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# Integrating Lean Construction, Kaizen, and JIT for Procurement Process Improvement: A Case Study in Construction SMEs in Peru

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## Abstract

The Peruvian construction sector, especially its SMEs, faces critical inefficiencies in supply chain management, particularly in procurement processes. Past research has shown that these inefficiencies lead to significant cost overruns and delays. This study addressed these challenges by implementing a procurement model integrating Lean Construction, Kaizen, and Just-In-Time (JIT). The main challenges identified were excess material purchases (20.12% of cost overruns) and late deliveries (25.84% of operations). The model reduced late deliveries from 25.84% to 8.95% and purchasing errors from 8.49% to 3.33%, confirming its effectiveness. The research has substantial academic and socio-economic implications for Peruvian SMEs, providing a solution that enhances efficiency and reduces operational costs. Further research should explore broader applications of this model and strategies to promote sustainable procurement practices, encouraging professionals to develop innovative solutions in supply chain management.

## Keywords
Lean Construction, Kaizen, Just-in-Time, Procurement Optimization, Construction SMEs.

## 1. Introduction
Small and medium-sized enterprises (SMEs) in the construction sector are paramount globally, particularly in Latin America and Peru. This sector not only represents a significant proportion of employment but also serves as a vital engine for economic and social development. Globally SMEs in construction contribute approximately 80% of employment in the construction industry, underscoring their relevance in creating job opportunities and generating income (International Labour Organization 2017). In Latin America, this sector faces unique challenges, including informality and limited access to financing, which restrict its growth and sustainability (World Bank 2019). In Peru, SMEs in construction are responsible for a substantial portion of housing development, highlighting their critical role in improving infrastructure and meeting the housing needs of the population (Ministerio de Vivienda, Construcción y Saneamiento 2020). However, despite their importance, these companies often operate under adverse conditions, emphasizing the necessity to strengthen their operational and managerial capabilities.

The supply chain issues faced by SMEs in construction are multifaceted and complex. Inefficient procurement management can lead to the accumulation of excess materials, which not only increases costs but can also result in

significant waste (Kumar & Singh 2021). Furthermore, the cancellation of multiple purchase orders is a common phenomenon that arises from the lack of coordination in the preparation of measurements, causing delays in project execution (Baker et al. 2018). Human errors in the data entry of purchase orders also contribute to inefficiencies in the procurement process, generating confusion and misunderstandings between suppliers and construction firms (Cheng et al. 2020). The inadequate evaluation of suppliers is another critical factor that affects SMEs' ability to procure quality materials in a timely manner (Ogunlana et al. 2019). Many suppliers lack the necessary stock to meet the demands of SMEs, resulting in delays that can jeopardize project continuity (Hwang & Ng 2013). Additionally, the absence of standardization in the procurement process leads to unforeseen purchases, further increasing uncertainty and associated costs (Zhang et al. 2021). These delays in the procurement cycle reflect the urgent need for more efficient and systematic practices in supply chain management (Mokhtar et al. 2020).

Addressing these issues is crucial for the construction sector of SMEs, as efficient procurement management not only enhances the profitability of companies but also contributes to the sustainability of the sector as a whole. Implementing methodologies that optimize the procurement process can lead to a significant reduction in costs and an improvement in project quality (Sadeghi et al. 2021). Moreover, by tackling these challenges, SMEs can enhance their competitiveness in an increasingly demanding market where responsiveness and efficiency are key determinants of success (Khan et al. 2019). The adoption of tools such as Lean Construction, Just-In-Time (JIT), and strategic procurement management can transform the operational practices of SMEs, allowing for better planning and execution of projects (Ballard & Howell, 2003). These methodologies not only help minimize waste but also promote a culture of continuous improvement that is essential for sustainable growth in the sector (Womack & Jones 2003).

Despite the relevance of these topics, there exists a significant gap in the literature that specifically addresses the challenges and solutions for SMEs in construction in Latin America and Peru. Existing research tends to focus on large enterprises or contexts that do not reflect the realities faced by SMEs (González et al. 2020). This research aims to fill this gap by developing a production model that integrates Lean Construction tools, Kaizen, JIT, and strategic procurement management. In doing so, it seeks to provide a practical framework that construction SMEs can adopt to enhance their operational efficiency and responsiveness to market challenges (Mason et al. 2019). This approach will not only benefit individual companies but also contribute to strengthening the construction sector as a whole, promoting more sustainable and equitable development in the region (Bertelsen 2003).In conclusion, the importance of the SME construction sector globally, and particularly in Latin America and Peru, cannot be overstated. Despite the numerous challenges they face, the implementation of appropriate methodologies can transform their operations and improve their competitiveness. This research aims to address the existing knowledge gap and offer practical solutions that will enable these companies to thrive in an increasingly complex and competitive environment.

## 2. Literature Review

### 2.1 Lean Construction Methodology in the Supply Chain of SMEs

The application of Lean Construction methodology in the supply chain processes of small and medium-sized enterprises (SMEs) has garnered significant attention in recent years. Lean principles focus on minimizing waste while maximizing value, which is particularly relevant for SMEs that often operate with limited resources. (Dauda et al. 2023) highlight that the implementation of Lean practices can lead to substantial improvements in organizational performance by streamlining supply chain operations and enhancing efficiency. This is crucial for SMEs in the construction sector, where supply chain disruptions can severely impact project timelines and costs (Kissi & Agyekum 2020). Furthermore, the integration of Lean principles into supply chain management allows SMEs to respond more effectively to market demands, thus improving their competitive edge . The findings of these studies suggest that SMEs can benefit from adopting Lean methodologies to create a more resilient and efficient supply chain.

In addition to improving operational efficiency, Lean Construction methodologies also foster a culture of continuous improvement within SMEs. By encouraging employees to identify and eliminate wasteful practices, organizations can enhance their overall productivity (Rupasinghe & Wijethilake 2021). This cultural shift is essential for SMEs aiming to adapt to the rapidly changing construction landscape, where agility and responsiveness are key to success. Moreover, the application of Lean principles has been shown to positively influence environmental sustainability, as it encourages the reduction of material waste and promotes resource efficiency (Carter & Washispack 2018). As SMEs increasingly recognize the importance of sustainability, Lean Construction methodologies provide a viable pathway to achieving both operational excellence and environmental responsibility.

The challenges faced by SMEs in implementing Lean Construction methodologies are not insignificant. Many SMEs struggle with the initial investment required for training and process redesign, which can deter them from fully embracing Lean practices (Yang & Zhang 2021). Additionally, the lack of a stable supply chain can hinder the successful implementation of Lean principles, as highlighted by (Dauda et al. 2023). To overcome these barriers, it is essential for SMEs to develop tailored strategies that align Lean practices with their specific operational contexts. By doing so, they can maximize the benefits of Lean Construction and enhance their overall supply chain performance.

