International Journal of Management Science and Information Technology
IJMSIT

E-ISSN: 2774-5694 P-ISSN: 2776-7388 OPEN ACCESS

Volume 6 (2), July-December 2026, 2459-2468
DOI: https://doi.org/10.35870/ijmsit.v6i2.8533

Application of Lean Logistics Framework to Enhance Inventory System Efficiency in SMEs

Stelly Julia Macpal [1*], Muhammad Nana Trisolvena [2], Andi [3]

[1*] Development Economics Study Program, STIE Bukit Zaitun, Sorong City, Southwest Papua Province, Indonesia.
[2] Industrial Engineering Study Program, Faculty of Engineering, Universitas Muhammadiyah Cirebon, Cirebon Regency, West Java Province, Indonesia.
[3] Tax Administration Study Program, Faculty of Economics and Business, Universitas Sultan Ageng Tirtayasa, Serang City, Banten Province, Indonesia.

Email: stellyjulia1707@gmail.com [1*], nana.trisolvena@umc.ac.id [2], andiplg69@untirta.ac.id [3]

Article history:
Received August 25, 2026
Revised September 11, 2026
Accepted September 12, 2026

Abstract

Managing inventory effectively remains a significant challenge for Small and Medium Enterprises (SMEs), especially when processes for recording, storing, and procuring lack a structured control system. Such deficiencies can result in mismatches between physical stock and administrative records, prolonged product search times, and inaccuracies in identifying purchasing needs. This study investigates the implementation of a Lean Logistics framework rooted in Lean Six Sigma DMAIC (Define, Measure, Analyze, Improve, Control) to enhance inventory efficiency in SMEs. Utilizing a descriptive analytical approach, data were gathered through observations of procurement activities, goods receipt, storage, stock recording, product distribution, interviews with owners and employees, and inventory documentation. Performance metrics included Inventory Turnover (IT), Inventory Record Accuracy (IRA), Mean Absolute Percentage Error (MAPE), and Lead Time. Results indicate that adopting Lean Logistics practices, such as 5S, Kanban, demand forecasting, and inventory control, led to notable improvements. Inventory Turnover rose from 2.18 to 4.35 times per year, IRA increased from 79.5% to 95.8%, MAPE decreased from 23.8% to 8.9%, and Lead Time was reduced from 5 days to 2 days.

Keywords:
Lean Logistics; Lean Six Sigma; DMAIC; Inventory Management; Small and Medium Enterprises (SMEs).

1. INTRODUCTION

Small and Medium Enterprises (SMEs) serve as a vital pillar in Indonesia's economy, contributing significantly to job creation and local economic growth. However, many SMEs encounter challenges in managing efficient inventory systems. The inability to optimize inventory management often hinders competitiveness. The implementation of a lean logistics framework presents a relevant solution to these issues. By focusing on waste reduction and enhancing the flow of goods, this approach can assist SMEs in optimizing their inventory processes. Adopting lean principles has the potential to lower operational costs while improving product delivery speed to customers. This research aims to analyze how the application of a lean logistics framework can enhance inventory system efficiency in SMEs. A better understanding of this application is expected to empower SMEs to strengthen their market position in an increasingly competitive landscape.

The urgency of implementing lean logistics in SMEs is heightened amid intense competition. By concentrating on waste reduction and efficiency improvement, SMEs can optimize existing processes, thereby enhancing their competitiveness. Research by Raeesah Wahlullizar et al. (2026) indicates that Lean Six Sigma methods effectively reduce waste and improve logistics systems. Although these findings are primarily applied in the healthcare sector, the proposed principles hold broad relevance across various business types, including SMEs. Hu et al. (2015) suggest that by applying a lean approach, SMEs can identify and eliminate non-value-adding activities, allowing for more efficient resource allocation. This has the potential to lower operational costs while enhancing product and service quality. Consequently, SMEs can not only meet customer expectations but also solidify their positions in a competitive market.

In a rapidly evolving business landscape, SMEs must adapt swiftly to changing market demands. The lean logistics approach offers a viable solution for achieving better operational efficiency. Afriana et al. (2023) explain that applying Lean Six Sigma in hospital management can enhance performance while reducing waste. These findings suggest that leveraging data-driven approaches enables SMEs to make more accurate decisions responsive to customer needs. Noel et al. (2026) emphasize that by adopting lean principles, SMEs can analyze existing processes, identify areas for improvement, and eliminate non-value-adding activities. This process not only enhances efficiency but also contributes to improved product and service quality. As a result, SMEs can boost customer satisfaction and strengthen their market position. With the right approach, SMEs can achieve sustainable success in a dynamic business environment.

