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Integrating Methods, Engineering, and Ergonomics to Optimize Retail Logistics: A Case Study in Productivity Enhancement and Cost Reduction

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Abstract

The operational inefficiencies of retail distribution centers, such as prolonged order preparation times, incomplete shipments, and increased costs, have a profound impact on supply chain performance and customer satisfaction. Previous studies have primarily focused on general logistics challenges, leaving a research gap in addressing these issues through Methods Engineering. This study aimed to optimize productivity and reduce operational costs in order preparation and dispatch processes by implementing a structured model comprising six interconnected phases. Key improvements included process standardization, ergonomic interventions, and data-driven workflow optimization. The results demonstrated a 40.85% increase in productivity, a reduction in headcount by 28%, and a 35.29% decrease in logistics costs, alongside a rise in on-time deliveries from 92% to 96.1%. These findings contribute to the academic field by providing a replicable and scalable framework, fostering both operational efficiency and worker safety. Future research should explore advanced technologies like automation to further enhance the model's adaptability.

Keywords

Methods Engineering, Productivity Optimization, Ergonomics Interventions, Process Standardization, Retail Logistics Efficiency.

1. Introduction

The importance of distribution centers in the retail sector is undisputed, especially in an increasingly globalized and competitive world. These centers act as critical nodes in the supply chain, facilitating efficient inventory management and distribution of products to end consumers. Globally, the retail sector is estimated to account for approximately 10% of global GDP, underlining its economic relevance (Heins 2022). In Latin America, the growth of e-commerce has driven the need for more sophisticated and efficient distribution centers to meet the demand of consumers who seek speed and convenience in their purchases (Li 2021). In Peru, the situation is similar; the retail sector has experienced significant growth in recent years, driven by digitalization and the rise of the middle class, which has led

to increased investment in distribution infrastructure (Li 2023). However, despite their importance, distribution centers face significant challenges that require urgent attention.
The production problems in retail distribution centers are varied and complex. These include deficiencies in unloaded orders due to delays, incomplete order fulfillment, mislabeling of orders and non-standardized picking and packing processes (Argyropoulou et al. 2023). These deficiencies not only affect operational efficiency, but also negatively impact customer satisfaction and ultimately the profitability of companies (Blackley et al. 2017). For example, a study revealed that errors in order preparation can result in significant additional costs as well as loss of customers (Montecchi et al. 2022). In addition, lack of standardization in the picking and packing processes can lead to variations in service quality, which in turn can affect customer loyalty and brand reputation (Chen 2023). Identifying and resolving these issues is crucial to improving operational efficiency and competitiveness in the retail sector.

Addressing these issues is of paramount importance, as efficiency in distribution centers can translate into significant competitive advantages. Implementing continuous improvement practices and adopting advanced technologies, such as automation and the Internet of Things (IoT), can help mitigate many of these problems (Amasiatu & Shah 2019). For example, the integration of real-time inventory management systems can significantly reduce errors in order preparation and improve supply chain visibility (Pantano et al. 2020). In addition, process standardization can facilitate staff training and improve consistency in service quality (Grant et al. 2014). In an environment where consumers expect fast and accurate deliveries, the ability of a distribution center to adapt and continuously improve is essential to maintain competitiveness in the market.

Despite the increasing attention to distribution centers in literature, there is a significant knowledge gap regarding the application of Method Engineering tools to address production problems in these environments. Most studies have focused on general aspects of supply chain management, leaving aside the specificity of operational processes in distribution centers (Guan et al. 2012). This research seeks to fill this gap by developing a production model that incorporates tools of Method Engineering, which will allow a better understanding and solution of the identified problems (Vass et al. 2021). By applying a systematic, data-driven approach, this model is expected to not only improve operational efficiency but also contribute to the sustainability and resilience of retail distribution centers (Blankson et al. 2017).In conclusion, retail distribution centers are critical to the efficient operation of the supply chain. However, they face significant challenges that require immediate attention. The identification and resolution of production problems, together with the application of Methods Engineering tools, are essential to improve efficiency and competitiveness in this sector. The research proposed aims to address these issues and contribute to the development of more effective practices in the management of distribution centers.