## 2.2 Kaizen Methodology in the Supply Chain of SMEs

The Kaizen methodology, which emphasizes continuous improvement through incremental changes, has also been applied to the supply chain processes of SMEs in the construction sector. This approach is particularly beneficial for SMEs, as it allows them to implement changes without the need for significant capital investment (Jamaludin 2023). The findings of Kosasih & Pujawan (2022) indicate that SMEs that adopt Kaizen practices can achieve notable improvements in their operational efficiency and overall performance. By fostering a culture of continuous improvement, SMEs can empower their employees to identify inefficiencies and propose solutions, leading to enhanced supply chain management.

Moreover, the integration of Kaizen principles into supply chain processes can lead to improved collaboration among stakeholders. Kissi et al. (2020) emphasize that the Kaizen approach encourages open communication and teamwork, which are essential for effective supply chain management. This collaborative environment allows SMEs to respond more effectively to disruptions and changes in demand, ultimately enhancing their resilience. Additionally, the application of Kaizen methodologies can lead to better quality control and reduced defects in construction projects, as continuous improvement efforts focus on eliminating non-value-added activities (Rupasinghe & Wijethilake 2021).

Despite the advantages of implementing Kaizen in supply chain processes, SMEs may face challenges in sustaining these improvements over time. The lack of commitment from management and employees can hinder the successful adoption of Kaizen practices (Yang & Zhang 2021). To address this issue, it is crucial for SMEs to establish a strong leadership commitment to continuous improvement and to provide ongoing training and support for employees. By fostering a culture that values Kaizen, SMEs can ensure that their supply chain processes remain agile and responsive to market demands.

## 2.3 Just-In-Time (JIT) Methodology in the Supply Chain of SMEs

The Just-In-Time (JIT) methodology has emerged as a critical strategy for enhancing supply chain efficiency in SMEs. JIT focuses on reducing inventory levels and ensuring that materials are delivered precisely when needed, thereby minimizing waste and lowering costs (Tseng & Chiu 2019). The implementation of JIT practices can significantly improve the operational performance of SMEs, as evidenced by the findings of (Yang et al. 2021), which highlight the positive impact of JIT on supply chain responsiveness and flexibility. By adopting JIT principles, SMEs can streamline their procurement processes and reduce the risk of overstocking or stockouts.

Furthermore, JIT methodologies encourage SMEs to develop strong relationships with suppliers, as timely deliveries are essential for the successful implementation of JIT practices (Agus & Hajinoor 2012). This collaboration fosters a more integrated supply chain, allowing SMEs to respond quickly to changes in demand and market conditions. The emphasis on supplier integration is particularly relevant for SMEs in the construction sector, where timely access to materials is crucial for project success (Meng 2019). By leveraging JIT principles, SMEs can enhance their supply chain resilience and improve their overall competitiveness.

However, the successful implementation of JIT in SMEs is not without challenges. The reliance on timely deliveries requires a high level of coordination and communication with suppliers, which can be difficult for SMEs with limited resources (Danese & Romano 2012). Additionally, external factors such as supply chain disruptions can significantly impact the effectiveness of JIT practices (So & Sun 2010). To mitigate these risks, SMEs must invest in building strong relationships with reliable suppliers and develop contingency plans to address potential disruptions. By doing so, they can maximize the benefits of JIT and enhance their supply chain performance.

## 2.4 Strategic Procurement Management in the Supply Chain of SMEs

Strategic procurement management plays a vital role in enhancing the supply chain processes of SMEs. This approach emphasizes the importance of aligning procurement strategies with overall business objectives, enabling SMEs to optimize their supply chain operations (Kosasih & Pujawan 2022). The findings of Almohtaseb (2024) indicate that

SMEs that adopt strategic procurement practices can achieve significant improvements in their operational efficiency and cost-effectiveness. By focusing on long-term relationships with suppliers and leveraging their purchasing power, SMEs can enhance their competitiveness in the construction sector.

Moreover, strategic procurement management allows SMEs to better manage risks associated with supply chain disruptions. By developing robust supplier networks and diversifying their sources of materials, SMEs can reduce their vulnerability to external shocks (Kosasih & Pujawan 2022). This proactive approach to procurement enables SMEs to maintain continuity in their operations, even in the face of unforeseen challenges. Additionally, strategic procurement practices can lead to improved quality control and reduced lead times, further enhancing the overall performance of SMEs in the construction sector (Zayed & Yaseen 2020).

Despite the benefits of strategic procurement management, SMEs may encounter challenges in its implementation. Limited resources and expertise can hinder their ability to develop and execute effective procurement strategies (Hwang & Ng 2013). To overcome these obstacles, SMES need to invest in training and capacity building for their procurement teams. By enhancing their procurement capabilities, SMEs can better navigate the complexities of supply chain management and improve their overall performance.

### 2.5 Standardization of Processes in the Supply Chain of SMEs

The standardization of processes is a critical aspect of supply chain management that can significantly benefit SMEs. By establishing standardized procedures for procurement and supply chain operations, SMEs can enhance efficiency and reduce variability in their processes (Hu et al. 2015). The findings of Kosasih et al. (2023) indicate that the implementation of standardized processes can lead to improved operational performance and reduced costs for SMEs. This is particularly important in the construction sector, where consistency and reliability are essential for project success. Standardization also facilitates better communication and collaboration among stakeholders in the supply chain. By establishing clear guidelines and procedures, SMEs can ensure that all parties involved in the supply chain are aligned and working towards common goals (Rajaguru & Matanda 2011). This collaborative environment fosters trust and transparency, which are essential for effective supply chain management. Additionally, standardized processes can lead to improved quality control and reduced errors, as employees are better equipped to follow established procedures (Al-Aomar & Hussain 2019).

However, the implementation of standardized processes in SMEs may face challenges related to resistance to change and the need for ongoing training (Meng 2019). To address these issues, it is crucial for SMEs to engage their employees in the standardization process and provide adequate training and support. By fostering a culture that values standardization and continuous improvement, SMEs can enhance their supply chain performance and achieve greater operational efficiency.

## 3. Methods

### 3.1 Basis of the Proposed Model

In Figure 1, the proposed sourcing management model for construction SMEs was developed based on the principles of Lean Construction and Kaizen. The model aimed to optimize the supply chain by reducing inefficiencies and minimizing waste throughout the procurement and material handling processes. Lean Construction focused on improving efficiency by ensuring that materials were delivered in a timely manner and with minimal waste, ultimately enhancing the overall performance of construction projects. Kaizen, as a philosophy of continuous improvement, sought to ensure that all levels of the supply process were consistently reviewed and improved, fostering better supplier relationships and more effective material delivery processes. Additionally, the model integrated Just in Time (JIT) practices to synchronize material deliveries with project needs, reducing excess inventory and storage costs. The inclusion of strategic supply management aligned procurement practices with the long-term goals of the construction SME, fostering better collaboration with suppliers and ensuring consistent material flow. The ultimate objective of this model was to address and reduce operational cost overruns in the construction supply process, thereby achieving more streamlined and cost-effective operations for SMEs in the construction sector.