Waste management poses a significant challenge for SMEs. Cholifaturochmah et al. (2022) describe how Lean Six Sigma implementation at UMKM Arryna Raya successfully reduced waste in the hijab production process. This success highlights the importance of waste identification and management in enhancing operational efficiency. By minimizing waste, SMEs can not only lower production costs but also improve the quality of their products. This quality enhancement contributes to customer satisfaction, a key factor in retaining loyalty and attracting new customers. Additionally, effective waste management has a positive environmental impact, which is increasingly important to society today. Therefore, the application of methods like Lean Six Sigma provides economic benefits for SMEs while supporting sustainability and social responsibility within the industry. This makes waste management a crucial aspect of SME business strategies. In the healthcare sector, Kam et al. (2021) illustrate the use of Lean Six Sigma techniques to enhance efficiency in ophthalmology clinics. While focused on healthcare services, these findings provide insight into how SMEs in other sectors can apply similar principles to improve services and efficiency.

Digitalization also plays a crucial role in enhancing the efficiency of SME logistics systems. Rhiswandi et al. (2026) examine efficiency improvements through inventory digitalization and assistance at De'Chick Kiarapedes. The research indicates that digitalization aids SMEs in managing inventory more effectively, enabling quicker responses to market demands. By leveraging digital technology, SMEs can enhance visibility and control over inventory, reducing the risks of stockouts or excess inventory. Wahyudi et al. (2025) investigate the implementation of lean management to improve efficiency and profitability for SMEs in Banjar Regency. This study shows that applying lean principles is not solely about cost reduction but also about enhancing product and service quality. By adopting lean management, SMEs can increase customer satisfaction, positively impacting profitability. Improved product and service quality creates essential differentiation for SMEs' success in the market.

Barriers to implementing lean methods must be a primary concern for SMEs. Pamungkas et al. (2021) identify various challenges faced, such as a lack of understanding of lean concepts and resource limitations. This lack of understanding often prevents SMEs from effectively executing lean practices. Therefore, it is crucial for SMEs to receive appropriate support and relevant training. Educational programs tailored for SMEs can enhance knowledge of lean principles and their application in business. Serna-Ampuero et al. (2022) indicate that with proper training, SMEs can better prepare to face existing challenges and implement lean strategies with confidence. This not only improves operational efficiency but also allows SMEs to adapt to market changes and strengthen their positions in an increasingly competitive industry. Through this approach, SMEs can achieve sustainable success.

A lean logistics-based management model has also been proposed to enhance services in SMEs. Massoni Gonzales et al. (2023) presents a management model that integrates lean warehousing and lean logistics to improve services in hardware stores. This approach demonstrates that by optimizing warehouse and logistics management, SMEs can enhance customer experience and operational efficiency. By implementing an integrated management model, SMEs can create a system that is more responsive to customer needs. Díaz-Estela et al. (2025) emphasize the importance of lean logistics-based warehouse management to reduce order inaccuracies in metal-mechanical SMEs. This research shows that applying a lean-based management model can help SMEs reduce order fulfillment errors. By decreasing error rates, SMEs not only enhance operational efficiency but also build a positive reputation among customers.

The application of a lean logistics framework in SMEs presents significant opportunities for improving inventory system efficiency. By adopting lean principles, SMEs can reduce waste, increase delivery speed, and optimize operational processes. However, achieving desired outcomes requires a deep understanding of lean concepts and a commitment to addressing potential barriers. Through planned efforts and adequate support, SMEs can harness the potential of lean logistics to achieve sustainable competitive advantage.

2. RESEARCH METHOD

This study adopts the Lean Six Sigma framework, specifically the DMAIC (Define, Measure, Analyze, Improve, Control) methodology, to enhance the efficiency of inventory systems within Small and Medium

Enterprises (SMEs). The Lean approach is particularly relevant as it enables organizations to pinpoint activities that do not add value, minimize waste, and improve operational effectiveness. In the SME sector, implementing Lean requires a systematic strategy due to constraints in resources, organizational readiness, and the ability to adapt, all of which play a crucial role in determining the success of the initiative (Hu et al., 2015; AlManei et al., 2017). The structured nature of the DMAIC process facilitates a thorough examination of issues, beginning with problem identification and progressing through measurement, analysis, solution design, and ongoing control of results. This integration of data-driven decision-making with waste reduction strategies is recognized for its effectiveness in process enhancement (Noel et al., 2026).

The research unfolds through five key stages. The Define stage focuses on identifying challenges within the inventory system through operational observations, stakeholder interviews, and document analysis. The Measure stage assesses the initial state of the system using relevant performance indicators. During the Analyze stage, the aim is to uncover root causes of inefficiencies using Lean Logistics principles. The Improve stage involves crafting strategies that incorporate methodologies such as 5S, Kanban, demand forecasting, and inventory control. Finally, the Control stage emphasizes the establishment of standard operating procedures and performance monitoring to ensure improvements are maintained. Data collection encompasses direct observations of inventory activities, interviews with SME owners and employees, and documentation related to purchasing, sales, inventory levels, and storage practices. Utilizing operational data is essential in Lean implementation, as decisions must be grounded in the actual dynamics of business processes and activity patterns within the organization (Novais et al., 2020).