2. Literature Review

Reviewing the literature on logistics processes in retail distribution centers is critical to understanding how contemporary methodologies and approaches can optimize the efficiency and effectiveness of these operations. In this context, a number of investigations have been carried out using specific methodologies to improve logistics processes. For example, studies have shown that the integration of logistics capabilities can significantly influence consumer purchasing attitudes, especially in the context of online shopping, where packet tracking capabilities have been identified as a crucial factor in improving the customer experience (Riley & Klein 2019). In addition, the geographical expansion of retailers has been supported by key logistics features that facilitate their integration into new markets, suggesting that logistics is not only an operational support but also a strategic growth engine (Haag & Sandberg, 2019). The research has also highlighted the importance of logistics information systems in the management of distribution networks, especially in an omnichannel trading environment, where adaptability and decentralization of material handling nodes are essential for success (Kembro & Norrman 2019). Finally, it has been observed that dynamic logistics capabilities are necessary for retailers to face contemporary challenges, allowing them to continuously modify their logistics systems to maintain competitiveness (Haag 2021).

Methods Engineering is another relevant approach in improving logistics processes in retail distribution centres. This discipline focuses on the analysis and optimization of work methods, which can lead to a significant improvement in operational efficiency. For example, it has been shown that the implementation of retail and consumer clustering techniques can improve the operational efficiency of outbound logistics, reducing delivery times and transport costs (Mohanty et al. 2018). In addition, the assessment of supply chain capabilities in different contexts, such as Russia, has shown that logistics practices need to be adapted to local cultural and economic conditions, This highlights the need for a flexible approach in Method Engineering (Lorentz & Lounela 2011). Integrating logistics into an omnichannel context also requires a review of current logistics strategies, which involves a detailed analysis of the methods used in inventory and distribution management (Ghatak 2023). Finally, research on logistics flexibility and supply chain integration has shown that these capabilities are critical to addressing demand uncertainty and improving overall efficiency (Jafari et al. 2022).

Process standardization is a critical aspect in logistics management, as it allows for the creation of uniform procedures that can improve quality and efficiency. The literature suggests that standardization in retail logistics not only improves service consistency, but also facilitates the integration of operations into an omnichannel environment (Hübner et al. 2016). For example, research has indicated that retailers developing integrated multi-channel inventory systems can optimize their replenishment and distribution processes, resulting in greater customer satisfaction (Melacini et al. 2018). In addition, the management of logistics performance in supplier-retailer relationships has been studied, highlighting how process standardization can lead to significant improvements in collaboration and overall performance (Forslund 2014). The implementation of advanced technologies, such as artificial intelligence and data analysis, can also facilitate process standardization, allowing retailers to adapt quickly to market demands (Chen, 2023).

The PDCA (Plan-Do-Check-Act) methodology is a widely used approach for continuous improvement in logistics processes. This cycle allows organizations to identify areas for improvement, implement changes and assess their effectiveness in a systematic manner. In the retail context, PDCA application has proven effective at optimizing distribution logistics, allowing retailers to adjust their operations based on customer feedback and market changes (Haag et al. 2021). Research has shown that collaboration between retailers and logistics service providers can benefit from the implementation of PDCA, as it encourages a proactive approach to supply chain management (Haag 2021). In addition, the use of PDCA in assessing logistics efficiency has enabled companies to identify and mitigate risks associated with variability in demand and supply (Jiang 2023). Finally, the integration of PDCA with other continuous improvement methodologies such as Six Sigma can provide a robust framework for process optimization in the retail sector (Liu & Song 2023).