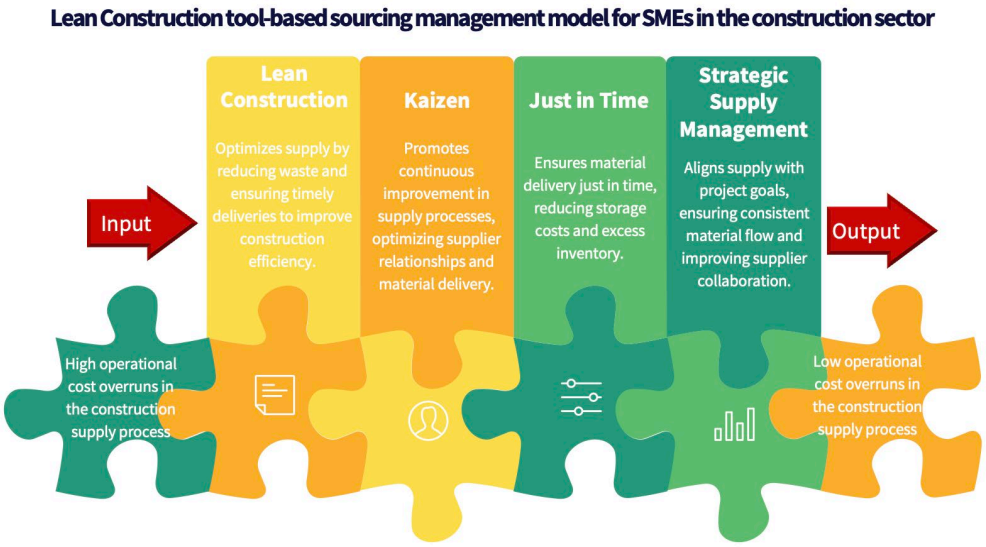



Figure 1. Proposed Model

### 3.2 Description of the model components

The proposed supply chain management model for construction SMEs, based on Lean Construction and Kaizen philosophies, contributed to the literature by addressing the inefficiencies and cost overruns that frequently affect the construction industry. Several studies have highlighted the critical need for improving supply chain practices in construction (e.g. Salem et al. 2006; Love et al. 2018). While Lean Construction has been widely adopted to streamline construction processes, its specific application to supply chain management has been less explored. Similarly, the Kaizen philosophy of continuous improvement has been primarily implemented in manufacturing, and its integration into construction supply chain practices represents a novel contribution to the field. This model incorporated core Lean principles such as waste reduction and flow optimization while embedding the continuous improvement mindset from Kaizen. The inclusion of Just in Time (JIT) practices further enhanced the model by aligning material delivery with construction schedules, thereby minimizing storage costs and delays. Strategic Supply Management was also integrated to align procurement decisions with long-term construction goals, thereby improving supplier collaboration and ensuring consistent material flow. These components worked together to address the common issues of time delays, cost overruns, and inefficiencies in the construction supply chain, especially in SMEs.

**Lean Construction: Enhancing Efficiency Through Waste Reduction**

Lean Construction, as the foundational philosophy of this model, focuses on reducing inefficiencies in the supply chain by minimizing waste in both materials and processes. The application of Lean principles to construction supply chains, which has been well-documented in prior research (Ballard & Howell 2003; Koskela 1992), emphasized the importance of delivering materials "just-in-time" and ensuring that no unnecessary resources were expended. In construction, where timelines and costs are tightly controlled, the Lean approach aims to eliminate waiting times, excess inventory, and defects, which are common issues affecting the flow of materials to job sites.

In the proposed model, Lean Construction was applied specifically to the procurement and material handling processes. By aligning material deliveries with the project's specific needs, this approach reduced the risk of materials arriving too early and occupying valuable storage space or arriving late and causing delays. The concept of "pull" in Lean Construction was crucial, meaning that materials were only ordered and delivered when there was a demand for them, thereby minimizing waste and ensuring that resources were used efficiently. This approach also fostered better relationships with suppliers, as consistent and timely communication was essential to ensure that materials were delivered exactly when needed, in the required quantities, and without defects (Koskela & Ballard 2006).

**Kaizen: Fostering Continuous Improvement in Supply Chain Processes**

Kaizen, or continuous improvement, was another critical component of the proposed model. The Kaizen philosophy encourages incremental improvements over time rather than large, disruptive changes. In the context of construction

SMEs, where resources are often limited, this approach was particularly valuable because it allowed companies to gradually improve their supply chain processes without requiring significant capital investments upfront (Imai, 1986). The application of Kaizen in this model focused on continuously reviewing and improving supplier relationships, material delivery processes, and inventory management.

The construction supply chain is complex, involving multiple suppliers, contractors, and stakeholders. The Kaizen philosophy helped to ensure that all parties were continuously looking for ways to improve the flow of materials and reduce waste. Regular feedback loops and performance reviews were incorporated into the model to assess where improvements could be made. For example, by tracking key performance indicators (KPIs) such as the rate of late deliveries or the amount of waste produced on-site, construction SMEs could identify areas where inefficiencies occurred and implement small changes to address them. These incremental improvements, although small, had a compounding effect over time, leading to more streamlined and efficient supply chain processes (Liker 2004).

**Just-in-Time: Synchronizing Material Deliveries with Project Needs**

Just-in-Time (JIT) practices were incorporated into the model to synchronize material deliveries with the construction schedule. JIT has been widely applied in manufacturing but is relatively underutilized in construction (Sacks et al. 2010). In the construction industry, materials are often ordered in bulk and stored on-site, which can lead to unnecessary storage costs, damage, or theft. The JIT philosophy in the proposed model sought to reduce these risks by ensuring that materials were delivered only when they were needed, thereby minimizing inventory and storage costs.

The implementation of JIT in the supply chain required precise planning and coordination with suppliers. The construction SME needed to have a clear understanding of the project timeline and material requirements at every stage of the project. This level of coordination reduced the need for large storage areas on-site and minimized the risk of materials being damaged or misplaced. Moreover, by reducing excess inventory, the construction company could free up valuable space and resources for other critical tasks, ultimately improving overall project efficiency. Studies have shown that JIT practices can significantly reduce waste and improve project timelines in construction when properly implemented (Sacks et al. 2010; Salem et al. 2006).

**Strategic Supply Management: Aligning Procurement with Long-Term Goals**

The final component of the model was Strategic Supply Management, which focused on aligning procurement decisions with the long-term goals of the construction SME. This approach was critical for ensuring that the supply chain not only met immediate project needs but also supported the company's broader strategic objectives (Chen & Paulraj 2004). In construction SMEs, where resources are often limited, aligning supply chain management with strategic goals ensured that procurement decisions were made with an eye toward long-term sustainability and profitability.

Strategic Supply Management involved developing long-term relationships with key suppliers, negotiating favorable contracts, and ensuring that suppliers were capable of meeting the company's evolving needs. This approach also helped to mitigate risks, as construction SMEs could rely on trusted suppliers to deliver materials on time and within budget, even in times of market volatility. Furthermore, by fostering stronger relationships with suppliers, the company could benefit from improved communication, better pricing, and more consistent material quality (Chen et al. 2004).

