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Analysis of Lean Manufacturing Efficiency and Effectiveness Using a Digital Kanban System at

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ABSTRACT

PT Yageo TMSS Indonesia faced challenges in the material delivery process when using the conventional Kanban system. Delays and errors in material filling were detected throughout the process. To enhance effectiveness, efficiency, and accuracy in material delivery, the company implemented the digitalization of the Digital Kanban System (SKD) integrated with the Enterprise Resource Planning (ERP) system. This study focuses on analyzing the effectiveness of the SKD implementation, which is connected to the ERP system in managing Kanban-based material delivery. This approach is expected to improve delivery time efficiency and reduce errors during the material delivery process. Three key indicators were used to evaluate the efficiency and effectiveness of SKD: On-Time Delivery (OTD), delivery efficiency, and material accuracy to the production line.. These indicators demonstrate how effectively the SKD supports a consistent and reliable material delivery process. The research findings show that On-Time Delivery (OTDm) achieved a 100% rate with no recorded delays. The observation period also indicated a consistently high level of delivery efficiency. The highest number of deliveries was recorded in the second month, with no delays observed during the study. According to the study's findings, a comprehensive rollout of the SKD across the entire production environment would be advantageous. To support system adaptability and long-term efficiency, it is essential to enhance monitoring processes, ensure continuous workforce development, and promote ongoing research initiatives.

INTRODUCTION

Within the manufacturing industry, the optimization of material consumption and adherence to delivery schedules are vital for operational efficiency, especially for manufacturers such as PT Yageo TMSS Indonesia, which is engaged in the production of industrial sensing equipment. Amid rising market demands and intensifying global competition, it is imperative for the company to maintain a responsive and flexible supply chain while upholding high standards of quality and productivity. The urgency of this challenge intensifies as the conventional Kanban system, as a core element within the Lean Manufacturing paradigm, demonstrates certain constraints when confronted with rising production demands and heightened variability in product types. Kanban is extensively adopted as an inventory management strategy aligned with the just-in-time (JIT) methodology, aiming to minimize surplus inventory, reduce waste, and enhance the efficiency of material flow across production processes (Marques et al., 2022; Popa & Gupta, 2024). As part of its Lean Manufacturing strategy, PT

Yageo TMSS Indonesia has adopted the system to support continuous improvement and operational efficiency. However, recent data from early 2024 revealed critical operational challenges, including over 500 cases of delayed material deliveries and 167 instances of wrong materials, leading to nearly 500 hours of production downtime (PT Yageo TMSS Indonesia, 2024). These issues are primarily due to manual processes, poor material sequencing, inefficient routing, and weak integration with the company's ERP systems.

The urgency of addressing these inefficiencies is high, as delays and inaccuracies directly affect JIT-based production systems, potentially increasing costs and reducing competitiveness. Based on consultations with the production, methods, and warehouse teams, the digitalization of the Kanban process has been identified as a logical and attainable solution. With robust digital infrastructure including a private cloud server, handheld mobile scanners, and a skilled digital transformation team, PT Yageo TMSS Indonesia is well-positioned to implement a Digital Kanban System (DKS), ensuring that the adoption is both operationally sound and strategically aligned with the company's long-term objectives. This study primarily aims to assess the effectiveness of implementing the Digital Kanban System (DKS) in enhancing on-time material delivery (OTDm), improving delivery accuracy, and increasing the responsiveness of the supply chain. The study also aims to analyze how the system reduces production downtime and aligns with the core principles of Lean Manufacturing. By integrating a real-time digital approach with the JIT model, this study contributes to the literature on Lean Manufacturing and digital transformation in supply chain management. The findings are expected to support broader applications of digital Kanban systems in manufacturing environments seeking operational agility and efficiency.

LITERATURE REVIEW

Effective operations management plays a crucial role in increasing organizational efficiency, minimizing waste within processes, and strengthening responsiveness to shifting customer needs. It offers a strategic foundation for the design, execution, and continuous improvement of systems that generate and deliver an organization's core products and services (Heizer et al., 2020). This process represents a vital part of the organization, directly driving value creation by delivering products or services to customers (Siregar & Rachman, 2024). Within manufacturing settings, operations management encompasses critical decision-making in areas such as capacity planning, inventory management, quality control, and the strategic design of facility layouts. These elements form the foundation for implementing advanced enhancement strategies, including lean manufacturing, supply chain integration, enterprise resource planning (ERP) systems, and the incorporation of Internet of Things technologies (IoT).