2.1. Lean Six Sigma DMAIC Framework Integrated with Lean Logistics

The research framework emerges from the integration of Lean Six Sigma DMAIC with Lean Logistics principles to bolster inventory efficiency in SMEs. This synthesis aims for waste reduction, enhanced accuracy in inventory information, improved material flow, and more effective procurement processes. The Lean Logistics approach has demonstrated its capacity to assist organizations in refining inventory management by controlling the flow of goods, increasing information visibility, and eliminating non-value-adding activities (Noel et al., 2026; Serna-Ampuero et al., 2022). Initial challenges analyzed include discrepancies between physical stock and inventory records, excessive product search times, disorganized storage practices, inaccuracies in purchasing planning, and imbalances between inventory levels and customer demand. Such issues are prevalent in SMEs where inventory management often relies on manual methods and has yet to fully embrace data-driven control mechanisms (Hu et al., 2015).

The Define stage is utilized to clarify the primary issues and the scope of the research. The Measure stage aims to capture the actual conditions of the inventory system based on performance indicators. The Analyze stage seeks to identify root causes of inefficiencies through waste analysis within the inventory process. The Improve stage implements Lean Logistics strategies utilizing 5S, Kanban, demand forecasting, and inventory control methods. The Control stage focuses on monitoring performance indicators to ensure consistent improvement. The framework for Lean implementation in SMEs must align methods with organizational characteristics, as the success of these initiatives is heavily influenced by resource readiness and the capacity to sustain operational standards (Belhadi & Touriki, 2016; Wanitwattanakosol & Sopadang, 2012).

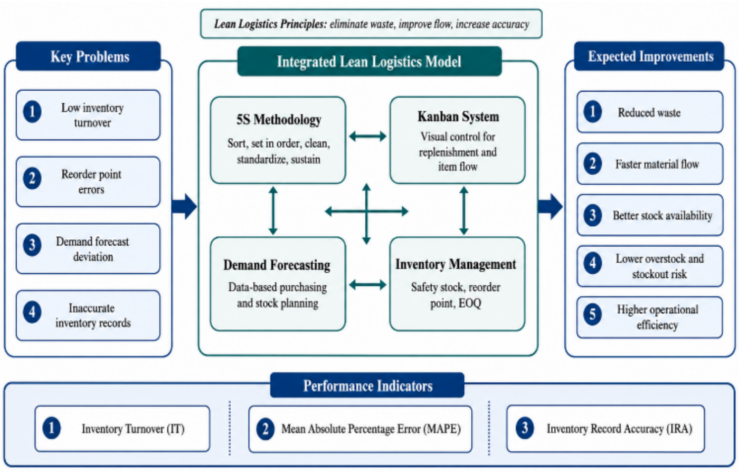

Figure 1. Lean Six Sigma DMAIC Framework Integrated with Lean Logistics for Enhancing Inventory Efficiency in SMEs

Figure 1 illustrates the application flow of the DMAIC method in improving inventory systems within SMEs. The research stages commence with problem identification, followed by initial condition measurement, waste cause analysis, implementation of improvement strategies, and result control. The integration of Lean

Logistics is particularly relevant during the Analyze and Improve stages, focusing on the elimination of non-value-adding activities and enhancing inventory management effectiveness.

2.2. Stages of the DMAIC Method

The DMAIC stages (Define, Measure, Analyze, Improve, Control) provide a systematic approach to improving inventory system performance in SMEs through Lean Logistics principles. The first stage, Define, aims to understand operational conditions and pinpoint the main issues affecting the effectiveness of inventory management. Identification is achieved through direct observation of procurement, goods receipt, storage, stock recording, and product distribution activities. Additional insights are gathered through interviews with business owners and employees involved in inventory processes. The Measure stage establishes a baseline performance of the inventory system prior to implementing improvement strategies. Measurements are conducted using indicators such as Inventory Turnover (IT), Inventory Record Accuracy (IRA), Lead Time, and stock availability levels. These indicators serve as a common approach in evaluating Lean Inventory, effectively depicting stock utilization, recording accuracy, and the speed of fulfilling customer demands (Serna-Ampuero et al., 2022). The Analyze stage identifies the root causes of inefficiencies in the inventory system through Lean Logistics principles. This analysis focuses on non-value-adding activities, including waiting times, excess inventory, ineffective material handling, recording errors, and prolonged product search processes. Root cause identification employs the Fishbone Diagram, while Pareto analysis prioritizes improvements based on the most significant factors influencing inventory issues.

