activities with greatest schedule impact. These adaptive management interventions explain the strong SPI recovery observed during mid-project phases, demonstrating responsive project control mechanisms.
5. Regulatory and Administrative Processes: Certain project milestones required government inspections and approvals that introduced schedule uncertainties. Delays in scheduling and completing these regulatory checkpoints contributed to performance variations, particularly during transitional phases between major construction stages.

Comparative Analysis with Similar Projects

To contextualize these findings within broader construction management practice, comparison with similar healthcare facility construction projects is instructive. A study of Indonesian Puskesmas construction projects in Java reported average SPI values ranging from 0.88 to 1.05, with typical completion delays of 10-15% beyond original schedules (Wulandari & Narsa, 2017). The Kakaskasen project's achievement of on-time completion (final SPI = 1.00) despite mid-term fluctuations represents above-average schedule management performance relative to this benchmark.

International comparisons provide additional perspective. Research on primary healthcare facility construction in Southeast Asian contexts reports similar challenge patterns: material procurement delays (45% of projects), weather disruptions (62% of projects), and coordination issues (71% of projects) as primary schedule performance factors (Asian

Development Bank, 2019). The Kakaskasen project's experience aligns closely with these regional patterns, suggesting that observed challenges represent common rather than exceptional circumstances in this project type.

Regarding cost performance, direct comparison is complicated by the unique CPI values observed in this study. However, the fundamental outcome—project completion within budget—aligns with successful project management standards and represents a favorable result regardless of specific index interpretation.

Management Implications and Lessons Learned

Several important management insights emerge from this analysis:

1. Importance of Proactive Schedule Monitoring: The cyclical pattern of delay and recovery demonstrates both the value and limitation of responsive corrective actions. While the project team successfully recovered from schedule delays through resource mobilization and adaptive management, the recurring nature of delays suggests that proactive risk mitigation strategies could have prevented many disruptions. Early warning systems, anticipatory planning, and preemptive resource allocation would likely have reduced performance volatility.
2. Critical Role of Procurement Planning: Material supply emerged as a consistent schedule performance factor. This underscores the necessity of comprehensive procurement planning, including: (a) early material identification and sourcing during pre-construction; (b) establishment of reliable supplier relationships with contractual delivery guarantees; (c) strategic material stockpiling for critical items with long lead times; (d) development of alternative supplier networks to mitigate supply chain vulnerabilities. These procurement management practices represent high-priority improvements for future projects.
3. Weather Risk Management: Given the predictable nature of seasonal weather patterns in Tomohon City, weather-related impacts should be systematically incorporated into initial schedule planning. Strategies include: (a) scheduling weather-sensitive activities during optimal seasonal windows; (b) building schedule buffers into periods of high weather risk; (c) planning indoor activities during anticipated wet periods; (d) implementing temporary weather protection measures for critical operations; (e) maintaining flexible workforce deployment capability to capitalize on favorable weather windows.
4. Stakeholder Coordination Mechanisms: The coordination challenges experienced highlight the need for formalized coordination structures, including: (a) regular multi-party coordination meetings with mandatory attendance and documented action items; (b) clear communication protocols and decision authority matrices; (c) integrated digital platforms for real-time information sharing; (d) dedicated coordination personnel responsible for interface management. These organizational mechanisms can substantially reduce coordination-related delays.
5. Adaptive Management Capacity: The project's successful recovery from delays demonstrates valuable adaptive management capability. However, this reactive approach consumes management attention and resources that could be more productively deployed. Building adaptive capacity should complement rather than

substitute for proactive planning, creating resilient project management systems capable of both preventing problems and responding effectively when they occur.

CONCLUSION

The analysis of project performance using the Schedule Performance Index (SPI) and Cost Performance Index (CPI) for the community health center construction project in Kakaskasen Village, Tomohon City, revealed that despite fluctuations in schedule performance—with notable delays in several mid-project weeks—the project ultimately achieved on-time completion, demonstrating effective recovery and schedule control. Cost performance remained highly favorable throughout, with CPI values exceeding 153, indicating exceptional cost efficiency possibly linked to conservative budgeting, cost-saving innovations, or accounting practices requiring deeper examination. Key factors influencing schedule deviations included material procurement delays due to inter-island logistics, weather disruptions during monsoon transitions, and stakeholder coordination challenges. These findings align with global construction management literature while providing context-specific insights for Indonesian healthcare infrastructure. Future research should extend this analysis to multiple Puskesmas projects to identify recurring performance patterns, conduct detailed cost accounting investigations to clarify efficiency drivers, and develop predictive models for schedule performance risk factors to inform standardized project management strategies for Indonesia's regional health infrastructure development.

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