Supply Chain Management (SCM)

Supply Chain Management (SCM) refers to the coordination and harmonization of activities among all entities involved in delivering a product or service, such as suppliers, manufacturers, and distributors. Supply Chain Management (SCM) prioritizes the precise fulfillment of product delivery in terms of quantity, location, and schedule, while also aiming to improve cost-effectiveness and maximize the efficiency of supply chain operations (Hendayani et al., 2025). As noted by Azis and Irjayanti (Azis & Irjayanti, 2024), effective SCM serves as a key determinant of operational success within the globalized economy, especially for manufacturing firms in emerging markets like Indonesia. Supply Chain Management (SCM) frameworks assist in synchronizing supply with demand, enhancing logistical operations, and minimizing disruptions across the production and distribution system.

Lean Manufacturing

Lean manufacturing, as outlined by Womack and Jones (2003), is a structured methodology designed to enhance efficiency by identifying and eliminating non-value-adding activities while promoting continuous improvement throughout operational processes. It emphasizes customer value, smooth production flow, and flexibility. The lean philosophy is strongly associated with operational practices including just-in-time (JIT) production, continuous improvement initiatives such as Kaizen, and the use of visual management tools to support process transparency and efficiency. According to Popa and Gupta (2024), the application of lean principles contributes to enhanced operational efficiency, cost reduction, and higher product quality. In addition, lean manufacturing establishes a strong basis for the integration of complementary operational strategies, including Supply Chain Management (SCM) and Enterprise Resource Planning (ERP), by promoting a culture centered on continuous process improvement.

Kanban System

The Kanban system is one of the most widely implemented lean tools for managing production flow in manufacturing environments. Visual signals, including physical cards and electronic displays, are used within the system to oversee and synchronize the flow of materials and components throughout different phases of the production process. Kanban, operating as a pull system, aligns production directly with real-time customer demand instead of relying on forecasts, thereby helping to limit work-in-progress (WIP) and decrease excess inventory (Fuentes-del-Burgo et al., 2024). his method increases operational agility by matching output with real-time consumption patterns. Kanban also enhances visibility and responsibility across production lines by displaying work queues and supporting structured task coordination (Das & Das, 2023).

Enterprise Resource Planning (ERP) Systems

Enterprise Resource Planning (ERP) systems consist of integrated software solutions aimed at facilitating and optimizing business processes across multiple functions such as finance, procurement, human resources, and production. Enterprise Resource Planning systems support immediate data exchange, promote interdepartmental cooperation, and reduce unnecessary process duplication (Mossa et al., 2025). In operations management, ERP systems are essential for aligning production planning, managing inventory effectively, and upholding quality compliance. Heizer et al. (Heizer et al., 2020) note that the integration of ERP with supply chain activities enhances end-to-end visibility, enabling more accurate forecasting and timely decision-making. Furthermore, ERP systems enhance lean manufacturing by providing centralized management, enabling performance analysis, and establishing standardized operating procedures that promote continuous improvement.

Internet of Things (IoT) in Operations

By integrating sensors, software, and network connectivity into physical devices, the Internet of Things (IoT) is fundamentally altering contemporary operational workflows. This technology enables real-time monitoring, remote control, and predictive analytics in manufacturing systems (Habib et al., 2025). The Internet of Things (IoT) offers detailed insights into machine performance, energy consumption, and environmental factors. This data is vital for enhancing production efficiency and avoiding unscheduled interruptions. This technology advances lean manufacturing by enabling precise detection of waste sources and guiding data-driven corrective actions. Furthermore, when integrated with ERP and Kanban systems, IoT facilitates automated workflows and smart alerts that enhance supply chain responsiveness and overall operational efficiency.

Framework of Thought

Within the competitive manufacturing sector, optimizing material utilization and delivery efficiency is crucial for maintaining uninterrupted production flow and minimizing waste. As a core element of the Just-in-Time (JIT) strategy, the Lean Kanban method has been extensively applied to manage material flow and ensure that components are available in alignment with production demands. The conventional card-based Kanban system encounters challenges, particularly when managing fluctuating demand and the increasing complexity of contemporary supply chains.
With technological advancements, the Digital Kanban System (DKS) emerges as a potential solution to the weaknesses of physical Kanban. The DKS leverages digital technologies such as the Internet of Things (IoT) and cloud computing to provide real-time visibility, automate stock monitoring, and integrate more effectively with the overall supply chain system.

