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Analysis of Delays in Production and Distribution Projects in Indonesia Using the Fishbone Diagram Method

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Abstract

The problem of defects in automotive components remains a major challenge in the manufacturing industry, as it directly impacts product quality, production process efficiency, and customer satisfaction. This research aims to analyze the most frequent types of defects in one automotive component, identify their root causes, and provide applicable improvement solutions. The study was conducted using a Quality Control Circle approach with the Pareto Diagram to prioritize defect types based on their frequency and impact, and the Fishbone Diagram to identify root causes based on the 4M+1E categories (Man, Machine, Method, Material, Environment). The results show that rust and out-of-standard defects are the most dominant, generally caused by a lack of operator understanding, unstable machine conditions, non-standard work methods, and suboptimal raw material quality and work environment. Improvement recommendations include operator training, machine repair, work method adjustments, and production environment supervision. The implementation of these solutions has proven to significantly reduce defect rates and improve product quality. The integration of Pareto and Fishbone diagrams has proven effective as an applicable quality control strategy in the automotive industry.

Keywords: *Cause analysis, distribution delay, fishbone diagram, manufacturing process, PDCA cycle.*

Abstrak

Masalah cacat pada komponen otomotif tetap menjadi tantangan utama dalam industri manufaktur, karena secara langsung berdampak pada kualitas produk, efisiensi proses produksi, dan kepuasan pelanggan. Penelitian ini bertujuan untuk menganalisis jenis cacat yang paling sering terjadi pada satu komponen otomotif, mengidentifikasi akar penyebabnya, dan memberikan solusi perbaikan yang dapat diterapkan. Studi ini dilakukan menggunakan pendekatan Lingkaran Kontrol Kualitas dengan Diagram Pareto untuk memprioritaskan jenis cacat berdasarkan frekuensi dan dampaknya, dan Diagram Tulang Ikan untuk mengidentifikasi akar penyebab berdasarkan kategori 4M+1E (Manusia, Mesin, Metode, Material, Lingkungan). Hasil menunjukkan bahwa karat dan cacat di luar standar adalah yang paling dominan, umumnya disebabkan oleh kurangnya pemahaman operator, kondisi mesin yang tidak stabil, metode kerja yang tidak standar, dan kualitas bahan baku serta lingkungan kerja yang suboptimal. Rekomendasi perbaikan meliputi pelatihan operator, perbaikan mesin, penyesuaian metode kerja, dan pengawasan lingkungan produksi. Implementasi solusi ini terbukti secara signifikan mengurangi tingkat cacat dan meningkatkan kualitas produk. Integrasi diagram Pareto dan Tulang Ikan terbukti efektif sebagai strategi kontrol kualitas yang dapat diterapkan dalam industri otomotif.

Kata Kunci: Analisis penyebab, keterlambatan distribusi, diagram tulang ikan, proses produksi, siklus PDCA.

INTRODUCTION

Recent developments in global production and distribution systems reveal an intensification of supply chain complexity characterized by increasing fragmentation and interdependence, particularly in the aftermath of global logistics disruptions and the rapid digitalization of manufacturing industries, thereby repositioning delays not as isolated operational anomalies but as systemic phenomena requiring root-cause-based analytical approaches; within this context, industries in developing countries such as Indonesia are subjected to dual pressures involving cost-efficiency demands and service quality enhancement, which in turn render delays in production and distribution as critical indicators of systemic failure in operations and logistics management, as reflected in the growing scholarly emphasis on causal analysis methods such as the Fishbone Diagram to comprehensively map cause–effect relationships (Abbasi et al., 2020; Windarto et al., 2023).

These dynamics indicate that timeliness extends beyond internal firm performance and exerts a direct influence on global competitiveness and operational sustainability within increasingly integrated industrial ecosystems. Prior studies have identified a range of key determinants of delays through diverse empirical and analytical approaches, in which factors such as production inefficiencies, machine capacity constraints, and weak distribution coordination frequently emerge as dominant causes; Nugroho et al. (2020) demonstrate that delays in material procurement within Indonesia's steel industry are rooted in misalignment between planning and operational execution, while Haris et al. (2023) and Octora et al. (2023) emphasize that delivery schedule inaccuracies in the logistics sector stem from a combination of human factors, work methods, and suboptimal transportation systems. In parallel, Fishbone Diagram-based approaches applied by Aqilah et al. (2024) and Wardhani et al. (2025) exhibit methodological robustness in categorizing causal variables into structured dimensions such as man, machine, method, material, and environment, thereby enabling more systematic root cause identification compared to conventional descriptive approaches.

