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Improving The Quality of Procurement Process Through Lean Six Sigma In The Indonesian Public Rail Transport Company

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Abstract

PT. X, a public railway transportation company in Indonesia, faces significant challenges in its procurement process, including delays and a high failure rate of 16.81%, which hinder timely project execution and budget utilization. To address these inefficiencies, this study applies the Lean Six Sigma methodology through the DMAIC (Define, Measure, Analyze, Improve, Control) framework. The research aims to identify key procurement issues, determine the current sigma level (3.33), analyze root causes, and propose actionable improvements. Data were collected via interviews, observations, and e-procurement records, with analysis tools including SIPOC diagrams, fishbone diagrams, and the 5 Whys technique. Findings reveal that the primary causes of procurement failures are bids exceeding the Owner's Estimate (OE) and the absence of qualified vendors. Thirteen recommendations were developed, such as creating a market price monitoring platform, standardizing procurement documents, and enhancing vendor evaluation processes. A cost-benefit analysis confirmed the feasibility of these improvements, showing a Net Present Value (NPV) of IDR 770,512,859, a Benefit-Cost Ratio (BCR) of 1.557, and an Internal Rate of Return (IRR) of 108%. The study demonstrates that Lean Six Sigma can significantly improve procurement efficiency and budget absorption in public sector transportation. The implications include reduced waste, better vendor management, and stronger alignment with organizational KPIs, offering a model for similar enterprises facing procurement challenges.

Keywords: Public railway transportation, Procurement challenges, Lean Six Sigma.

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INTRODUCTION

PT. X is a state-owned enterprise located in the DKI Jakarta Province, was established in March 2018 and specializes in the public transportation sector (Faridah et al., 2021). Since the commencement of its operation, the total number of passengers has reached 102 million. The average total number of trips increased by 1.4%, while the average increase in the total number of passengers was 3.54%. (Statistics Indonesia, 2024).

The growth in passenger volume and train operations has been paralleled by an expansion in procurement packages for goods and services essential to operational and maintenance functions (Pratiwi et al., 2021). This trend underscores the critical role of procurement efficiency in supporting transportation service reliability (Al-Hazmi & Kandil, 2020). Nevertheless, in practice, delays persist within the procurement process, adversely affecting timely completion of tasks (Wijayanti & Harjanto, 2022). The average percentage of

procurement packages experiencing delays in the procurement process was 5.5%, with the highest delay percentage being 19.53% in direct procurement (Hanafi & Kadir, 2020). Such inefficiencies are often linked to bureaucratic hurdles, inadequate planning, and poor vendor performance (Indrawati & Yuniarti, 2019). In the transportation sector, these issues can lead to service disruptions, cost overruns, and reduced public satisfaction (Lestari et al., 2023). Hence, improving procurement governance and leveraging digital tools have been recommended as strategic solutions (Susanto et al., 2022).

In addition to delays in the procurement of goods and services, the incidence of unsuccessful procurement or package purchases has increased annually. Procurement is deemed unsuccessful when it proceeds without finalizing a contract or fails to select a successful bidder. An unsuccessful procurement process has significant implications, resulting in repeated procurement efforts that lead to inefficiencies in time and resource allocation, as well as project delays. The average procurement failure rate at PT X was 5% from 2020 to August 2024, with a peak failure rate of 7% in 2024.

Unsuccessful procurement packages adversely impact the timeliness of procurement processes and budget utilization. The factors influencing budget absorption include budget planning, budget execution, human resource competency, procurement of goods and services, and organizational commitment (Maria et al., 2023). Unabsorbed budgets indicate that the set objectives have not been reached (Hapsari, 2020). PT. X's budget absorption showed significant variability, with an average rate of 55% and a typical reduction in budget absorption of 7%. As PT. X is a publicly operated train company with a portion of its revenue sourced from government subsidies, and budget absorption is one of the company's annual Key Performance Indicators (KPIs).

Analysis of the procurement of goods and services reveals issues that have resulted in financial losses for the company. Mitigating this impact necessitates the identification of issues within the procurement process. Problem identification can be effectively conducted through the integration of the Lean methodology with Six Sigma. Lean represents a comprehensive approach, encompassing a philosophy, method, and management strategy, which seeks to maximize customer value by eliminating non-value-adding activities (Vikaliana et al., 2021). In contrast, Six Sigma is a methodological framework aimed at enhancing process capability through the identification of problems and the implementation of improvements to address these issues (Widiwati et al., 2024). Although Lean and Six Sigma have been utilized independently for many years, their integration occurred in the late 1990s and early 2000s. Presently, Lean Six Sigma is recognized as a "business strategy and methodology that improves process performance by combining two different methodologies." (Nicoletti, 2013). Six Sigma seeks to minimize defects and variations in output, while lean thinking focuses on reducing cycle time and waiting time.