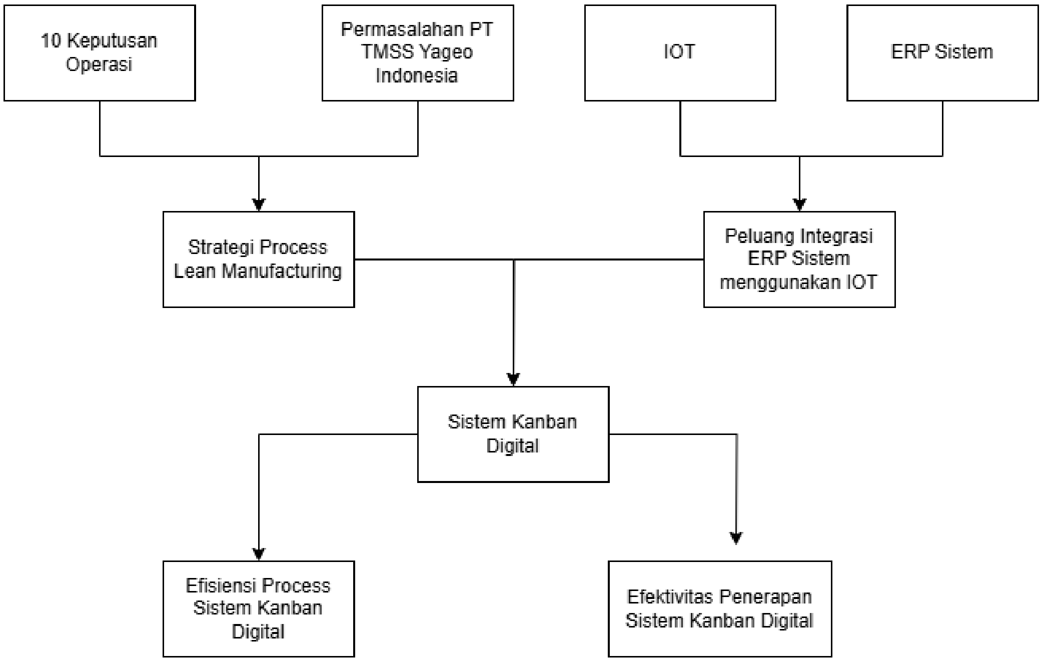

Fig. 1. Framework of Thought

Grounded in the concept and depicted in Figure 1, this study addresses the practical challenges encountered by PT Yageo TMSS Indonesia in material management, particularly concerning delayed deliveries. To address these challenges, the company implements a Digital Kanban System (DKS) as part of its Lean Manufacturing strategy to eliminate waste and accelerate material flow.
This approach is reinforced by the integration of ERP systems and IoT technology, aiming to enhance visibility, data accuracy, and responsiveness to demand fluctuations. This integration is expected to improve both:
The efficiency and implementation effectiveness of the Digital Kanban System are assessed using indicators like delivery speed and material accuracy.

METHOD

This section outlines the research design, scope, materials and tools used, study location, data collection techniques, operational definitions of research variables, and analytical techniques used to examine the impact of the Digital Kanban System (DKS) regarding its effects on material utilization and delivery performance within a sensor manufacturing firm.

Type of Research

This study adopts a quantitative research approach to analyze the effect of implementing a Digital Kanban System (DKS) on the efficiency of material usage and delivery at Yageo TMSS Indonesia, a sensor manufacturing company. The quantitative method involves collecting measurable data, such as material lead time, minimum stock levels, order accuracy, and Kanban efficiency (Barella et al., 2024; Hardani et al., 2020).

Operational Definition of Variables

Operational definitions are used to clarify variable boundaries and unify researchers' perceptions during data collection, measurement, and analysis. The aim is to maintain consistency and efficiency throughout the research process (Hardani et al., 2020). The variables investigated are as follows:

Material Request Accuracy

Material request accuracy indicates how precisely material forecasting systems predict production needs. It measures the congruence between planned and actual material consumption, which is crucial in avoiding overstocking or stockouts (Stevenson & William J, n.d.).

A high accuracy score indicates an effective material planning system, while a low score suggests potential data entry errors or mismatches between planning and actual needs.

$$\text{Accuracy (\%)} = (\text{Number of materials })/(\text{Total materials ordered}) \times 100 \qquad (1)$$

On-Time Delivery (OTD)

On-Time Delivery (OTD) is a key performance indicator for evaluating the effectiveness of the Kanban system. It indicates the system's capacity to supply materials according to the scheduled time. OTD is calculated as follows:

$$\text{OTD (\%)} = (\text{Number of jobs completed on time}/(\text{Total jobs delivered})) \times 100 \qquad (2)$$

High OTD indicates reliability and strong process control. Contributing factors include accurate inventory management, realistic scheduling, high product quality, supplier integration, and trained teams (Gehringer, 2023).

Kanban Efficiency

Kanban efficiency measures how effectively time is used during the production cycle. It focuses on minimizing waste while enhancing activities that add value (Stevenson & William J, n.d.). Kanban systems enable real-time control and reduce idle time by using digital signals for material movement.

$$\text{Efisiensi Kanban} = 100\% - ((\text{Actual Time} - \text{Cycle Time})/(\text{Cycle Time})) \qquad (3)$$

This formula quantifies the proportion of productive time, helping identify process bottlenecks and opportunities for improvement.

Research Stages

The study was conducted through three organized phases: an initial investigation, data analysis, and the formulation of conclusions along with recommendations.