2.3. Evaluation Indicators for the Model

The success of implementing Lean Six Sigma DMAIC based on Lean Logistics is evaluated using several key performance indicators: Inventory Turnover (IT), Mean Absolute Percentage Error (MAPE), and Inventory Record Accuracy (IRA). These indicators measure performance changes in the inventory system before and after the implementation of improvement strategies. Inventory Turnover (IT) quantifies the rate of inventory turnover over a specific period, calculated using the formula:

$$IT = \frac{Cost\ of\ Goods\ Sold}{Average\ Inventory}$$

A high Inventory Turnover value indicates effective inventory utilization, thereby minimizing the risk of stock accumulation and storage costs. Moreover, Mean Absolute Percentage Error (MAPE) assesses the accuracy of demand forecasting by comparing the difference between actual demand and predicted results, calculated using the formula:

$$\text{MAPE} = \frac{\text{Actual Demand} - \text{Forecast Demand}}{\text{Actual Demand }|} \times 100\%.$$

A low MAPE value signifies that the forecasting method has a smaller error rate, thereby supporting more accurate purchasing and inventory planning decisions. The final indicator, Inventory Record Accuracy (IRA), measures the alignment between physical stock levels and inventory records, calculated using the formula:

$$\text{IRA} = \frac{\text{Jumlah Catatan Persediaan Akurat}}{\text{Total Catatan Persediaan}} \times 100\%.$$

A high IRA value reflects a robust inventory recording and control system, ensuring that stock information serves as a reliable basis for operational decision-making. These three indicators form the foundation for evaluating the effectiveness of Lean Six Sigma DMAIC implementation based on Lean Logistics in enhancing inventory system efficiency in SMEs (Novais et al., 2020; Serna-Ampuero et al., 2022).

3. RESULTS AND DISCUSSION

3.1. Results

3.1.1. Define: Identifying Inventory System Issues

The Define stage focuses on assessing the initial state of the inventory system and identifying the challenges that impact operational efficiency within SMEs. Data collection involved observing procurement activities, goods receipt, storage, stock recording, and product distribution. Observations indicated that the inventory systems in SMEs encounter several obstacles, particularly in stock control and storage practices. The reliance on manual inventory recording leads to discrepancies between physical stock and administrative records. Additionally, product placement does not reflect usage levels, resulting in longer search times for items. Further issues arise in the procurement process, where purchasing decisions are made based on estimates rather than historical demand patterns. This approach often results in excess inventory for certain products and stock shortages for those with high demand. The primary issues identified in the inventory system are summarized in Table 1.

Table 1. Identification of Initial Inventory System Issues

No	Issue	Cause	Impact
1	Discrepancies between physical stock and records	Non-standardized recording	Inaccurate purchasing decisions
2	Long product search times	Non-optimal storage layout	Increased operational activities
3	Purchases not based on demand patterns	Lack of forecasting methods	Overstock and stockouts
4	Absence of minimum stock levels	Lack of control systems	Delayed reorder timing

The initial inventory system still has several weaknesses that affect daily operations. Differences between physical stock and records stem from unstandardized recording, which can lead to poor purchasing decisions. Slow product searching comes from an inefficient storage layout and adds unnecessary work. Purchases are not guided by demand patterns because forecasting is not used, creating overstock and shortages. The absence of minimum stock levels also delays reordering.

3.1.2. Measure: Assessing Initial Inventory System Performance

The Measure stage aims to establish a baseline performance of the inventory system prior to implementing Lean Logistics improvements. Measurements were taken using indicators such as Inventory Turnover (IT), Mean Absolute Percentage Error (MAPE), Inventory Record Accuracy (IRA), and Lead Time. Data was gathered from sales, purchasing records, and storage activities throughout 2025. The results of these initial measurements are displayed in Table 2.

Table 2. Initial Performance Measurement of the Inventory System

Indicator	Initial Result	Target Standard
Inventory Turnover (IT)	2.18 times/year	> 4 times/year
Inventory Record Accuracy (IRA)	79.5%	> 95%
MAPE	23.8%	< 10%
Order Fulfillment Lead Time	5 days	< 3 days

The Inventory Turnover value of 2.18 times per year reflects a low turnover rate, indicating that some products remain in storage longer than necessary. The IRA of 79.5% reveals discrepancies between physical stock and recorded data, complicating the determination of actual inventory levels. Furthermore, the MAPE of 23.8% suggests that previous planning methods were inadequate for accurate demand forecasting, leading to significant uncertainty in purchasing decisions.

3.1.3. Analyze: Identifying Waste Causes

The Analyze stage investigates the root causes of inventory system issues through the lens of Lean Logistics. This analysis focuses on identifying non-value-adding activities. Observations uncovered various types of waste prevalent within the inventory system.

Table 3. Identification of Waste in the Inventory System

Type of Waste	Observed Conditions	Impact
Waiting	Extended product search times	Increased service times
Excess Inventory	Certain products stored beyond need	Rising storage costs
Motion	Inefficient worker movements	Decreased productivity
Defect	Errors in stock recording	Inaccurate inventory data
Transportation	Repeated movements of products	Increased processing time

The inventory system still shows several types of waste that weaken performance. Long product search times create waiting and slow down service. Some items are stored longer than needed, which raises storage costs. Inefficient worker movement reduces productivity, while stock recording errors lead to unreliable data. Repeated product movements also increase processing time and make operations less efficient.

3.1.4. Improve: Implementing Lean Logistics Solutions

The Improve stage is carried out based on the issues identified in the analysis. Improvements are applied through 5S, Kanban, demand forecasting, and inventory control to make the workflow more orderly, reduce waste, and strengthen response speed. These actions are expected to support better logistics performance and create more reliable operational results.