This study advocates for the application of the Lean Six Sigma methodology within the procurement process, employing the Define, Measure, Analyze, Improve, and Control

(DMAIC) framework to evaluate the procurement operations at PT. X. The aim of this research is to identify the primary challenges in PT. X's procurement process, determine the current sigma level, ascertain the most frequent causes of these challenges, identify their root causes, propose enhancements, and conduct a cost-benefit analysis based on the proposed improvements and the development of monitoring methods.

METHODS

This study employed a quantitative research approach with a case study design, focusing on the procurement process at PT. X, a public railway transportation company in Indonesia. The research utilized primary and secondary data, including procurement records, interviews, and observations, to analyze inefficiencies and propose improvements using the Lean Six Sigma DMAIC framework. The population consisted of all procurement transactions from 2020 to 2024, while the sample included 41 failed procurement packages identified through purposive sampling to target the most critical issues.

Data collection involved multiple techniques: (1) interviews with procurement staff, supply chain managers, and maintenance teams to gather qualitative insights; (2) document analysis of e-procurement records and financial reports; and (3) brainstorming sessions to validate findings. Research instruments included structured interview guides, checklists, and SIPOC diagrams to map procurement workflows. Validity was ensured through triangulation (cross-verifying data from interviews, documents, and observations), while reliability was tested via inter-coder agreement for qualitative data and Cronbach's alpha for survey-based metrics (if applicable). Microsoft Excel and Draw.io were used for data processing and visualization.

Data analysis followed the DMAIC phases: (1) Define: SIPOC diagrams identified key processes; (2) Measure: Sigma level (3.33) and Defects Per Million Opportunities (DPMO) were calculated; (3) Analyze: Root causes were determined using fishbone diagrams and the 5 Whys technique; (4) Improve: Recommendations were prioritized via Pareto analysis; and (5) Control: A cost-benefit analysis (NPV, BCR, IRR) assessed feasibility. Statistical tools like descriptive analysis and financial modeling quantified improvements, ensuring actionable and sustainable results.

RESULTS AND DISCUSSION

Define

The SIPOC diagram is used to describe the procurement business process, starting from the procurement request submitted by the work unit to the selection of the winning vendor. The following outlines of the process and all parties involved.

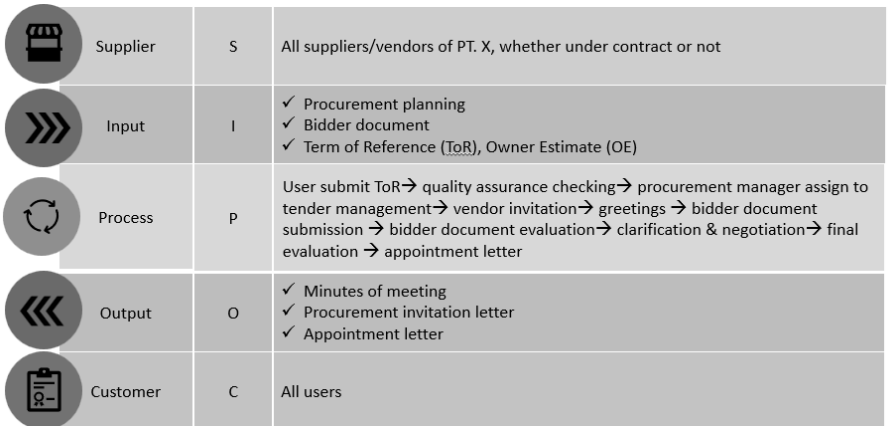

Figure 1. SIPOC Diagram

Based on the interview results, the procurement VOC of the PT. X are as follows:

1) "Goods/services must meet the specifications requested by the user."
2) "Procurement must be completed on time."
3) "There should be no failed procurements."
4) "The price of goods/services must align with the budget set by each user."
5) "Vendors must be responsive."