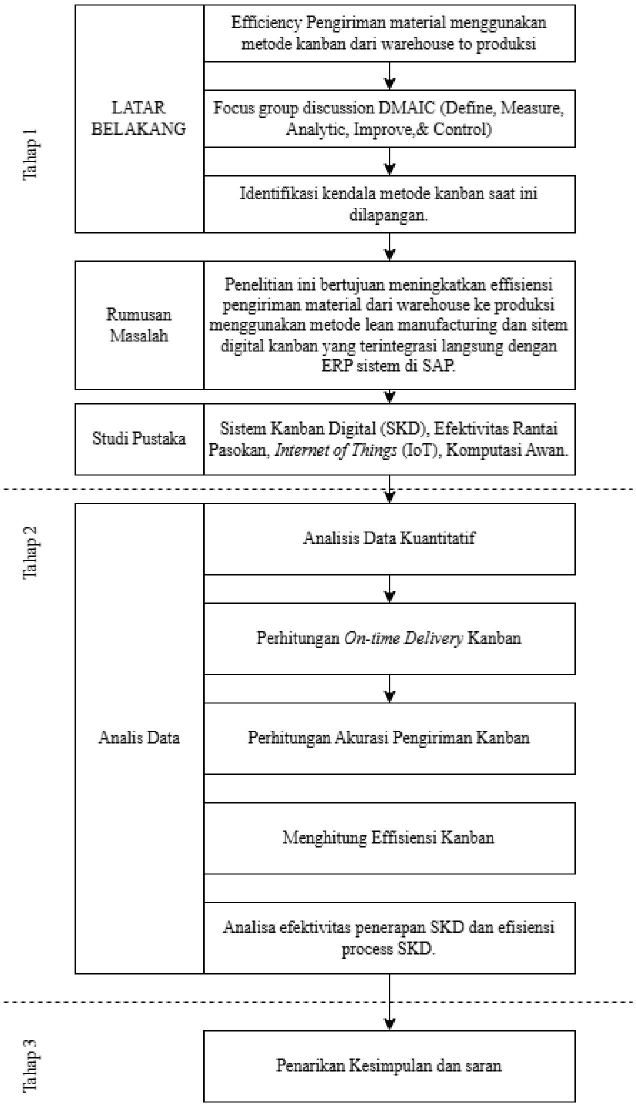

Fig. 2. Research Stages

First Stage: Based on Figure 2 preliminary Study was conducted between March and April 2025 and focused on identifying inefficiencies in the conventional Kanban system used by the company. This phase included a background investigation focusing on practical challenges like delivery delays and errors in material handling. To better investigate these challenges, Focus Group Discussions (FGDs) were conducted using the DMAIC (Define, Measure, Analyze, Improve, Control) framework to systematically define the research problem. The formulation of the problem focused on enhancing delivery efficiency through Lean Manufacturing strategies and the integration of a digital Kanban system linked with the SAP ERP. This stage was reinforced by a comprehensive literature review encompassing themes such as digital Kanban implementation, supply chain management, Internet of Things (IoT) integration, and cloud-based technologies.

The second phase of the research, which took place in May 2025, focused on the systematic collection and analysis of quantitative data related to material delivery processes. In this phase, performance metrics including delivery timeliness and Kanban signal accuracy were assessed to evaluate the improvements associated with the implementation of the Digital Kanban System. In addition, Kanban efficiency was calculated to assess whether cycle times had been optimized. The analysis also included a review of the effectiveness and efficiency of DKS in a descriptive manner to evaluate its operational impact.

Last Stage: Conclusion and Recommendations, carried out in June 2025, involved drawing conclusions based on the results of the data analysis. The final phase produced recommendations intended to support the continuous improvement of the digital Kanban system. The conclusions presented a thorough assessment of the performance of the Digital Kanban System, while the recommendations were intended to support its long-term adoption and ongoing enhancement in future operational contexts.

Population and Sample

The study population comprises all recorded instances of material delivery and associated error reports from production areas where the Digital Kanban System was implemented at PT Yageo TMSS Indonesia. To ensure the relevance of the data, purposive sampling was employed, targeting datasets most representative of the research objectives. The chosen sample consists of post-implementation data gathered from Floor 1 during the period of January to March 2025.

Data Collection and Sources

This study utilizes secondary data analysis by comparing material delivery performance indicators after the implementation of DKS. This study relies exclusively on internal transactional data extracted from the company's Digital Kanban System (DKS).

Data Analysis Techniques

Data collected during the study were processed using both qualitative synthesis and quantitative statistical methods. Descriptive statistical techniques were applied to evaluate the primary variables by examining their central tendency and dispersion through mean, median, mode, and standard deviation. In addition, data were presented in tabular form and visualized graphically to illustrate emerging trends and operational patterns. These techniques enabled a clearer interpretation of the data, providing a foundation for identifying the effectiveness of the Digital Kanban System in improving production and material delivery performance (Ghozali, 2023; Sugiyono, 2020; Walpole et al., 2023).