3.1.4.1. Implementation of 5S and Kanban

Improvements in the storage system were achieved through the implementation of the 5S method and Kanban to enhance organization and inventory control. The Seiri stage involved sorting active from inactive products, resulting in the removal of 32 unused items from the main warehouse area. The Seiton stage focused on organizing storage locations according to demand levels, ensuring frequently used products are easily accessible. The Seiso, Seiketsu, and Shitsuke stages were implemented by establishing cleanliness standards, labeling storage locations, and conducting regular compliance checks. The Kanban system was introduced using stock control cards to set minimum inventory levels and streamline replenishment processes. The results of the 5S and Kanban implementation are presented in Table 4.

Table 4. Results of 5S and Kanban Implementation

Parameter	Before	After
5S Audit Score	40%	90%
Product Search Time	15 minutes	5 minutes
Picking Errors	10 cases/month	2 cases/month
Storage Location Discrepancies	25 items	4 items

The results of implementing 5S and Kanban reveal substantial improvements in operational performance. The 5S audit score rose dramatically from 40% to 90%, indicating a significant enhancement in workplace organization. Product search time was cut from 15 minutes to 5 minutes, showcasing increased efficiency. Additionally, picking errors decreased from 10 cases per month to just 2, while storage location discrepancies fell from 25 items to 4. These changes reflect the positive impact of these methodologies on overall productivity.

3.1.4.2. Enhancing Purchasing Planning through Demand Forecasting

To improve purchasing planning, historical sales data was carefully analyzed to identify the most effective forecasting methods. Three approaches were assessed: Moving Average, Weighted Moving Average, and Exponential Smoothing. This evaluation aimed to pinpoint which method delivers the most accurate predictions, thereby enhancing inventory management. The findings from this analysis are vital for refining purchasing strategies and ensuring that stock levels meet actual demand efficiently.

Table 5. Comparison of MAPE Values for Forecasting Methods

Product	Moving Average	Weighted Moving Average	Exponential Smoothing
Product A	12.5%	8.4%	10.1%
Product B	18.2%	13.7%	15.4%
Product C	15.6%	10.9%	12.8%

The comparison of MAPE values for different forecasting methods reveals notable variations in accuracy across three products. For Product A, the Moving Average method results in a MAPE of 12.5%, while the Weighted Moving Average significantly reduces this to 8.4%, indicating a more reliable forecast. Exponential Smoothing offers a MAPE of 10.1%. For Product B, the Moving Average shows a higher MAPE of 18.2%, compared to 13.7% for the Weighted Moving Average and 15.4% for Exponential Smoothing. Finally, Product C demonstrates MAPE values of 15.6%, 10.9%, and 12.8%, respectively, highlighting the effectiveness of the Weighted Moving Average across all products.

3.1.4.3. Inventory Control

Effective inventory control is essential for optimizing stock management within the organization. To achieve this, calculations for Safety Stock, Reorder Point, and Economic Order Quantity (EOQ) were meticulously conducted. These metrics provide a framework for maintaining optimal inventory levels, reducing carrying costs, and ensuring that products are available when needed. The outcomes of these calculations are detailed in Table 6, offering valuable insights into the stock management strategies necessary for enhancing operational efficiency and responsiveness to market demands.

Table 6. Inventory Control Calculations

Product	Safety Stock	Reorder Point	EOQ
Product A	45 units	150 units	280 units
Product B	60 units	210 units	350 units
Product C	35 units	130 units	220 units

The inventory control calculations for three products provide key metrics for effective stock management. Product A requires a safety stock of 45 units, with a reorder point of 150 units and an Economic Order Quantity (EOQ) of 280 units. For Product B, the safety stock is set at 60 units, the reorder point at 210 units, and the EOQ at 350 units. Lastly, Product C maintains a safety stock of 35 units, a reorder point of 130 units, and an

EOQ of 220 units. These figures are vital for maintaining optimal inventory levels and ensuring timely restocking.

3.1.5. Control: Evaluating Improvement Results

The Control stage ensures that the outcomes of Lean Logistics implementation are maintained within the operational activities of SMEs through regular performance monitoring. Evaluation involves comparing the inventory system conditions before and after the DMAIC method application. This comparison assesses performance changes based on inventory indicators, such as stock turnover rates, recording accuracy, forecasting precision, and order fulfillment lead times. The evaluation results provide a basis for confirming that improvement strategies are consistently applied and capable of fostering ongoing enhancements in inventory system efficiency.

Table 7. Comparison of Inventory System Performance

Indicator	Before Improvement	After Improvement	Change
Inventory Turnover	2.18	4.35	+99.5%
Inventory Record Accuracy	79.5%	95.8%	+20.5%
MAPE	23.8%	8.9%	-62.6%
Lead Time	5 days	2 days	-60%

The evaluation results demonstrate that the implementation of Lean Six Sigma DMAIC, grounded in Lean Logistics, significantly enhanced the inventory system performance of SMEs. Inventory turnover nearly doubled following the improvements. The accuracy of inventory recording improved from 79.5% to 95.8% due to the standardization of recording and stock control practices. The reduction in MAPE indicates that the forecasting methods employed have enhanced purchasing planning accuracy. Additionally, the decrease in lead time illustrates that improvements in warehouse layout and the Kanban system have expedited operational activities.