Despite these advancements, the existing body of literature exhibits significant conceptual and empirical limitations, particularly in terms of integrating production and distribution analyses as an interdependent system; most studies tend to isolate problems at a single node within the value chain without accounting for cross-process interdependencies, resulting in a fragmented understanding of delay phenomena (Puspitasari, 2024; Tarigan et al., 2024). Methodological inconsistencies are also evident, as some studies rely heavily on statistical approaches such as Statistical Process Control without sufficiently exploring underlying causal mechanisms, while others employ the Fishbone Diagram in a limited manner without integrating it into continuous improvement frameworks, thereby constraining the practical applicability of their findings (Rahayu & Rachmawati, 2025).

Such conditions underscore the scientific urgency of developing analytical approaches that not only comprehensively identify the determinants of delays but also elucidate causal relationships among variables within an integrated production–distribution system; from a practical standpoint, the inability to effectively address delays leads to increased operational costs, declining customer satisfaction, and weakened competitive positioning in both domestic and global markets, necessitating an analytical framework capable of bridging the gap between problem diagnosis and data-driven solution implementation (Setiawan & Prastyo, 2025; Mutiara & Prastyo, 2025).

In the Indonesian automotive and manufacturing sectors, high defect rates and process inconsistencies further exacerbate the potential for distribution delays, indicating a causal linkage that remains insufficiently explored in a systematic manner within the literature. This study positions itself within the scholarly landscape as an integrative effort that combines the analysis of delays in both production and distribution stages through an extended Fishbone Diagram approach, incorporating holistic interactions among operational variables; this approach not only adopts established causal categorization frameworks but also advances the analysis by embedding cross-process interdependencies that have been largely overlooked in prior studies, thereby aiming to produce a more comprehensive and applicable mapping of root causes within the complex and dynamic context of Indonesian industry (Aqilah et al., 2024).

This study contributes to the enrichment of the operations and logistics management literature through an integrated causal approach. It aims to comprehensively analyze the factors causing delays in production and distribution projects in Indonesia using the Fishbone Diagram as the primary tool for root cause identification, while also offering theoretical contributions in strengthening integrated causal analysis models and methodological contributions in advancing the application of the Fishbone Diagram to better accommodate the complexity of modern industrial systems.

RESEARCH METHOD

This study employs a case-based empirical research design situated within production and distribution projects in the Indonesian manufacturing sector, structured through a multi-layered analytical architecture consisting of three interrelated components, namely the input layer (operational datasets), the process layer (causal analysis using the Fishbone Diagram), and the output layer (identification of delay root causes and formulation of corrective strategies); the empirical materials comprise both primary and secondary data sources, including production cycle time records, distribution schedules, delay incident reports, and product quality indicators such as rejection rates, while the analytical toolkit integrates data processing platforms (e.g., spreadsheet-based systems and statistical software), the Fishbone Diagram (Ishikawa), and the 5M+1E causal categorization framework (Man, Machine, Method, Material, Measurement, Environment) to ensure systematic, transparent, and reproducible classification of contributing factors. The implementation procedure is executed through four sequential stages, encompassing (1) systematic collection and validation of historical delay data, (2) end-to-end mapping of production and distribution workflows to identify critical control points, (3) construction of the Fishbone Diagram based on triangulated insights from field observations and structured interviews with operators and production managers, and (4) preliminary validation of the causal structure through expert judgment to ensure internal coherence and logical consistency among identified variables (Aqilah et al., 2024; Puspitasari, 2024).