Continuous improvement is a fundamental concept in logistics management, as it involves a constant commitment to process optimization and customer satisfaction. The literature highlights that implementing dynamic logistics capabilities is essential for retailers to adapt to an ever-changing environment, allowing them not only to survive but also to thrive in a competitive market (Haag 2021). In addition, research has shown that continuous improvement in logistics can be achieved through the adoption of emerging technologies such as drone delivery, which promise to revolutionize the way logistics operations are managed (Muricho & Mogaka 2022). Collaboration between retailers and logistics service providers is also crucial to fostering continuous improvement, as it allows for the exchange of knowledge and implementation of best practices (Haag et al. 2021). Finally, continuous improvement in logistics focuses not only on operational efficiency but also on sustainability, implying a holistic approach that considers the environmental impact of logistics operations (Jiang 2023).

In conclusion, the literature review on logistics processes in retail distribution centers reveals a number of approaches and methodologies that can contribute significantly to improving operational efficiency and effectiveness. From the application of specific methodologies to process standardization and implementation of continuous improvement cycles, each of these aspects plays a crucial role in optimizing logistics in the retail sector. The integration of emerging technologies and collaboration between supply chain actors are key elements that will enable retailers to adapt and thrive in a competitive and ever-changing environment.

3. Methods

3.1 Basis of the Proposed Model

In Figure 1, an operating model based on Methods Engineering is presented, designed to improve productivity in retail distribution centers. This model was developed in six interconnected phases, beginning with project selection, where the need to optimize the order preparation process was identified as a key area for improvement. The second phase involved collecting and presenting relevant data on times, extraction flows, and dispatch processes, establishing a quantitative foundation for subsequent analysis. In the third phase, a thorough analysis of the collected data was conducted, evaluating current process times and productivity to identify bottlenecks and non-productive activities. The fourth phase focused on developing and presenting the ideal method, emphasizing process standardization, time studies, and ergonomic improvements to ensure uniform and safe performance. Subsequently, the fifth phase included a detailed work analysis, involving the implementation of optimal headcount, productivity measurements, and the practical application of standards and ergonomic improvements in order preparation. Finally, the sixth phase centered on time standardization, ensuring the model's replicability and sustainability through the evaluation of each dispatch and the calculation of specific machine requirements for each process. This comprehensive approach aimed not only to increase operational efficiency but also to establish sustainable and scalable practices for future applications in the sector.