3.2. Discussion

The findings from this research indicate that implementing Lean Six Sigma DMAIC, rooted in Lean Logistics, effectively addresses various challenges within the inventory systems of SMEs, particularly regarding recording accuracy, storage efficiency, demand planning, and stock control. The initial issues identified during the Define stage reveal a reactive approach to inventory management, where procurement decisions rely on experience and estimates instead of being informed by data analysis. This reliance creates a mismatch between inventory levels and actual customer demand, increasing the likelihood of both overstock and stockouts. Such challenges are frequently observed in Lean implementations within the SME sector. Hu et al. (2015) point out that SMEs differ from larger enterprises in their resource constraints, undocumented management systems, and reliance on individual experience for decision-making. These factors complicate the processes of standardization and operational control.

In this study, a significant problem identified was the manual inventory recording system. The discrepancies between physical stock and administrative records reveal that inventory data lacks the necessary accuracy to support operational decisions. This inaccuracy can lead to mistakes in determining purchase quantities, reorder timing, and product procurement priorities. Serna-Ampuero et al. (2022) emphasize that effective inventory management in SMEs requires robust recording and control mechanisms to provide accurate stock information, as misinformation can directly affect fulfillment delays and operational costs. The initial measurements obtained during the Measure stage indicated that the inventory system's performance was below established targets. An Inventory Turnover rate of 2.18 times per year suggests that some inventory items are not being utilized efficiently. This low turnover rate indicates that certain products remain in storage for extended periods, tying up working capital in inventory. In Lean Inventory terms, this situation exemplifies waste in the form of excess inventory, which should be minimized as it does not add value to business activities. Additionally, the Inventory Record Accuracy of 79.5% indicates discrepancies between recorded data and actual stock levels. Such inaccuracies hinder SMEs' ability to respond effectively to market demand fluctuations. Serna-Ampuero et al. (2022) assert that improving inventory record accuracy is vital for reducing order fulfillment errors and enhancing warehouse management effectiveness.

The MAPE value of 23.8% further suggests that previous purchasing planning methods were inadequate in generating accurate demand predictions. A dependence on estimates without thorough demand pattern analysis results in high uncertainty in procurement decisions. In a Lean Logistics framework, inventory decisions should be based on real-time information to align stock levels with customer needs. Novais et al. (2020) explain that integrating information systems, logistics management, and supply chain coordination can enhance a company's ability to control material flows and improve operational performance. The Analyze stage revealed that waste originated from several non-value-adding activities, such as prolonged product search times, repeated movements of goods, recording errors, and unnecessary storage of products. These findings indicate that inventory challenges arise not only from stock levels but also from how materials move and how inventory information is managed. The Fishbone Diagram analysis highlighted that factors such as human resources, work methods, technology, and storage environment contribute to waste generation. Human factors relate to a lack of understanding of recording and stock control procedures. Methodological issues involve the absence of standardized processes for storage and reorder practices. Technological factors pertain to simple recording systems that fail to provide timely information. Meanwhile, environmental factors concern warehouse layouts that do not facilitate efficient material flow.

These findings reinforce the research by AlManei et al. (2017), which indicates that Lean implementation in SMEs often faces barriers related to technology readiness, organizational culture, and the ability to maintain work standards. Thus, adopting Lean practices requires more than just applying specific tools; it necessitates a transformation in work systems that can sustain continuous improvement processes. The Improve stage demonstrated that implementing the 5S and Kanban methods positively impacted storage area management. The increase in the 5S audit score from 40% to 90% indicates that improvements in layout and storage standardization foster a more organized working environment. Separating active and inactive products during the Seiri stage reduced congestion in storage areas, while organizing locations based on usage levels in the Seiton stage accelerated item retrieval processes. The reduction in product search time from 15 minutes to 5 minutes illustrates that enhancements in warehouse layout directly influence operational efficiency. These results align with the research by Ambrosio-Flores et al. (2022), which shows that integrating Lean Warehousing with warehouse management improves order fulfillment accuracy by minimizing inefficient activities. The Lean Warehouse approach has also proven effective in refining picking processes, reducing operational errors, and enhancing material flow organization.