The proposed model integrated Lean Construction, Kaizen, JIT, and Strategic Supply Management to create a comprehensive approach to supply chain management for construction SMEs. Each component played a critical role in addressing the specific challenges faced by SMEs, including limited resources, cost overruns, and inefficiencies in material handling. By applying Lean principles, the model reduced waste and improved the efficiency of material deliveries. Kaizen ensured that continuous improvements were made throughout the supply chain, while JIT practices minimized inventory and storage costs. Strategic Supply Management aligned procurement decisions with the company's long-term goals, ensuring that the supply chain supported both immediate project needs and future growth. Together, these components formed a robust framework for improving supply chain performance in construction SMEs, contributing to the literature by offering a practical solution to common challenges in the industry.

### 3.3 Model Indicators

To assess the impact of the lean construction-based supply management model for SMEs in the construction sector, specialized metrics were developed. These metrics were designed to monitor and evaluate performance throughout the case study, providing a solid basis for analyzing critical aspects of warehouse management within an SME environment. This systematic approach facilitated an in-depth review of key performance indicators. This comprehensive evaluation ensured effective monitoring and supported the continuous improvement of procurement processes, ultimately contributing to reducing operational overheads in the supply process for SMEs in the construction sector.

**Rate of orders received out of time:** This indicator measures the percentage of orders that were received past the expected delivery time. A lower value indicates better performance in timely deliveries.

$$\text{Rate of orders received out of time} = \frac{\text{Number of late orders received}}{\text{Total orders received}} \times 100 \quad (1)$$

Rate of misplaced orders: This measures the percentage of orders that were misplaced or lost in the supply chain. Reducing this rate improves overall supply chain accuracy.

$$\text{Rate of misplaced orders} = \frac{\text{Number of misplaced orders}}{\text{Total orders processed}} \times 100 \quad (2)$$

Rate of orders issued out of time: This measures the percentage of orders dispatched or issued after the agreed time, impacting overall project timelines.

$$\text{Rate of orders issued out of time} = \frac{\text{Number of late issued orders}}{\text{Total orders issued}} \times \mathbf{100} \quad (3)$$

**Rate of orders received with problems:** This measures the percentage of orders that were received with issues, such as damaged or incorrect materials, impacting supply chain quality.

$$\text{Rate of orders received with problems} = \frac{\text{Number of problem orders}}{\text{Total orders received}} \times \mathbf{100} \quad (4)$$

**Rate of materials served out of budget:** This indicator measures the percentage of materials that exceeded the planned budget, which affects cost management in construction projects.

$$\text{Rate of materials served out of budget} = \frac{\text{Cost of over-budget materials}}{\text{Total cost of materials served}} \times \mathbf{100} \quad (5)$$

## 4. Validation

### 4.1 Validation Scenario

The validation scenario was conducted in a case study of a construction company operating in the Peruvian market. The company faced significant challenges in its material supply process, resulting in operational cost overruns and inefficiencies in project execution. The company focused on residential building projects, which included multifamily housing and commercial spaces. Due to poor coordination in the supply chain, excess material purchases, late deliveries, and frequent order cancellations were common issues. The company's supply chain issues led to a 6.33% operational cost overrun, higher than the industry standard of 5%. The economic impact of these inefficiencies amounted to 332,220 PEN annually, equivalent to 10% of its revenue. The validation process sought to reduce these cost overruns by implementing Lean Construction, Kaizen, and Just in Time tools to streamline the material supply chain and enhance overall efficiency. The ultimate goal was to achieve operational improvements and align supply processes with project demands effectively.

## 4.2 Initial Diagnosis

In Figure 2, the problem tree presents a summary of the diagnosis conducted in the case study to identify the causes and root causes of high operational cost overruns in the construction supply process. The operational overrun rate in the case study was 6.33%, exceeding the industry standard of 5%, resulting in an economic impact of 332,220 PEN annually, representing 10% of the company's total revenue. The analysis identified three primary causes: purchases of excess materials (28.6%), multiple canceled purchase orders (29.9%), and late delivery of materials (25.8%). Further root cause analysis revealed that purchases of excess materials were driven by a lack of coordination (20.1%) and human errors (8.5%). Multiple canceled orders resulted from inadequate supplier evaluation (17.4%) and the unavailability of stock (12.5%). The delays in material delivery were primarily due to unplanned purchases (17.4%) and inefficiencies in the purchasing process (8.4%). This diagnostic process enabled the identification of key areas contributing to cost overruns, allowing the development of a targeted intervention strategy to improve supply chain efficiency within the construction SME. The structured approach of the problem tree facilitated a clear understanding of the relationships between symptoms and underlying causes.

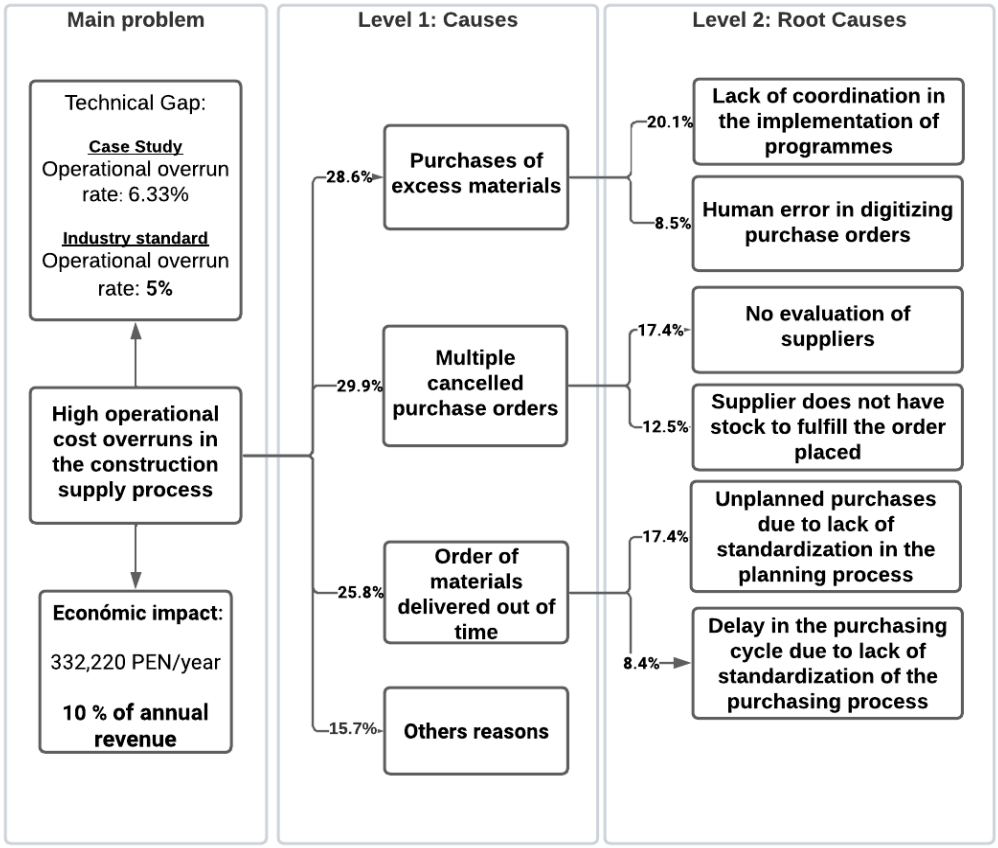



Figure 2. Problem Tree

## 4.3 Implementation of the model in the case study

The detailed design of the solution proposed in the case study focuses on the supply chain and purchasing processes with the objective of reducing operational costs and achieving higher performance levels. The solution was divided into general and specific models of implementation based on Lean Construction principles and Kaizen philosophy.