Figure 1. Plan Do Check Act (pdca Quality Cycle) In Circle Diagram And Circle Arrow Vector Illustration

To address the identified operational inefficiencies, this study further integrates two complementary quality management instruments, namely the Fishbone Diagram for comprehensive root cause visualization and the PDCA (Plan–Do–Check–Act) cycle as a continuous improvement framework, thereby bridging diagnostic analysis with actionable intervention; the testing procedure is conducted through a data triangulation approach that compares identified causal factors against actual delay patterns, integrating Fishbone outputs with quantitative descriptive analysis of delay frequency and duration across process stages, while validation is ensured through content validity (expert review) and construct validity (alignment between causal categories and empirical operational indicators). The PDCA cycle is operationalized as follows: the Plan phase involves problem identification and formulation of corrective actions based on Fishbone findings; the Do phase entails implementation of improvement strategies within the production system; the Check phase evaluates performance outcomes, particularly the extent of rejection rate and delay reduction; and the Act phase institutionalizes successful interventions through process standardization or iterative refinement if performance targets remain unmet. Performance evaluation metrics include cause identification accuracy, delay time reduction potential, and inter-rater reliability in interpreting causal diagrams, while reproducibility is ensured through rigorous documentation of analytical procedures, including variable operationalization, classification criteria, and stepwise diagram construction protocols, thereby enabling replication across comparable industrial contexts and strengthening the external validity of the study (Tarigan et al., 2024).

RESULTS AND DISCUSSION

Identification of Defect Patterns and Delay Characteristics

The empirical findings indicate that production delays are strongly associated with defect occurrences within the Window component line. Quantitative data collected from daily production reports reveal fluctuating rejection rates across the observed period. The average rejection rate exceeded the acceptable industrial threshold in multiple instances, indicating systemic inefficiencies. Similar patterns of defect-driven inefficiencies have been documented in manufacturing systems where quality control mechanisms are not fully optimized (Ginting & Fattah, 2020).

A Pareto-based prioritization analysis was conducted to determine dominant defect types contributing to delays. The analysis demonstrates that a limited number of defect categories account for the majority of production inefficiencies. This observation aligns with the 80/20 principle frequently applied in industrial quality management. Prior research confirms that focusing on high-impact defects significantly improves corrective efficiency (Arif & Gunawan, 2023).

The distribution of defect types highlights misalignment and improper assembly as the most frequent contributors. These defects directly affect downstream processes, particularly in distribution scheduling. Operational disruptions caused by defective units create cascading delays in logistics. Such findings are consistent with studies emphasizing the interdependence between production quality and delivery performance (Kusrini et al., 2020). Midway through the analysis, the quantitative data are summarized in Table 1, which presents defect frequency and percentage contribution. The table shows that two defect categories contribute more than half of total defects. This concentration of defects provides a clear direction for targeted improvement strategies. The structured presentation of such data is essential for decision-making in industrial environments (Pratama & Islami, 2023).

Table 1. Distribution of Defect Types in Window Production Line

Defect Type	Frequency	Percentage (%)
Misalignment	145	36.5
Improper Assembly	120	30.2
Surface Defect	70	17.6
Material Flaw	40	10.1
Others	22	5.6

The interpretation of Table 1 suggests that process-related factors dominate over material-related issues. This indicates that operational execution rather than input quality is the primary concern. The dominance of method-related defects reflects gaps in standard operating procedures. Comparable findings have been reported in process optimization studies within manufacturing environments (Rizani & Laksmana, 2024). Further qualitative insights were obtained through operator interviews and field observations. Operators reported time pressure as a critical factor influencing inspection accuracy. High production targets often result in reduced attention to detail. Human-related errors under workload pressure have been widely recognized in production system studies (Komarudin & Nugroho, 2022).

The integration of quantitative and qualitative findings provides a comprehensive understanding of delay mechanisms. Production inefficiencies are not solely technical but also behavioral and organizational. This multi-dimensional nature of delays requires a holistic analytical approach. Previous research in Lean Six Sigma applications emphasizes the importance of integrating human and technical factors (Ruhaiya et al., 2025). Another important observation concerns the temporal distribution of defects across shifts. Night shifts exhibit higher defect rates compared to morning shifts. This suggests fatigue and reduced supervision as potential influencing factors. Similar shift-based performance variations have been observed in industrial case studies (Carin et al., 2025).