The application of the Kanban system transformed inventory control mechanisms. Before improvements, SMEs lacked minimum stock thresholds, leading to purchasing decisions made only after stock shortages occurred. By utilizing stock control cards, replenishment needs can now be determined based on actual inventory conditions. This approach aligns with Just-In-Time principles, emphasizing inventory control based on real needs to minimize unnecessary storage (Dowlatshahi & Taham, 2009). Subsequent improvements were achieved through the implementation of demand forecasting methods. Testing revealed that the Weighted Moving Average method produced the lowest error values compared to other approaches. The decrease in MAPE from 23.8% to 8.9% demonstrates that leveraging historical data significantly enhances purchasing planning accuracy. This outcome illustrates that integrating data analysis with Lean principles assists SMEs in reducing demand uncertainty. Chen (2026) notes that applying Lean strategies in SMEs in developing countries requires a combination of Lean methods, operational analytical capabilities, and adaptations to organizational conditions. Data-driven approaches become increasingly vital as SMEs face rapid market demand changes and require more flexible decision-making systems. The Control stage illustrated that improvement results can be sustained through regular monitoring of performance indicators. The increase in Inventory Turnover from 2.18 to 4.35 indicates that inventory is being utilized more effectively. The improvement in Inventory Record Accuracy from 79.5% to 95.8% reflects that standardized recording practices enhance the quality of stock information. Additionally, the reduction in Lead Time from 5 days to 2 days demonstrates that enhancements in layout, the Kanban system, and inventory control expedite operational processes.

4. CONCLUSION

This study illustrates that implementing a Lean Logistics framework grounded in Lean Six Sigma DMAIC can significantly enhance the efficiency of inventory systems in SMEs through a structured approach focused on performance measurement. The initial assessment revealed that key issues within the inventory system arise from discrepancies between physical stock and administrative records, inefficient storage layouts, excessive product search times, and procurement processes that rely on estimates without proper demand analysis. These factors contribute to various forms of waste, including overstock, inaccurate purchasing decisions, and increased operational delays. The DMAIC methodology offers a clear framework for identifying root causes and developing targeted improvement strategies. The Analyze stage identified that human factors, work methods, technology, and storage environments are critical contributors to inefficiencies in the inventory system. Improvements were implemented through the application of 5S, Kanban, demand forecasting, and inventory control techniques, including Safety Stock, Reorder Point, and Economic Order Quantity. These strategies effectively enhanced warehouse organization, improved accuracy in record-keeping, and facilitated purchasing decisions based on actual demand. Final evaluations indicate notable improvements in inventory system performance after adopting Lean Logistics. The Inventory Turnover rate increased from 2.18 to 4.35 times per year, Inventory Record Accuracy rose from 79.5% to 95.8%, MAPE decreased from 23.8% to 8.9%, and Lead Time was reduced from 5 days to 2 days. These outcomes demonstrate that integrating Lean Six Sigma DMAIC with Lean Logistics provides SMEs with a viable approach to minimize waste, enhance inventory control, and create more efficient and sustainable operational frameworks.

REFERENCES

Afriana, W., Zulyani, F., & Kurniawan, T. (2023). Application of Lean Six Sigma method in hospital management process: Performance optimization and waste reduction. ENDLESS: International Journal of Futures Studies, 6(3). https://doi.org/10.54783/endlessjournal.v6i3.212

AlManei, M., Salonitis, K., & Xu, Y. (2017). Lean implementation frameworks: the challenges for SMEs. Procedia Cirp, 63, 750-755.

Ambrosio-Flores, K. L., Lazo-de-la-Vega-Baca, M., Quiroz-Flores, J. C., & Cabrera-Gil-Grados, E. (2022, October). Warehouse management model integrating BPM-Lean Warehousing to increase order fulfillment in SME distribution companies. In 2022 8th International Engineering, Sciences and Technology Conference (IESTEC) (pp. 17-24). IEEE. https://10.1109/IESTEC54539.2022.00012

Belhadi, A., & Touriki, F. E. (2016). A framework for effective implementation of lean production in small and medium-sized enterprises. Journal of Industrial Engineering and Management, 9(3), 786-810. https://doi.org/10.1016/j.ajsl.2024.02.003

Chen, C. K. (2026). Lean strategy implementation in SME manufacturing in developing countries: a systematic literature review. International Journal of Lean Six Sigma, 1-24. https://doi.org/10.1108/IJLSS-06-2025-0161

Cholifaturochmah, Widyaningrum, D., & Jufriyanto, M. (2022). Upaya mengurangi waste pada produksi kerudung dengan penerapan metode Lean Six Sigma di UMKM Arryna Raya. JISI: Jurnal Integrasi Sistem Industri, 9(1), 37–45. https://doi.org/10.24853/jisi.9.1.37-45

Díaz-Estela, C. M., Atao-Carrasco, J. D., & Calderón-Gonzales, W. D. (2025). Lean logistics-based warehouse management model to reduce non-conforming orders in a metal-mechanic SME: A case study in Peru. International Research Journal of Economics and Management Studies IRJEMS, 4(4). https://doi.org/10.56472/25835238/IRJEMS-V4I4P118

Dowlatshahi, S., & Taham, F. (2009). The development of a conceptual framework for Just-In-Time implementation in SMEs. Production planning and control, 20(7), 611-621. https://doi.org/10.1080/09537280903034305

Hu, Q., Mason, R., Williams, S. J., & Found, P. (2015). Lean implementation within SMEs: a literature review. Journal of Manufacturing Technology Management, 26(7), 980-1012. https://doi.org/10.1108/JMTM-02-2014-0013