### General Implementation Plan

The general model of implementation follows a three-phase action plan. The first phase involved an in-depth analysis of the existing situation where data collection and identification of problems and potential root causes were conducted. Quantitative data was gathered to assess current inefficiencies, and specific problems related to purchasing delays, stock shortages, and poor supplier performance were identified.

In the second phase, concrete actions were defined. Improvement proposals were developed, including the creation of performance indicators to track progress. The implementation of new procedures focused on strategic sourcing, based on a systematic flow presented in the company's supply and planning processes (see figures 3 and 4). This phase also involved the approval of new procedures by upper management, ensuring alignment with the company's long-term goals. Training programs were designed to ensure that all employees were properly prepared for the new processes.
In the final phase of the general implementation plan, verification of the results was carried out through the proposed indicators. A culture of continuous training and improvement was promoted, with mechanisms in place to monitor and measure the outcomes of the changes. This phase emphasized the importance of fostering long-term engagement and adherence to the newly implemented procedures, which were consistently reviewed for future improvement.

**Specific Implementation Model**
The specific solution utilized Lean Construction methodology, centered around the Kaizen philosophy and Strategic Sourcing, integrating the PDCA (Plan-Do-Check-Act) cycle. In the planning phase, a training schedule was created for the personnel in charge of purchasing, focusing on Lean Construction principles and procurement management. Additionally, a procedural manual was developed for the operations team. The emphasis on knowledge transfer was key to ensuring that all employees understood their roles in the new procurement strategy.During the implementation phase, the purchasing workflow was redesigned, which included homologating suppliers based on their ability to meet the company's needs. Lean tools such as the Last Planner System were employed to ensure that the procurement process was streamlined, and bottlenecks were eliminated. The training programs were conducted as planned, covering both Lean methodologies and operational strategies specific to the company's supply chain.

In the verification phase, key indicators were established to monitor the outcomes. Diagrams of the restructured supply processes were developed, helping to evaluate whether the goals were being met. These indicators were also designed to track performance at both internal (procurement team) and external (supplier) levels. Internal audits were proposed to verify compliance with the new standards.Finally, in the act phase, the company committed to promoting continuous training and personnel involvement even after the implementation. This ongoing engagement ensured that the improvements would be sustained and refined over time, fostering a culture of continuous improvement throughout the organization.

**Quantitative Support for the Solution**
Throughout the solution design, quantitative data played a crucial role in shaping the interventions. For example, delays in order reception accounted for 25.84% of the total delays, while errors in purchasing orders were at 8.49%. Additionally, supplier performance issues caused significant disruptions, with 29.98% of orders being received with problems. These metrics highlighted the need for improved supplier evaluation processes, which were integrated into the solution through performance tracking and periodic assessments.

Overall, the detailed design of the solution aimed to address the root causes of inefficiencies in the supply process, and the implementation followed a structured and data-driven approach, ensuring that the company's operational costs could be reduced while performance improved significantly. Figures such as the supply chain flow and the purchasing process diagram (See Figures 3, 4, and 5 from the document) provide essential support to the solution's implementation. Moreover, the incorporation of Kaizen's continuous improvement philosophy, alongside Lean Construction, ensured that the changes made would have lasting impacts on the organization.

Figure 3 presents the proposed flow of the supply process, detailing the stages from material selection to receipt. It includes multiple areas such as technical, planning, and operational processes. The process begins with the selection of materials to offer, followed by adjudication and technical evaluation. After the planning stages, negotiations with suppliers occur, leading to the issuance of purchase orders. Finally, the process concludes with the reception of materials. Each stage is linked to ensure a seamless transition between steps, promoting an organized and efficient procurement workflow for the supply chain.

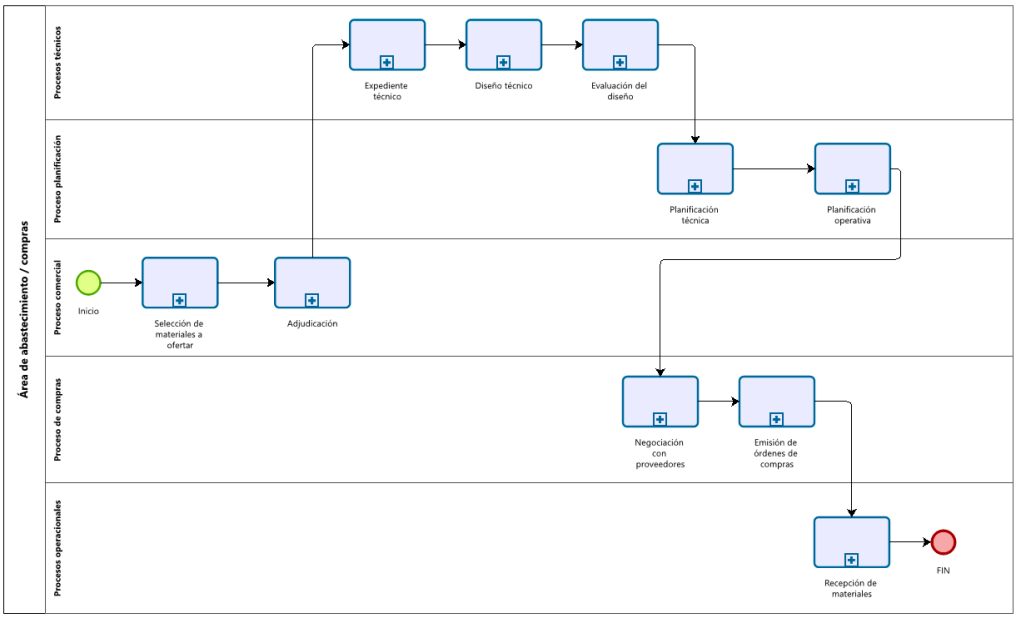



Figure 3. Proposed flow of the supply process

Figure 4 illustrates the proposed flow of the planning process, starting with the approval of the design and the preparation of a report. The report is sent through the architecture department, where it is reviewed, and the necessary requirements are calculated. A report of metrics is generated and sent for further evaluation. The process continues through the technical offices, where the report is assessed. If the report is deemed unsatisfactory, it is sent back for corrections; if acceptable, the costing is calculated, and a material cost report is generated. This report undergoes further evaluation before being sent to the site engineer. The site engineer receives the report and confirms its accuracy, concluding the process. This structured flow ensures that every stage of planning, from design approval to report finalization, is meticulously verified and that necessary adjustments are made to meet project needs efficiently, with each department playing a crucial role in the overall process.