Based on the VOC, the researcher compared the CTQ and achievement of the Key Performance Indicator (KPI) for 2024 as follows:

Table 1. Comparison of CTQ with KPI 2024

CTQ	KPI	KPI Value 2024	Description
No complaints from user regarding the specifications of the goods/services delivered by the vendor	Customer satisfaction index	4.13 (scale 0-5)	KPI achieved
SLA for direct purchase (DP): 3 working days SLA for direct procurement (DS): 14 working days SLA for direct appointment (DA): 14 working days SLA for open bidding (OB): 32 working days	SLA DP: 3 working days or 24 hours SLA DS: 14 working days or 112 hours SLA DA: 14 working days or 112 hours SLA OB: 32 working days or 256 hours	Average lead time:DP: 1.17 working days or 9.36 hours DS: 13.9 working days or 111.2 hours DA: 10.57 working days or 84.56 hours OB: 23.25 working days or 186 hours	KPI achieved
Failed procurement percentage: 0%	Procurement success rate minimum 90%	Successful procurement: 83.19%	KPI not achieved
Price of goods/services ≤ Owner estimate (OE)	Minimum efficiency 5%	6.84%	KPI achieved
No complaints from the user regarding the vendor's responsiveness	Customer satisfaction index	4.03 (scale 0-5)	KPI achieved

Based on (Table 1), the KPI for procurement success has not yet been achieved, so further analysis is needed regarding issues related to failed procurement.

Measure

The issue of failed procurement was caused by 5 issues. The most common issue is that the offer exceeds the Owner Estimate (OE), accounting for 39% of the failures with 16 procurement packages affected. Closely following this, 37% of the failures (15 packages) occur because no procurement participants passed the evaluation. Other notable causes include tenders failing due to only one vendor submitting a bid, which accounts for 5% (2 packages), and both requests for cancellation from the user and no vendors submitting proposals, each representing 10% of failures (4 packages each). In total, there were 41 procurement packages that experienced failures for these reasons.

Based on the current sigma-level calculation using defect per million opportunities (DPMO), the procurement process at PT. X has a sigma value of 3.33 and needs improvement in the procurement process. In addition, based on the Pareto diagram analysis, 80% of the most common causes were offer exceeds the Owner Estimate (OE) and no procurement participants passed the evaluation.

A procurement failure rate of 16.81% has led to unutilized budget allocations, with an estimated unabsorbed budget of IDR 245,043,871,229. Procurement failures have caused several non-value-added activities (waste), as outlined below.

Table 2. Non-Value-Added Activities Resulting from Procurement Failures

No	Activity Description	Person in Charge (PIC)	Average time (days)	Type of Waste
1	Failed procurement process	Tender management	14	Overprocessing
2	Corrective actions and evaluation of failed procurement	User	5	Waiting
3	Resubmission of procurement documents	User	2	Waiting
4	Review of newly submitted procurement documents	Quality assurance	2	Overprocessing
	Total		23	

Based on (Table 2), the types of waste identified owing to procurement failures include overprocessing and waiting (Alfiansyah et al., 2018). Moreover, each failed procurement resulted in 23 working days for non-value-added activities per procurement package and impacted to company's losses of IDR 5,297,716 per procurement package.

Therefore, the next step is to conduct a root cause analysis for these two causes using the fishbone diagram and five Whys.

Analyze

At this stage, a fishbone diagram analysis is conducted to examine the problem of price offers exceeding the Owner's Estimate (OE), and a 5 Whys analysis is performed to identify the detailed root causes.

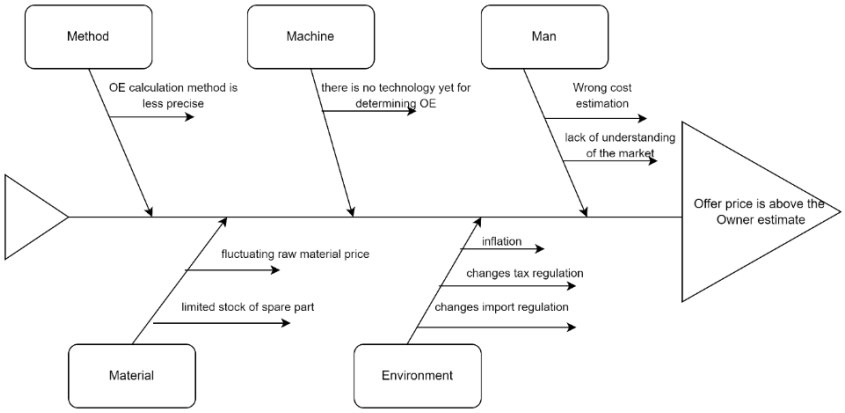

Figure 2. Fishbone Diagram – Offers Above OE

Next, a 5 Why analysis was conducted, resulting in the following summary of root causes:

Table 3. 5 Why Analysis – Offers Above OE

Category	Problem	Why 1	Why 2	Why 3
Human	Cost estimation error	Outdated or inaccurate data used for OE calculation.	Users lack access to current market price info.	No standardized process to update market data regularly.
Human	Users lack market understanding	No regular market research or price benchmarking.	Inadequate training on market research in procurement.	–
Machine	No technology for OE calculation	No automated or integrated system for OE calculation.	–	–
Method	Inaccurate OE calculation method	Users don't follow standard procurement methods.	Lack of understanding of correct OE methods.	No training or clear documentation on OE procedures.
Material	Fluctuating spare part prices	Market instability or external factors (weather, policies).	Influenced by global supply chains and unpredictable factors.	No strategy to anticipate price changes.
Material	Limited spare parts stock	Poor inventory planning and demand forecasting.	Inaccurate data on spare part needs.	No real-time monitoring system for spare part demand.
Environment	Inflation drives bids above OE	Vendors adjust bids for rising costs.	OE based on outdated data or assumptions.	No control to update OE for economic factors.
Environment	Tax regulation changes push prices above OE	Vendors adjust bids for new tax burdens.	OE made before tax changes are anticipated.	No coordination between procurement and tax units.
Environment	Import regulation changes push prices above OE	New import rules increase vendor costs.	Vendors face higher logistics expenses, inflating bids.	OE is inflexible to regulatory changes.

In addition, the fishbone diagram analysis for the cause of no procurement participants passing the evaluation:

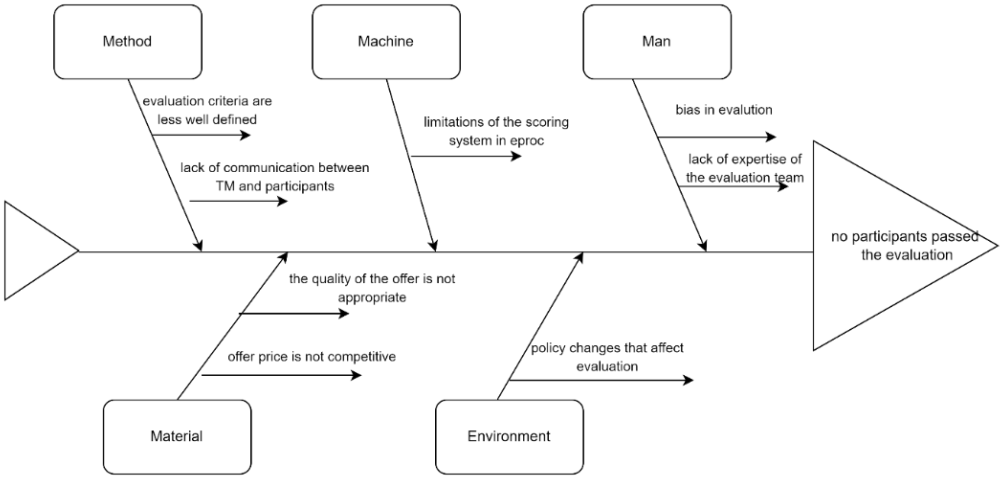

Figure 3. Fishbone Diagram – No Procurement Participants Passing the Evaluation

Next, a 5 Why analysis was conducted, resulting in the following summary of the root causes:

Table 4. 5 Why Analysis - No Procurement Participants Passing the Evaluation

Category	Problem	Why 1	Why 2	Why 3
Human	Evaluation bias	Lack of training to recognize and mitigate bias.	No clear guidelines on conducting objective evaluations.	–
Human	Lack of evaluation skills	Inexperienced evaluation team.	No regular training on procurement and evaluation.	–
Machine	Limited e-procurement system	System is not configured to assess relevant criteria.	No templates or criteria for different procurement types.	–
Method	Poorly defined evaluation criteria	Criteria are unclear or unmeasurable.	TOR requirements vary by procurement type.	No standardized TOR format.
Method	Poor communication between TM and bidders	Incomplete or unclear information.	No standard procedures for sharing information.	Lack of training on effective communication.
Material	Proposal quality below standards	Vendors do not meet qualifications or requirements.	No comprehensive vendor selection or mapping.	No structured supplier management system.
Material	Uncompetitive bid prices	Vendors can't align with market prices.	PT. X withholds OE, reducing pricing transparency.	–
Environment	Policy changes affect procurement	Regulatory changes impact vendor operations.	No system to monitor and incorporate policy changes.	–