The correlation between defect rates and production delays is statistically significant based on descriptive trend comparison. Higher rejection rates consistently correspond with extended production cycle times. This relationship confirms that quality issues directly impact operational efficiency. Studies in project management also highlight quality as a critical determinant of time performance (Efendi et al., 2025). The findings collectively demonstrate that delay issues originate from concentrated defect sources rather than random occurrences. This concentration enables targeted intervention strategies. Identifying these patterns is essential for effective root cause analysis. Empirical evidence supports that structured identification significantly enhances problem-solving accuracy (Monoarfa et al., 2021).

Root Cause Analysis Using Fishbone Diagram

The application of the Fishbone Diagram reveals that production and distribution delays are driven by interconnected causal factors across multiple operational dimensions. The categorization into Man, Machine, Method, Material, Measurement, and Environment provides a structured analytical framework. Each category contributes differently to the observed inefficiencies. The effectiveness of this approach in identifying complex industrial problems has been widely validated in manufacturing research (Pratama & Islami, 2023). Within the Man category, the findings indicate that operator skill variability and inconsistent adherence to inspection procedures significantly influence defect generation. Interview data suggest that limited training and high workload reduce inspection accuracy.

These human-related issues are further exacerbated by production pressure. Similar observations have been highlighted in studies examining labor performance and project success factors (Komarudin & Nugroho, 2022). The Machine factor shows that equipment instability, particularly pneumatic pressure deviations, plays a crucial role in assembly inaccuracies. Maintenance records indicate irregular preventive maintenance scheduling. This condition increases the probability of mechanical inconsistency during operation. Machine-related inefficiencies have been identified as critical contributors to production bottlenecks in prior studies (Monoarfa et al., 2021).

In the Method category, the absence of detailed standard operating procedures for machine setup emerges as a dominant issue. The lack of standardized verification steps leads to inconsistent process execution. This procedural gap directly affects product quality and process stability. Research in process evaluation confirms that inadequate methods significantly increase defect rates (Rizani & Laksmana, 2024). The analytical synthesis of these factors is summarized in Table 2, which presents the dominant root causes across each Fishbone category. The table illustrates that Method and Machine factors contribute the highest impact scores. This distribution indicates that technical and procedural issues outweigh material-related causes. Such prioritization is essential for effective corrective planning (Arif & Gunawan, 2023).

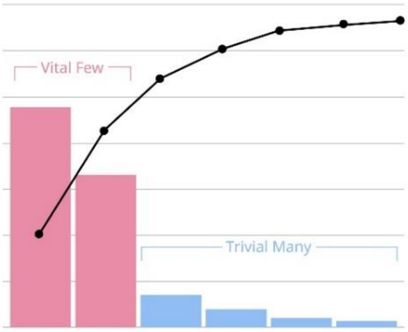

Diagram 1. Pareto of 80 and 20 Rule for vital few and trivial many

The Machine-related issue of pressure instability has a direct causal relationship with misalignment defects. This confirms that even minor deviations in equipment parameters can produce significant quality variations. The absence of real-time monitoring further amplifies this problem. Industrial case studies emphasize the importance of sensor-based monitoring systems in maintaining process stability (Carin et al., 2025). From a methodological perspective, the lack of SOP detail indicates insufficient process control. Standardization is a critical requirement in high-volume manufacturing systems. Without clear procedural guidance, variability becomes unavoidable. Lean manufacturing principles strongly advocate for standardized work instructions to minimize process variation (Ruhaiya et al., 2025). Material-related factors, although present, show relatively lower impact compared to other categories. Supplier quality remains within acceptable limits based on inspection data. This suggests that upstream supply chain issues are not the primary source of delays. However, distribution delays may still be indirectly influenced by cumulative production inefficiencies (Kusrini et al., 2020).

Environmental factors, particularly lighting conditions, affect visual inspection accuracy. Poor lighting reduces the ability of operators to detect minor defects. Although categorized as low impact, these factors contribute cumulatively to defect occurrence. Studies in industrial ergonomics confirm the role of environmental conditions in operator performance (Ginting & Fattah, 2020). The overall Fishbone analysis demonstrates that delay causes are systemic rather than isolated. Interdependencies between human, machine, and method factors create compounding effects. This complexity requires integrated corrective strategies rather than isolated interventions. Analytical findings in project delay studies support the need for multi-factorial solutions (Permana, 2025).