Kam, A. W., Collins, S., Park, T., Mihail, M., Stanaway, F. F., Lewis, N. L., Polya, D., Fraser-Bell, S., Roberts, T. V., & Smith, J. E. H. (2021). Using Lean Six Sigma techniques to improve efficiency in outpatient ophthalmology clinics. BMC Health Services Research, 21(1). https://doi.org/10.1186/s12913-020-06034-3

Lefebvre, V. (2025). Navigating challenges: lean inventory management and SMEs performance during the COVID-19 crisis and beyond. Small Business Economics, 64(4), 1901-1927. https://doi.org/10.1007/s11187-024-00969-1

Lemberger, I. (2025). Optimising Inventory Management to Enhance Operational Efficiency: gaining advantages in manufacturing start-ups and SMEs. https://urn.fi/URN:NBN:fi:amk-2025112529548

Lezama-Colantes, F. A., Rojas-Núñez, S. S., Chavez-Ugaz, R., & Leon-Chavarri, C. C. (2025). A Lean Warehousing Approach to Improve OTIF in a Peruvian HVAC Distribution SME. LACCEI, 2(13). https://doi.org/10.18687/LEIRD2025.1.1.793

Massoni Gonzales, A. M., Alzamora Pachacama, M., & Taquía Gutiérrez, J. A. (2023). Management model based on lean warehousing & lean logistic to increase the level of service in smes in a hardware store. In Industrial Engineering and Applications: Proceedings of the 10th International Conference on Industrial Engineering and Applications (ICIEA 2023), April 4–6, 2023, Phuket, Thailand (pp. 149-160). 1 Oliver's Yard, 55 City Road, London, EC1Y 1SP: SAGE Publications. https://doi.org/10.3233/ATDE230040

Nadeem, S. P., Garza-Reyes, J. A., & Anosike, A. I. (2025). A C-Lean framework for deploying Circular Economy in manufacturing SMEs. Production Planning & Control, 36(5), 650-670. https://doi.org/10.1080/09537287.2023.2294307

Noel, A., Buics, L., & Sós, E. (2026). Unlocking Lean Potential in SME Logistics and Supply Chains: A Study on Commitment, Tools, and Outcomes Through a Systematic Review and Survey Analysis. Logistics, 10(8), 174. https://doi.org/10.3390/logistics10080174

Novais, L., Maqueira Marin, J. M., & Moyano-Fuentes, J. (2020). Lean production implementation, cloud-supported logistics and supply chain integration: interrelationships and effects on business performance. The International Journal of Logistics Management, 31(3), 629-663. https://doi.org/10.1108/IJLM-02-2019-0052

Pamungkas, M. R., Maulina, E., & Purnomo, M. (2021). Identifikasi Hambatan Penerapan Lean di Usaha Kecil dan Menengah (UKM). Organum: Jurnal Saintifik Manajemen Dan Akuntansi, 4(2), 107–124.

Raeesah Wahlullizar, Alvamuna Khairani Sudarmadji, Rifa Neisya Azalia Putri, & Acim Heri Iswanto. (2026). Literature Review: Penerapan Lean Six Sigma dalam Mengurangi Pemborosan dan Meningkatkan Efisiensi Sistem Logistik Kesehatan. Jurnal Rumpun Ilmu Kesehatan, 6(2), 63–78. https://doi.org/10.55606/jrik.v6i2.6364

Rhiswandi, R., Masum, A., Vigo, A. N., Farid, M. A., Irsyad, M., & Septian, Z. (2026). Peningkatan Efisiensi Sistem Logistik UMKM melalui Pendampingan dan Digitalisasi Persediaan pada De'Chick Kiarapedes. SANISKALA: Jurnal Pengabdian Masyarakat, 4(1), 30–37. https://doi.org/10.31949/jsk.v4i1.16672

Serna-Ampuero, M. A., Arias-Navarro, M., & Quiroz-Flores, J. C. (2022, September). Inventory management model under the lean warehousing approach to reduce the rate of returns in SME distributors. In Proceedings of the 8th International Conference on Industrial and Business Engineering (pp. 103-108). https://doi.org/10.1145/3568834.3568894

Soriano, P. (2025). Developing a Lean implementation framework for SMEs through case research. Journal of Industrial Engineering and Management, 18(3), 373-393. https://doi.org/10.3926/jiem.7174

Wahyudi, W., Widiyanto, R.., Effendy, I. R.., & Maulana, A. J.. (2025). Implementasi Lean Management Dalam Peningkatan Efesiensi Operasional Dan Keuntungan Umkm Di Kabupaten Banjar. Jurnal Ekonomi Utama, 4(2), 429–440. https://doi.org/10.55903/juria.v4i2.292

Wanitwattanakosol, J., & Sopadang, A. (2012). A framework for implementing lean manufacturing system in small and medium enterprises. Applied Mechanics and Materials, 110, 3997-4003. https://doi.org/10.3926/jiem.1907