Improve

Based on the root cause analysis conducted during the analysis phase, the following recommendations can be implemented:

Table 5. Recommendation to Address the Issue of Bids Exceeding the OE

No	Issue	Root Cause	Recommendation
1	Cost estimation error	Lack of standardized systems or processes to routinely collect and update market information.	Development of a market price monitoring platform
2	No existing technology for OE determination	The organization has not implemented specific systems or tools to automatically or integratively calculate OE (Owner's Estimate).	—
3	Users lack market understanding	Inadequate training for users on the importance of market research in procurement.	OE preparation training for all user work units
4	Inaccurate OE calculation method	Lack of sufficient training or socialization on correct OE calculation procedures, or lack of clear documentation or guidelines.	—
5	Volatile raw material price increases	Dependence on global suppliers and lack of diversification in sourcing more local or stable spare parts.	Formation of an ad hoc team to increase the use of local content
6	Spare parts stock limitations	Absence of effective systems or tools to monitor and analyze spare parts needs in real-time or over the long term.	Enhancement of demand-supply material dashboard function, especially for railway spare parts and infrastructure
7	Inflation	No internal control system mandating OE updates based on economic indicators such as inflation, exchange rates, and producer price indices.	Consider inflation rates during annual budgeting
8	Changes in tax regulations	No active mechanism or coordination between procurement and tax units to monitor and adjust OE policies according to tax regulation changes.	Procurement unit to collaborate with the company's tax team to stay updated on applicable tax regulation changes
9	Changes in import regulations	OE is prepared without accounting for uncertainty due to sudden changes in regulations, making OE inflexible in responding to such changes.	Procurement unit to collaborate with the supply chain team to stay updated on changes in import regulations

Table 6. Recommendations for Addressing the Issue of No Bidders Pass the Evaluation

No	Issue	Root Cause	Recommendation
1	Evaluation bias	Lack of training or clear guidelines on how to evaluate objectively and avoid biases that may affect judgment.	Conduct training for procurement teams and prospective procurement committees on evaluation procedures and the entire tender process.
2	Lack of evaluation expertise within the team	No regular training or knowledge updates provided to evaluation team members regarding procurement processes or proper evaluation techniques.	—
3	Lack of communication between Tender Management (TM) and participants	Insufficient attention to the importance of clear and transparent communication between tender management and participants, as well as lack of training for	—

No	Issue	Root Cause	Recommendation
		tender management on effective communication.	
4	Limited resources among participants	The company or organization has not yet established a well-structured supplier management system or prioritized the development of comprehensive supplier mapping as part of the procurement process.	Development of a supplier management system
5	Proposal quality does not meet user standards	The company or organization has not yet established a well-structured supplier management system or prioritized the development of comprehensive supplier mapping as part of the procurement process.	—
6	Limitations in e-procurement scoring system	Absence of evaluation templates and scoring criteria for each procurement classification (goods, services, consultancy, construction, IT services).	Standardization of evaluation templates in the e-procurement system
7	Poorly defined evaluation criteria	No standardized format for terms of reference based on the type of procurement.	Standardization of terms of reference documents based on procurement classifications: goods, services, consultancy, construction, and IT services
8	Uncompetitive bid prices	PT. X conceals the OE (Owner's Estimate) during procurement to increase negotiation leverage.	Disclose the OE during procurement to foster competition and achieve better efficiency
9	Changes in government/company policies	Lack of internal coordination regarding changes in government policies.	Add a discussion topic on government policy updates in the procurement unit's monthly meetings

Cost and Benefit Ratio

At this stage, a cost-benefit analysis is conducted by quantifying the estimated costs and the anticipated benefits that would be gained if the proposed recommendations are implemented. The cost-benefit analysis of implementing the given recommendations can be seen in Table 7.