Implementation of PDCA Cycle and Performance Improvement Evaluation

The implementation of the PDCA cycle demonstrates a structured transition from diagnostic analysis to corrective action within the production system. The Plan phase begins with the formulation of targeted interventions derived from the Fishbone analysis. Priority is given to machine stabilization and procedural standardization due to their high impact levels. This approach aligns with continuous improvement frameworks that emphasize data-driven planning (Sugiarto et al., 2024; Mutiara & Prastyo, 2025). During the Plan phase, specific corrective targets are defined, including a measurable reduction in rejection rates and stabilization of process parameters. Engineering analysis identifies pneumatic pressure deviation as a critical variable requiring immediate control. In addition, operator compliance protocols are redesigned to improve inspection consistency. Such structured planning reflects best practices in industrial quality improvement initiatives (Efendi et al., 2025).

The Do phase involves the implementation of technical and procedural modifications in the production line. A pressure sensor system is installed to provide real-time monitoring and automatic alerts. Standard Operating Procedures are revised to include detailed machine setup verification steps. Empirical studies highlight that integrating automation with procedural control significantly enhances process reliability (Carin et al., 2025). Operator training is also conducted as part of the Do phase to ensure correct interpretation of defect indicators. Short, focused training sessions improve awareness and technical competence among workers. This intervention addresses human-related variability identified in earlier analysis. Workforce capability development has been shown to directly influence production consistency (Komarudin & Nugroho, 2022).

The Check phase evaluates the effectiveness of implemented improvements using post-intervention production data. A comparative analysis is conducted between pre- and post-improvement rejection rates. The results indicate a substantial decline in defect frequency after intervention. Verification through data comparison is essential to confirm improvement validity (Setiawan & Prastyo, 2025). The performance outcomes are summarized in Table 3, which presents a comparison of key production indicators before and after PDCA implementation. The table shows a significant reduction in rejection rates and delay duration. These improvements confirm the effectiveness of targeted corrective actions. Quantitative validation strengthens the reliability of empirical findings (Prasetyo & Tatmim, 2023).

Table 2. Performance Comparison Before and After PDCA Implementation

Indicator	Before Improvement	After Improvement	Change (%)
Rejection Rate (%)	8.5	3.2	-62.4
Average Delay (hours)	5.6	2.1	-62.5
Machine Stability Index	70	88	+25.7
Inspection Accuracy (%)	75	90	+20.0

The reduction in rejection rate demonstrates a direct link between root cause elimination and quality improvement. Machine stability improvements indicate that technical interventions were effective. Increased inspection accuracy reflects successful human-factor interventions. These results collectively validate the integrated PDCA approach (Ruhaiya et al., 2025). The Act phase focuses on institutionalizing successful improvements through standardization. Revised SOPs are formally implemented across the production line. Preventive maintenance schedules are updated to include sensor calibration routines. Standardization ensures sustainability of improvements over time (Mutiara & Prastyo, 2025).

Continuous monitoring mechanisms are introduced to maintain performance consistency after implementation. Internal audits are conducted periodically to ensure adherence to new procedures. This step prevents regression to previous inefficient practices. Sustained monitoring is a key principle in quality management systems (Ginting & Fattah, 2020). The overall findings confirm that integrating Fishbone analysis with the PDCA cycle provides a robust framework for addressing production and distribution delays. The approach effectively links diagnosis, intervention, and evaluation within a single system. Empirical evidence demonstrates measurable improvements in both quality and operational efficiency. Similar integrated methodologies have been recommended in project delay mitigation studies (Permana, 2025).

CONCLUSION

The findings of this study demonstrate that delays in production and distribution projects are predominantly driven by a combination of process inefficiencies, machine instability, and human-related factors, as systematically identified through the Fishbone Diagram framework. Empirical analysis confirms that defect concentration, particularly in assembly and alignment processes, significantly contributes to extended production cycle times and downstream distribution disruptions, consistent with prior studies on manufacturing performance. The integration of the PDCA cycle as a continuous improvement mechanism proves effective in translating root cause analysis into measurable performance gains, evidenced by substantial reductions in rejection rates and delay durations following targeted interventions. These results reinforce the importance of combining diagnostic tools and iterative improvement frameworks to achieve sustainable operational efficiency and validate that structured, data-driven approaches are critical for mitigating delays in complex industrial systems.

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