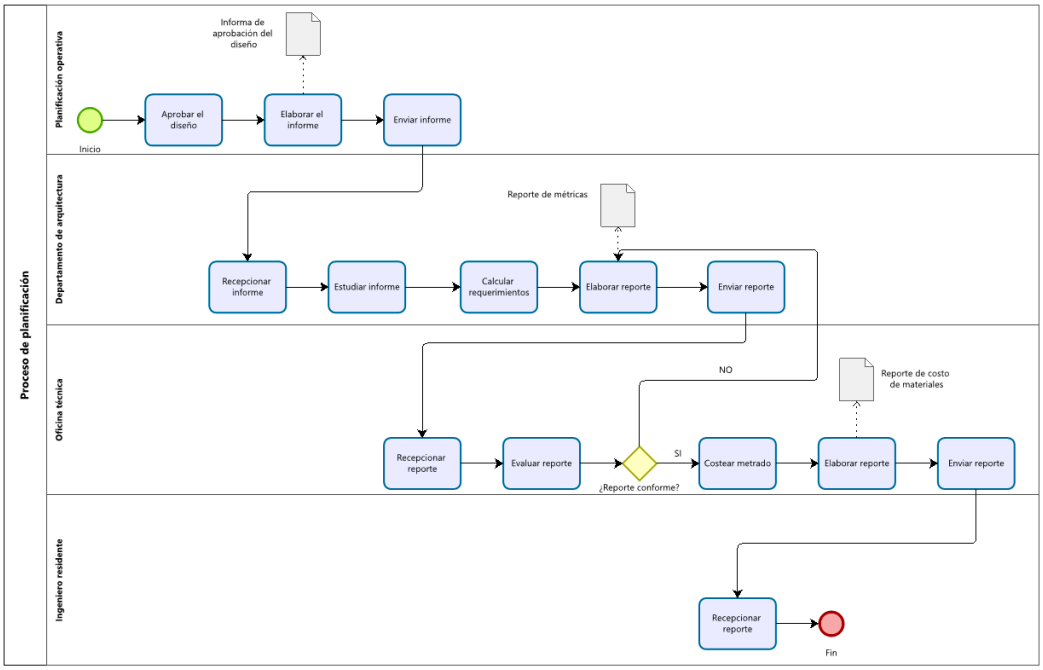



Figure 4. Proposed flow of the planning process

Figure 5 outlines the proposed flow for issuing purchase orders, beginning with the site management reviewing the current stock of materials. If additional materials are required, a request is submitted. The request is then received and evaluated by the administration. If the request is approved, it proceeds through a financial evaluation to ensure the requested amount is not excessive. If the amount exceeds the set limits, the request is sent for further approval by upper management. Once the amount is validated, the purchase order is issued. If the request is not approved at any step, it is returned for reassessment or rejection. This process ensures that every purchase order is carefully scrutinized to prevent overspending while maintaining an efficient supply of materials. The flowchart emphasizes coordination between different departments, including site management, procurement, and financial oversight, ensuring all orders are thoroughly evaluated before purchase execution.

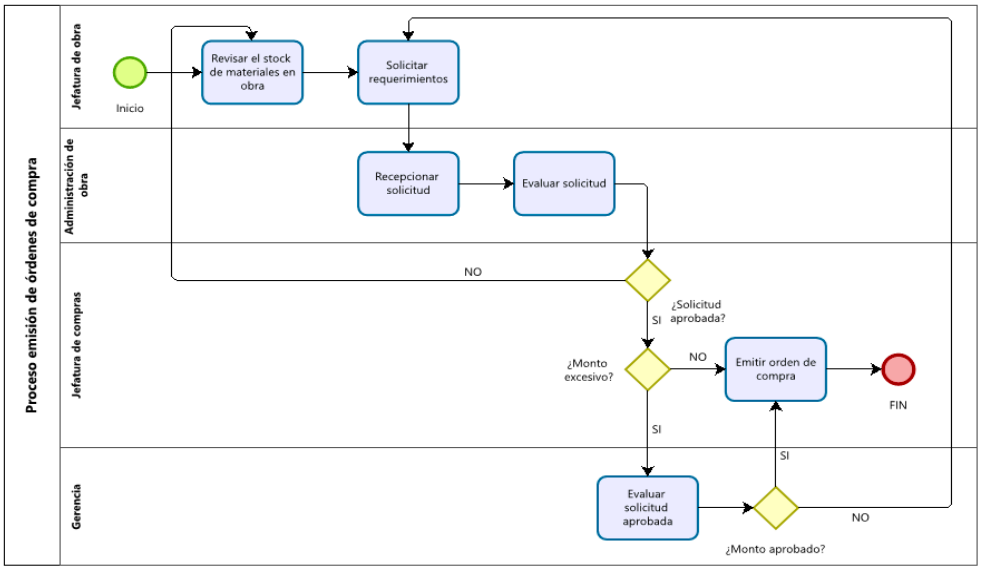
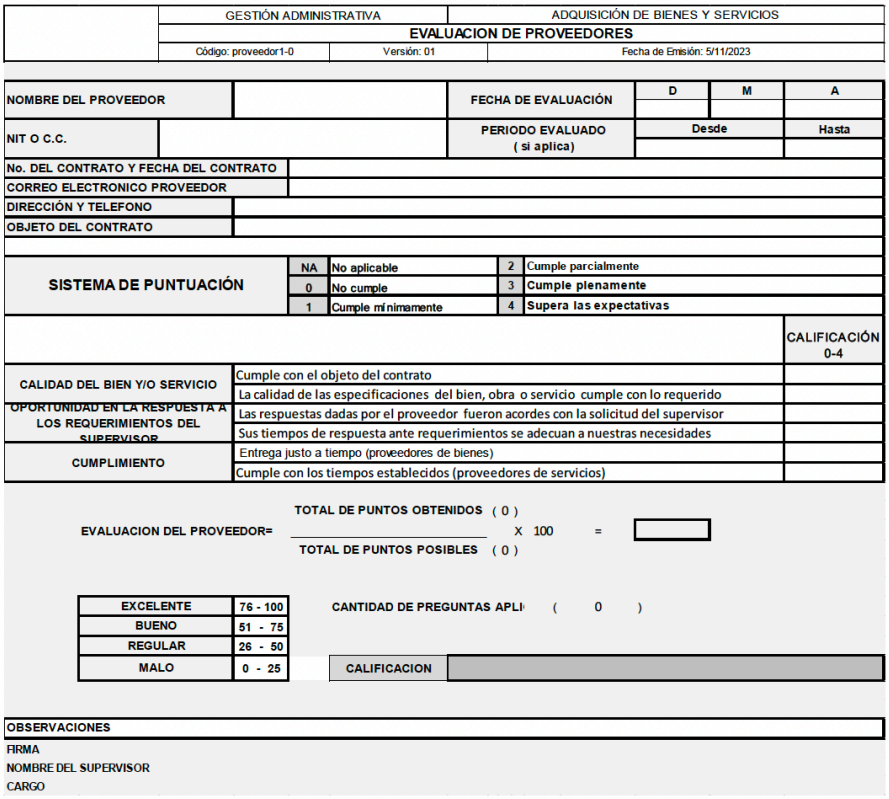