RESULT AND DISCUSSION

The evaluation results indicate measurable improvements in material delivery efficiency and On-Time Delivery of Materials (OTDm) following the implementation of the Kanban-based system. Data collected from January to March 2025 show consistent alignment between delivery timing and production requirements, reflecting enhanced operational accuracy and system responsiveness.

1. Cycle Time Calculation in Kanban Implementation

Cycle Time was calculated to assess how long it takes on average to process one Kanban box. Based on the observed data (Table 1), a total of 25 Kanban boxes were delivered within one hour. Using the standard formula:

$$\text{Cycle Time} = (\text{Kanban Operational Time per Delivery}) / (\text{Delivery Output}) \tag{4}$$

This result indicates that, on average, it takes approximately 2.4 minutes to deliver one material box under current operational conditions.

Table 1. Cycle Time Calculation for Kanban Delivery

No	Material Code	Delivered Quantity
1	Material 1	1
2	Material 2	1

No	Material Code	Delivered Quantity
...	...	...
19	Material 19	2
	Total Boxes	25
	Total Time (min)	60
	Cycle Time	2.4 min/box

2. Material Delivery Efficiency Analysis

To determine the efficiency of material delivery, actual delivery times were compared against the established cycle time benchmark of 2.4 minutes per box. The efficiency was determined by applying the formula presented in Equation (3).

Table 2 presents a comprehensive summary of 1062 Kanban delivery instances, showcasing delivery time, actual cycle time per delivery, calculated efficiency, and delivery performance (in-time vs. late).

The results reveal a consistent improvement in delivery efficiency over time, with several deliveries achieving over 90% efficiency. This improvement aligns with the adoption of lean practices, including enhanced route planning, strict time discipline, and improved work rhythm.

Table 2. Efficiency Calculation of Kanban Material Delivery (Excerpt)

No	Date	Total Delivery Item in a Day	Average of Cycle Time	Average of Effisiensi	Total of In-Time	Total of Late
1	02/01/2025	67	1,9106936	126,86655	16	0
2	03/01/2025	62	1,9761419	131,27267	18	0
3	06/01/2025	73	1,8959802	127,23783	13	0
...	...	...	...	...	...	...
65	28/03/2025	12	2,4830369	110,9499	12	0

Note: The full dataset contains 1062 entries; this table is a representative excerpt group by day.

Table 3. Efficiency Calculation of Kanban Material Delivery (Excerpt)

No	Average of Effisiensi	Total of In-Time Delivery	Total of Late Delivery	Total Delivery	OTDm (On-Time Delivery Material)
1	127,45	336	0	336	100,00%
2	123,58	404	0	404	100,00%
3	119,67	322	0	322	100,00%

3. Accuracy and Timeliness of Material Delivery

To evaluate delivery accuracy and timeliness, this analysis focused on two critical indicators: Wrong Supply and Late Supply. Late Supply was further classified into two subcategories: critical late supply, which leads to immediate production downtime, and acceptance late supply, which does not halt operations but reflects deviations from the planned delivery schedule.

Figure 3 presents instances of critical late supply observed in 2024, particularly those that resulted in production disruptions on the first production floor. During that year, Wrong Supply incidents were recorded five times in both January and February and increased to six in March. Concurrently, Late Supply occurred 14 times in January, 13 times in February, and 19 times in March. These results highlight inconsistencies in the traditional delivery system prior to the digital Kanban implementation.

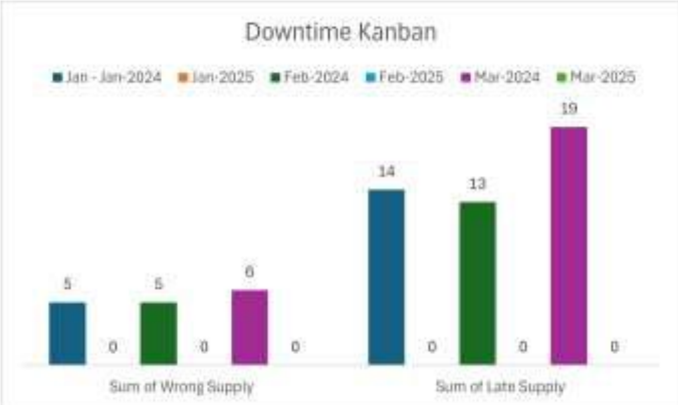

Fig. 3 Downtime Application Kanban

In contrast, data from January to March 2025 demonstrate significant improvements in both delivery parameters. The implementation of the Digital Kanban System (DKS) resulted in zero instances of Wrong Supply and Late Supply across the entire observation period. This outcome signifies substantial progress in ensuring material accuracy and punctuality, reflecting enhanced control and responsiveness within the internal logistics process.