Table 7. Cost-Benefit Analysis of Recommendation Implementation Summary

	Cost			Benefit	
Year	Manpower	Training	Maintenance	Process Efficiency	Reduction in Failure Rate
0	Rp 257,324,385	Rp 161,000,000	Rp 6,377,982	Rp 61,326,750	Rp 0
1	Rp 217,339,344	Rp 161,000,000	Rp 12,265,350	Rp 724,128,184	Rp 106,463,240
2	Rp 217,339,344	Rp 161,000,000	Rp 12,265,350	Rp 724,128,184	Rp 106,463,240
3	Rp 217,339,344	Rp 161,000,000	Rp 12,265,350	Rp 724,128,184	Rp 106,463,240

Financial Metrics:

a. Net Present Value (NPV): Rp 770,512,859
b. Benefit-Cost Ratio (BCR): 1.557

c. Internal Rate of Return (IRR): 108%
d. Payback Period (PP): 1 year
e. Minimum Attractive Rate of Return (MARR): 5.50%
f. Investment period: 3 years

According to Sajidil (2019), a project is considered feasible if the payback period is shorter than the investment duration. Meanwhile, Basher (2018) states that a project is considered profitable if the NPV > 0, the IRR is higher than the MARR, and the BCR > 1.

Based on the cost-benefit analysis, it can be concluded that the proposed recommendation is feasible and profitable to implement, as indicated by the NPV of Rp 770,512,859, a BCR greater than 1 (1.557), an IRR exceeding the MARR, and a payback period shorter than the investment period (1 year).

Control

At this stage, several activities are conducted to support the maintenance of improvements. The development and maintenance of a market price monitoring platform are overseen by the IT and Procurement team, supported by manuals, standard operating procedures (SOP), dashboards, training lists, and feedback forms. Training on Owner's Estimate (OE) creation is managed by Procurement, with evidence in the form of email submissions to Human Capital. The formation of an ad hoc team for improving domestic content involves both the team and management, documented through timeline updates and KPIs. Supply Chain and IT collaborate to enhance the demand-supply dashboard for spare parts and infrastructure, with monitoring dashboards and update notifications serving as proof.

Financial activities include incorporating inflation into annual budgeting and coordinating with the tax team regarding regulatory updates, both evidenced by meeting minutes. Supply Chain coordinates on import regulation updates, while training for procurement staff and committees on evaluation and tender procedures is organized by Human Capital and Procurement. The IT and Procurement teams jointly develop a vendor management system and standardize evaluation templates in the e-procurement platform, supported by manuals, work instructions, meeting minutes, and feedback. Procurement leads the standardization of TOR documents and disclosure of OE to improve competition, with email feedback as evidence. Finally, Procurement also manages internal coordination to stay current on economic and regulatory changes, documented through minutes of meetings.

Based on the results of the cost and benefit ratio analysis, it was found that the recommendations provided using the Six Sigma method had a positive impact on both the procurement process and the company's budget absorption. This aligns with several previous studies, which have shown that the use of Lean Six Sigma can have a beneficial effect on organizational performance.

Nicoletti (2013) concluded that the Six Sigma method contributed to a faster and more streamlined bidding process, increased competitiveness, substantial cost reductions through synergy, greater flexibility with quicker responses to organizational needs, broader reach and a wider pool of suppliers, improved procurement governance, and reduced risk through better inventory management. Similarly, the study by Daniyan et al. (2022) found that the Lean Six Sigma method led to a 46.8% improvement in process cycle efficiency, a 27.9% reduction in lead time, and a 59.3% increase in value-added time. This study demonstrated that integrating Lean and Six Sigma is effective in reducing waste and improving process performance in the railway industry, thus making a significant contribution to the understanding of continuous improvement implementation in the railway manufacturing sector. In addition, the research conducted by Al Hafiish (2022) concluded that the Lean Six Sigma method contributed to reducing cycle time and administrative costs through the implementation of simpler and standardized SOPs.

CONCLUSION

Based on the study, the problem focuses on the procurement process at PT. X is a high failure procurement of 16,81% which causes failure to achieve KPI. The company's current sigma value is 3.33 and the most frequent cause of failed procurement problems is due to the bid price being above the OE and the absence of vendors who passed the evaluation. There are nine root causes related to bids exceeding the OE and eight root causes related to no vendors passing the evaluation. Thirteen improvement recommendations were proposed to address procurement failures in PT. X. These include creating a market price monitoring platform, training for OE preparation, forming an ad hoc team to boost local components, enhancing the material demand-supply dashboard, and incorporating inflation into budgeting. Other suggestions include closer coordination with tax and supply chain teams, training in procurement evaluation, improving e-procurement systems, standardizing documents and templates, increasing transparency in OE disclosure, staying updated on economic and regulatory changes, and implementing a control checklist to monitor the execution of these recommendations.

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