Figure 5. Proposed flow of issuing purchase orders

Figure 6 presents a detailed supplier evaluation form used to assess the performance and compliance of suppliers in terms of contract obligations and service delivery. The form evaluates various aspects such as product quality, timeliness of responses, and adherence to delivery deadlines. It includes a scoring system ranging from 0 (non-compliance) to 4 (exceeds expectations) for each criterion. The final score is calculated based on the total points obtained relative to the possible points. Suppliers are categorized as excellent (76-100), good (51-75), regular (26-50), or poor (0-25) based on their overall performance, ensuring that all supplier evaluations are standardized and transparent.



| | GESTIÓN ADMINISTRATIVA | ADQUISICIÓN DE BIENES Y SERVICIOS |
|---|---|---|
| | EVALUACION DE PROVEEDORES | |
| | Código: proveedor1-0 / Versión: 01 | Fecha de Emisión: 5/11/2023 |

| | | | | | |
|---|---|---|---|---|---|
| NOMBRE DEL PROVEEDOR | | FECHA DE EVALUACIÓN | D | M | A |
| NIT O C.C. | | PERIODO EVALUADO ( si aplica) | Desde | | Hasta |
| No. DEL CONTRATO Y FECHA DEL CONTRATO | | | | | |
| CORREO ELECTRONICO PROVEEDOR | | | | | |
| DIRECCIÓN Y TELEFONO | | | | | |
| OBJETO DEL CONTRATO | | | | | |

| SISTEMA DE PUNTUACIÓN | | | | |
|---|---|---|---|---|
| | NA | No aplicable | 2 | Cumple parcialmente |
| | 0 | No cumple | 3 | Cumple plenamente |
| | 1 | Cumple mínimamente | 4 | Supera las expectativas |

| | | CALIFICACIÓN 0-4 |
|---|---|---|
| CALIDAD DEL BIEN Y/O SERVICIO | Cumple con el objeto del contrato | |
| | La calidad de las especificaciones del bien, obra o servicio cumple con lo requerido | |
| OPORTUNIDAD EN LA RESPUESTA A LOS REQUERIMIENTOS DEL SUPERVISOR | Las respuestas dadas por el proveedor fueron acordes con la solicitud del supervisor | |
| | Sus tiempos de respuesta ante requerimientos se adecuan a nuestras necesidades | |
| CUMPLIMIENTO | Entrega justo a tiempo (proveedores de bienes) | |
| | Cumple con los tiempos establecidos (proveedores de servicios) | |

EVALUACION DEL PROVEEDOR= TOTAL DE PUNTOS OBTENIDOS ( 0 ) / TOTAL DE PUNTOS POSIBLES ( 0 ) X 100 =

| | |
|---|---|
| EXCELENTE | 76 - 100 |
| BUENO | 51 - 75 |
| REGULAR | 26 - 50 |
| MALO | 0 - 25 |

CANTIDAD DE PREGUNTAS APLI ( 0 )

CALIFICACION

OBSERVACIONES

FIRMA

NOMBRE DEL SUPERVISOR

CARGO

Figure 6. Format for supplier approval

## 5. Results

Table 1 shows the key results of the validation of the supply model based on Lean Construction and Kaizen, applied in a construction SME. The proposed model demonstrated significant improvements in various supply chain indicators. There was a 65.36% reduction in the rate of orders received out of time, a 60.78% decrease in misplaced orders, and an 88.89% reduction in orders received with problems. Additionally, the rate of orders issued out of time was reduced by 26.74%, while the rate of materials served out of budget showed a smaller but notable improvement, with a decrease of 22.12%. These results confirm the effectiveness of the proposed model in addressing the identified problems in the supply chain of the SME.

Table 1. Results of validation of the proposed model

| Indicator | Unit | As-Is | To-Be | Results | Variation (%) |
|---|---|---|---|---|---|
| Rate of orders received out of time | % | 25.84% | 20% | 8.95% | -65.36% |
| Rate of misplaced orders | % | 8.49% | 5% | 3.33% | -60.78% |
| Rate of orders issued out of time | % | 20.12% | 15% | 14.74% | -26.74% |
| Rate of orders received with problems | % | 29.98% | 10% | 3.33% | -88.89% |
| Rate of materials served out of budget | % | 6.33% | 5% | 4.93% | -22.12% |

## 6. Conclusions.

The study identified significant inefficiencies in the procurement processes of small and medium enterprises (SMEs) in the construction sector, particularly regarding delays in material deliveries, excess purchases, and poor supplier performance. The implementation of a procurement model integrating Lean Construction, Kaizen, and Just-In-Time (JIT) methodologies led to substantial improvements. Key findings include a reduction in late deliveries from 25.84% to 8.95%, a 60.78% decrease in misplaced orders, and an 88.89% reduction in orders received with problems. These results confirm the effectiveness of the proposed model in addressing the primary challenges in the supply chain.

The importance of this research lies in its direct application to construction SMEs, a sector often overlooked in academic literature. By optimizing supply chain management, the study contributes to enhancing operational efficiency and reducing costs in a field crucial to economic development. The model's success in reducing delays and improving supplier relationships highlights its practical significance for SMEs aiming to enhance their competitiveness in the market.

This research makes several contributions to the field of industrial engineering, particularly in supply chain optimization for SMEs in the construction industry. The integration of Lean Construction and Kaizen methodologies into the procurement process represents a novel approach to tackling inefficiencies in supply chains. Additionally, the use of JIT principles ensures that materials are delivered as needed, minimizing waste and storage costs. These contributions offer valuable insights for further research and practical applications in similar industries.

Final observations suggest that while the model significantly improved procurement efficiency, further studies could explore its scalability and adaptability to other sectors. It would also be beneficial to investigate the long-term sustainability of the implemented changes and their impact on the overall performance of construction SMEs. Future research could focus on integrating advanced technologies such as automation and artificial intelligence to enhance supply chain management further. This study provides a solid foundation for future explorations into optimizing procurement processes in construction and beyond.