Additionally, acceptance late supply was thoroughly monitored to assess minor discrepancies that might not immediately disrupt production. As shown in Table 4.4, no deviations from scheduled delivery were recorded from January to March 2025. Every delivery occurred within the expected timeframe, confirming the absence of both acceptance and critical late supply cases during the evaluation period.

Further assessment of delivery precision revealed a 100% accuracy rate for each month within the same period, with 336, 404, and 322 material units delivered in January, February, and March respectively. All deliveries met the requested specifications without error or mismatch, indicating excellent performance in order fulfilment.

This high level of accuracy is attributed to the poka-yoke (error-proofing) mechanism embedded within the DKS workflow. As depicted in Figure 4, this system mandates dual scanning procedures: first during the loading phase at the warehouse, and subsequently during handover at the production line. Each scan is validated in real-time to ensure that the correct materials are placed in the correct locations, thereby minimizing human error and strengthening the reliability of internal material distribution.

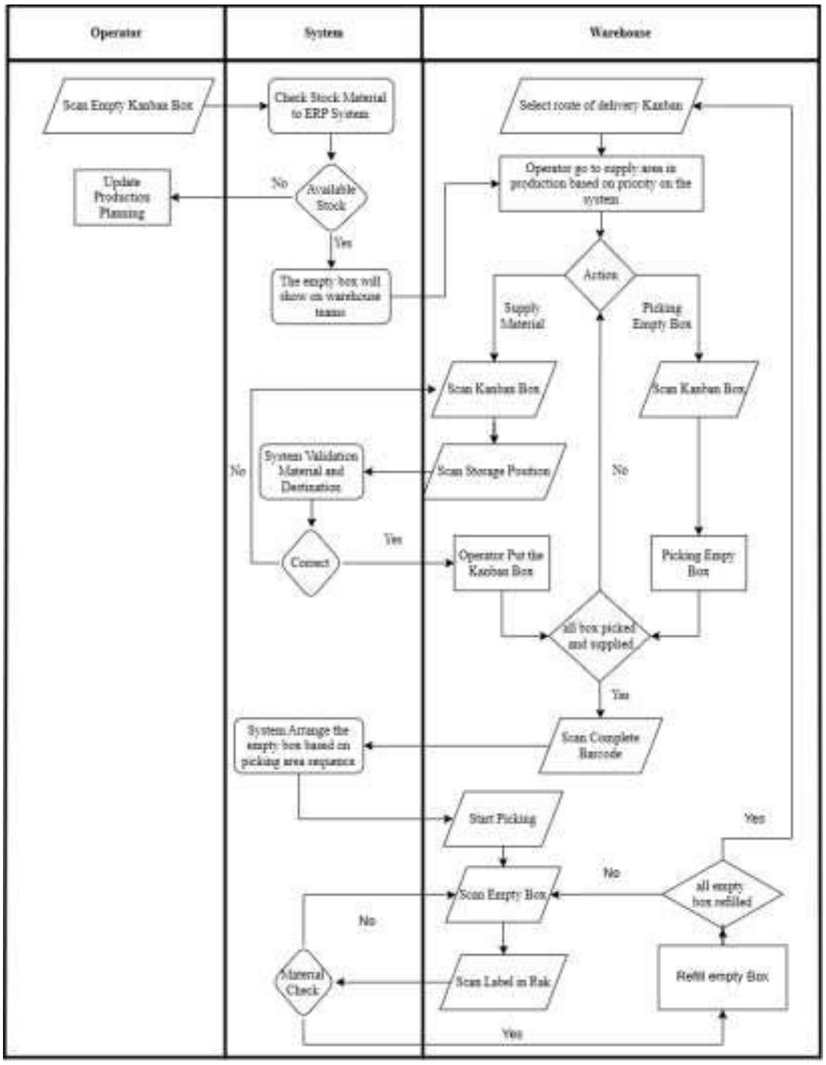

Fig. 4. Process Flow DKS

4. Trend Analysis and Continuous Improvement

The trend of increasing efficiency across successive deliveries reflects the positive impact of continuous improvement initiatives embedded in the Kanban system. Initially, deliveries exhibited efficiency levels below 50%; however, through systematic process refinements and operational discipline, recent records show efficiency surpassing 90%. These improvements are strongly associated with the high delivery accuracy and timeliness outlined in the previous section, where the complete elimination of Wrong Supply and Late Supply cases during the 2025 observation period demonstrated the effectiveness of the Digital Kanban System (DKS). The integration of error-proofing mechanisms such as poka-yoke further contributed to the robustness and reliability of material flow. Collectively, these results underscore the strategic value of the Kanban methodology in optimizing internal logistics performance and sustaining lean operational practices.

DISCUSSION

This study employed a descriptive analysis focused on three core aspects of the Digital Kanban System (SKD): material delivery efficiency, on-time delivery performance (OTDm), and overall distribution consistency. The analysis is based on performance data observed between January and March 2025, as presented in Table 4.4 and visualized in Figures 3 and 4. The discussion emphasizes both the trends in each parameter and the interrelations among them to provide a comprehensive view of system performance.

Material Delivery Efficiency

The exceptional delivery efficiency in January, measured at 127.45%, indicates performance beyond the expected cycle time threshold. This indicates that the material distribution process operated significantly faster than the average standard of 2.4 minutes per box. This performance is attributed to the availability of delivery fleets, streamlined workflows, and effective cross-functional coordination. However, efficiency declined slightly in February to 123.58%, and further to 119.67% in March. Although these values remain above the 100% efficiency threshold, the downward trend signals an early warning of possible performance degradation. Potential factors contributing to the decline include elevated workload pressures, reduced consistency in delivery procedures, and minor disturbances in daily operations. This trend suggests that, while the system remained functional, its capacity was beginning to be affected by shifting operational demands. Continuous monitoring, proactive countermeasures, and further investigation are necessary to prevent continued decline in subsequent periods.

On-Time Delivery Performance (OTDm)

Throughout the observation period from January to March 2025, all material deliveries achieved a 100% on-time rate. This indicates that the delivery process consistently met scheduled times without any delays. Sustained performance reflects the efficiency of scheduling practices, accuracy in information dissemination, and the operational discipline maintained by the logistics team. The dependability of on-time deliveries significantly contributes to sustaining production continuity and reducing the likelihood of production halts. The absence of any delays—both major and minor—reinforces the system's robustness and indicates that the SKD not only supports time efficiency but also delivers operational consistency and dependability.

Delivery Accuracy and Delay Elimination

Post-implementation evaluation revealed a significant improvement in delivery accuracy and timeliness. Compared to the conventional system implemented in 2024, the digital SKD demonstrated superior control and accuracy, effectively preventing any instances of incorrect or delayed material supply during the 2025 observation period. This achievement demonstrates the system's ability to minimize human error, enhance supply chain visibility, and accelerate both information flow and validation processes.Furthermore, the absence of acceptance late supply indicates that the system effectively eliminated not only critical delays but also minor ones, which, if left unchecked, could impact overall production efficiency. This indicates a strong degree of operational consistency in internal distribution processes.The 100% delivery accuracy also underscores the success of quality control mechanisms in ensuring material compliance with specifications. It indicates optimal performance by warehouse teams operating within a digitized system environment. The integration of the poka-yoke mechanism within the SKD was instrumental in minimizing the risk of operational errors. Through two-way validation using barcode scanning at both loading and delivery points, the system established an automated safeguard that effectively minimized errors from the earliest stages. This mechanism directly supports the maintenance of consistent and dependable operational standards, which in turn helps minimize production interruptions.

CONCLUSION

Based on three months of observing the Kanban system for material delivery at PT Yageo TMSS Indonesia, the following conclusions can be drawn.: The Kanban system showed a high level of efficiency during the observation period. The peak efficiency was recorded in the first month at 127.45 percent. However, a gradual decrease was observed in the second month at 123.58 percent and further in the third month at 119.67 percent. Although efficiency levels stayed above the anticipated benchmark, the declining trend suggests mounting pressure on distribution capacity. This suggests the importance of periodic evaluation and strengthening of warehouse support systems to maintain performance. Throughout January to March 2025, the system consistently achieved a 100 percent on-time delivery rate each month. This reflects the system's ability to ensure consistent and timely delivery of materials, thereby facilitating seamless production operations. The adoption of the SKD significantly improved the accuracy of material deliveries. During the observation period, all shipments aligned with production requirements and specifications, resulting in a perfect accuracy rate of 100 percent. This outcome reflects the system's capacity to enforce quality control through standardized and digitized validation procedures. The poka-yoke mechanism played a vital role in maintaining accuracy and reliability by employing dual barcode scanning during the loading and dispatch stages. This method effectively prevented operational errors and minimized the risk of human mistakes from the outset of the distribution process. In conclusion, the SKD implementation succeeded in establishing a precise and stable material distribution process. It demonstrated alignment with real-time production workflows, contributing to improved efficiency, delivery accuracy, and dependable operational execution.

Recommendations

Based on the conclusions outlined above, the following recommendations are proposed to enhance the performance of the Kanban system at PT. Yageo TMSS Indonesia:

1) Expansion of E-Kanban Implementation to Floors 2 and 3:

Considering the successful implementation of the Digital Kanban System (SKD) on Floor 1, particularly in improving material delivery efficiency and timeliness, it is recommended that the system be extended to Floors 2 and 3. This expansion aims to promote process standardization across production areas and strengthen the integration of inter-floor material distribution processes.

Periodic Monitoring and Evaluation of Kanban Performance:

Implementing a data-centric, real-time monitoring framework is recommended to evaluate critical metrics such as delivery performance and material timeliness (OTDm). Regular evaluations will support early detection of potential performance declines and allow for timely corrective actions, ensuring continued reliability in material distribution.