## References

Agus, A., & Hajinoor, M. , Lean production and its effect on business performance: A case study of manufacturing companies in Malaysia. International Journal of Productivity and Performance Management, 61(5), 547-570,2012. https://doi.org/10.1108/17410401211255653

Al-Aomar, R., & Hussain, M. , The role of standardization in enhancing the performance of construction projects. International Journal of Construction Management, 19(4), 353-365,2019. https://doi.org/10.1080/15623599.2018.1478924

Baker, S., Bouchlaghem, D., & Waller, S. , The impact of procurement strategies on project performance. International Journal of Project Management, 36(1), 1-12, 2018. https://doi.org/10.1016/j.ijproman.2017.05.001

Ballard, G., & Howell, G. , Lean project management. Building Research & Information, 31(2), 119-133,2003. https://doi.org/10.1080/09613210301997

Ballard, G., & Howell, G. , Lean project management. Building Research & Information, 31(2), 119-133,2003. https://doi.org/10.1080/09613210302055

Ballard, G., & Howell, G. , Lean project management. Building Research & Information, 31(2), 119-133,2003. https://doi.org/10.1080/09613210302055

Bertelsen, S. (2003). Construction as a complex system. Proceedings of the 11th Annual Conference of the International Group for Lean Construction, 1-10. https://doi.org/10.24928/iglc.2003.0010

Carter, C. R., & Washispack, S. , The role of lean thinking in the sustainability of supply chains. International Journal of Physical Distribution & Logistics Management, 48(2), 191-210,2018. https://doi.org/10.1108/IJPDLM-05-2017-0170

Chen, I. J., & Paulraj, A. , Towards a theory of supply chain management: the constructs and measurements. Journal of Operations Management, 22(2), 119-150,2004. https://doi.org/10.1016/j.jom.2003.12.003

Cheng, J. C. P., Li, H., & Love, P. E. D. (2020). The impact of human error on construction project performance: A review. Journal of Construction Engineering and Management, 146(3), 04019122. https://doi.org/10.1061/(ASCE)CO.1943-7862.0001748

Danese, P., & Romano, P. (2012). The role of supply chain management in the implementation of lean production. International Journal of Production Research, 50(1), 1-20. https://doi.org/10.1080/00207543.2011.558898

González, V., & Rojas, C. (2020). Challenges and opportunities for SMEs in the construction sector in Latin America. Journal of Small Business Management, 58(2), 234-250. https://doi.org/10.1111/jsbm.12452

Hwang, B.-G., & Ng, W. J. (2013). Project management knowledge and skills for green construction: Overcoming challenges. International Journal of Project Management, 31(3), 272-284. https://doi.org/10.1016/j.ijproman.2012.07.002

Hwang, B.-G., & Ng, W. J. (2013). Project management knowledge and skills for green construction: Overcoming challenges. International Journal of Project Management, 31(3), 272-284. https://doi.org/10.1016/j.ijproman.2012.07.002

Imai, M. (1986). Kaizen: The key to Japan's competitive success. McGraw-Hill.

International Labour Organization. (2017). World Employment Social Outlook 2017: Sustainable Enterprises and Jobs. https://www.ilo.org/global/research/global-reports/weso/2017/lang--en/index.htm

Jamaludin, M. (2023). Implementing Kaizen in small and medium enterprises: A case study in the manufacturing sector. Journal of Small Business Management, 61(1), 123-145. https://doi.org/10.1111/jsbm.12452

Khan, M. A., & Memon, A. H. (2019). Enhancing the performance of construction SMEs through strategic procurement. International Journal of Construction Management, 19(5), 425-435. https://doi.org/10.1080/15623599.2018.1478925

Khan, M. A., & Memon, A. H. (2019). Enhancing the performance of construction SMEs through strategic procurement. International Journal of Construction Management, 19(5), 425-435. https://doi.org/10.1080/15623599.2018.1497927

Kissi, J., & Agyekum, K. (2020). Linking supply chain disruptions with organizational performance of construction firms: The moderating role of innovation. Journal of Financial Management of Property and Construction, 25(2), 123-139. https://doi.org/10.1108/JFM-11-2019-0084

Kosasih, S., & Pujawan, I. (2022). Integrated Lean-Green practices and supply chain sustainability for manufacturing SMEs: A systematic literature review and research agenda. Sustainability, 15(16), 12192. https://doi.org/10.3390/su151612192

Koskela, L. (1992). Application of the new production philosophy to construction. Stanford University. https://doi.org/10.1016/S1474-0346(06)80013-7

Kumar, S., & Singh, R. (2021). Waste management in construction: A review of the literature. Waste Management, 120, 1-12. https://doi.org/10.1016/j.wasman.2020.11.021

Mason, J., & Barlow, J. (2019). Lean construction: A review of the literature. Construction Management and Economics, 37(1), 1-16. https://doi.org/10.1080/01446193.2018.1541278

Meng, X. (2019). The role of standardization in construction project management: A review. International Journal of Project Management, 37(6), 748-757. https://doi.org/10.1016/j.ijproman.2019.03.002

Ministerio de Vivienda, Construcción y Saneamiento. (2020). Informe Anual de Vivienda 2020. https://www.gob.pe/institucion/vivienda/informes-publicaciones

Mokhtar, M. A., & Kamaruzzaman, S. N. (2020). The role of procurement in construction project success: A review. International Journal of Construction Management, 20(4), 335-344. https://doi.org/10.1080/15623599.2018.1497927

Rajaguru, R., & Matanda, M. J. (2011). The role of standardization in enhancing supply chain performance. Supply Chain Management: An International Journal, 16(4), 238-247. https://doi.org/10.1108/13598541111158573

Rupasinghe, T., & Wijethilake, C. (2021). The impact of Kaizen on operational performance in small and medium enterprises. International Journal of Productivity and Performance Management, 70(5), 1031-1046. https://doi.org/10.1108/IJPPM-10-2020-0451

Sadeghi, A., & Khosravi, Y. (2021). The impact of procurement strategies on project performance: A case study of construction projects. Journal of Construction Engineering and Management, 147(2), 04020175. https://doi.org/10.1061/(ASCE)CO.1943-7862.0001947

Sadeghi, A., & Khosravi, Y. (2021). The impact of procurement strategies on project performance: A case study of construction projects. Journal of Construction Engineering and Management, 147(2), 04020175. https://doi.org/10.1061/(ASCE)CO.1943-7862.0001947

So, S., & Sun, H. (2010). The impact of supply chain disruptions on operational performance: A study of the automotive industry. International Journal of Production Economics, 124(1), 1-12. https://doi.org/10.1016/j.ijpe.2009.10.005

Tseng, M.-L., & Chiu, A. S. F. (2019). The role of just-in-time in enhancing supply chain performance. International Journal of Production Research, 57(1), 1-15. https://doi.org/10.1080/00207543.2018.1488479

Womack, J. P., & Jones, D. T. (2003). Lean Thinking: Banish Waste and Create Wealth in Your Corporation. Simon & Schuster.

World Bank. (2019). Doing Business 2019: Training for Reform. https://www.worldbank.org/en/publication/doing-business

Yang, Y., & Zhang, J. (2021). Achieving a just-in-time supply chain: The role of supply chain intelligence. International Journal of Production Economics, 232, 107878. https://doi.org/10.1016/j.ijpe.2020.107878

Zayed, T., & Yaseen, M. (2020). Strategic procurement management in construction: A review of the literature. International Journal of Construction Management, 20(4), 365-375. https://doi.org/10.1080/15623599.2019.1589461

Zhang, Y., & Zhao, X. (2021). Standardization in construction procurement: A systematic review. Journal of Construction Engineering and Management, 147(5), 04021014. https://doi.org/10.1061/(ASCE)CO.1943-7862.0001952

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