Operational Workforce Development and Refresher Training Programs:

The competency of human resources plays a pivotal role in the sustainable success of the Kanban system. Accordingly, sustained educational initiatives for operators and warehouse teams are imperative to ensure operational consistency. Training programs ought to cover the essential concepts of the SKD, field-level troubleshooting approaches, and strategic responses to distribution-related disturbances. In addition to initial training sessions, routine refresher programs should be conducted to ensure a shared understanding among team members and consistent operational performance.

Further Research on Efficiency Decline Factors

Although delivery efficiency remained above the defined standard, the downward trend observed over the three-month period indicates the need for a deeper investigation into its underlying causes. Further research could focus on warehouse team performance, operator workload, lead time effectiveness, and operational constraints such as fluctuating demand. The insights obtained from this study contribute to a comprehensive understanding of the key determinants of system efficiency and lay the groundwork for strategic planning aimed at developing a more adaptive and sustainable material distribution framework. By implementing these recommendations, PT. Yageo TMSS Indonesia is projected to uphold and further optimize the performance of its Kanban system to guarantee efficient, timely, and resilient material delivery in support of uninterrupted production operations.

REFERENCES

Azis, A. M., & Irjayanti, M. (2024). Strengthening the accuracy and visibility of supply chain management data in the coffee industry. *Cogent Business & Management*, *11*(1). https://doi.org/10.1080/23311975.2024.2380811

Barella, Y., Fergina, A., Mustami, M. K., Rahman, U., & Alajaili, H. M. A. (2024). Quantitative Methods in Scientific Research. *Jurnal Pendidikan Sosiologi Dan Humaniora*, *15*(1), 281. https://doi.org/10.26418/j-psh.v15i1.71528

Das, A. K., & Das, M. C. (2023). Productivity improvement using different lean approaches in small and medium enterprises (SMEs). *Management Science Letters*, *13*(1), 51–64. https://doi.org/10.5267/j.msl.2022.9.002

Fuentes-del-Burgo, J., Ruiz Fernandez, J. P., & Navarro-Astor, E. (2024). Kanban applied to construction: a literature review. *Construction Economics and Building*, *24*(4/5). https://doi.org/10.5130/AJCEB.v24i4/5.8642

Gehringer, A. (2023). *On-Time Delivery KPIs: Examples to Improve On-Time Delivery for Manufacturing*. https://www.rhythmsystems.com/blog/improve-delivery-kpis-how-to

Habib, M., Kabir, M. A., & Zheng, L. (2025). *LEISA: A Scalable Microservice-based System for Efficient Livestock Data Sharing*. http://arxiv.org/abs/2501.14781

Hardani, A., Ustiawaty, J., & Juliana Sukmana, D. (2020). *Buku Metode Penelitian Kualitatif & Kuantitatif*. https://www.researchgate.net/publication/340021548

Heizer, J., Render, B., & Munson, C. (2020). *Operations management : sustainability and supply chain management*. Pearson.

Hendayani, R., Majid, A. A., & Anggadwita, G. (2025). Criteria of Supplier Selection for a Small Coffee Shop Business. *The 8th International Seminar and Conference on Learning Organisation*.

Marques, P. A., Jorge, D., & Reis, J. (2022). Using Lean to Improve Operational Performance in a Retail Store and E-Commerce Service: A Portuguese Case Study. *Sustainability (Switzerland)*, *14*(10). https://doi.org/10.3390/su14105913

Mossa, Y., Smith, P., & Bland, K. (2025). Reconceptualizing Enterprise Resource Planning (ERP) Systems from a Software Architecture Perspective Using a Framework Based on ERP System Characteristics. *Procedia Computer Science*, *256*, 174–189. https://doi.org/10.1016/j.procs.2025.02.110

Popa, A. M., & Gupta, K. (2024). USING LEAN MANUFACTURING TO IMPROVE PROCESS EFFICIENCY IN A FABRICATION COMPANY. *Applied Engineering Letters*, *9*(3), 172–184. https://doi.org/10.46793/aeletters.2024.9.3.5

PT. Yageo TMSS Indonesia. (2024). *Implementation Kanban Project*.

Siregar, K. R., & Rachman, A. A. (2024). *Importance-Performance Between Mobile Service Shopping Quality and Zalora Customer Loyalty* (pp. 107–129). https://doi.org/10.2991/978-94-6463-558-4_7

Stevenson, & William J. (n.d.). *Operations Management Save time with the right summary on*.

Womack, J. P., & Jones, D. T. (2003). *Lean Thinking: Banish Waste and Create Wealth in Your Corporation* (2nd ed.). Free Press, Simon \& Schuster. https://www.researchgate.net/publication/200657172_Lean_Thinking_Banish_Waste_and_Create_Wealth_in_Your_Corporation