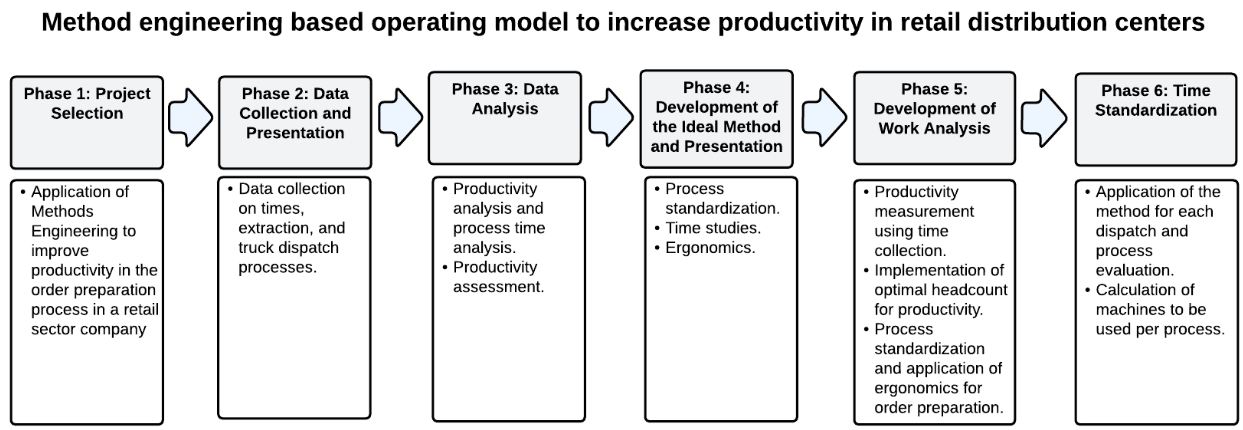

Figure 1. Proposed Model

3.2 Description of the model components

The proposed model represents a structured approach to addressing productivity challenges in retail distribution centers through the application of Methods Engineering. This methodology focuses on the systematic analysis and optimization of work processes to enhance efficiency and reduce operational inefficiencies. The model offers a significant contribution to the literature by integrating process standardization, ergonomic considerations, and time analysis, which are critical components for achieving sustainable improvements in the retail sector. Built on six interconnected phases, the model provides a comprehensive framework that emphasizes the collection and use of quantitative data to guide decision-making and ensure the replicability of results. Its design reflects the principles of continuous improvement, adaptability, and a human-centric approach to process optimization, making it applicable to a wide range of operational contexts within the retail industry.

Phase 1: Project Selection

The initial phase focused on identifying the need for improvement within the order preparation process in a retail distribution center. This phase highlighted the growing challenges in meeting operational efficiency standards due to increasing demand variability and logistical complexities. The analysis prioritized the order preparation process as a critical area of intervention, as it directly impacts delivery timelines and customer satisfaction. The application of Methods Engineering in this context was determined to be the most suitable approach for addressing inefficiencies, given its emphasis on systematic analysis and redesign of work processes. By defining clear objectives and focusing on measurable outcomes, this phase laid the foundation for a targeted intervention aimed at enhancing productivity while maintaining operational flexibility.

Phase 2: Data Collection and Presentation

The second phase involved an extensive data collection process to provide a detailed understanding of the current state of operations. Time studies were conducted to measure the duration of key activities within the order preparation and dispatch processes. Additionally, data on material flows and resource utilization were gathered to identify bottlenecks and areas of inefficiency. The information collected during this phase served as the baseline for subsequent analyses and was presented in a structured manner to ensure clarity and facilitate decision-making. This phase emphasized the importance of using accurate and reliable data as a basis for designing effective interventions, ensuring that the proposed solutions would be grounded in a thorough understanding of existing conditions.

Phase 3: Data Analysis

Building on the information gathered in the previous phase, the third phase focused on analyzing the collected data to identify specific inefficiencies and opportunities for improvement. Key performance indicators, such as cycle times, productivity rates, and error frequencies, were evaluated to establish a comprehensive picture of operational performance. The analysis revealed significant variations in process times and highlighted areas where standardization could lead to measurable gains in efficiency. By identifying the root causes of inefficiencies, such as delays in material handling and inconsistencies in task execution, this phase provided the insights needed to inform the development of targeted solutions. The findings underscored the potential for reducing variability and improving throughput through process optimization.

Phase 4: Development of the Ideal Method and Presentation
In the fourth phase, the focus shifted to designing an ideal method for the order preparation process. This involved the standardization of workflows to ensure consistency in task execution and the elimination of non-value-adding activities. Time studies were revisited to refine process sequences and establish optimal task durations. Ergonomic principles were also integrated into the design to enhance worker comfort and reduce the risk of injury, recognizing the importance of human factors in maintaining productivity. The proposed method was presented in a detailed and actionable format, including visual aids and procedural guidelines to facilitate its implementation. This phase emphasized the importance of aligning process improvements with worker well-being to achieve sustainable gains in efficiency.

Phase 5: Development of Work Analysis
The fifth phase involved a detailed analysis of work practices to validate the effectiveness of the proposed method. Productivity measurements were conducted to compare the performance of the redesigned process against the baseline established in earlier phases. The implementation of an optimal headcount was a key aspect of this phase, ensuring that labor resources were allocated efficiently to meet demand without overburdening workers. The analysis also included the application of process standards and ergonomic enhancements, which were shown to improve task completion times and reduce errors. This phase demonstrated the practical feasibility of the proposed method and highlighted its potential for scaling across similar operational contexts.

Phase 6: Time Standardization
The final phase focused on standardizing time measurements to ensure the replicability and sustainability of the improvements achieved. This involved the systematic application of the method across multiple dispatch cycles and the evaluation of its impact on key performance metrics. Calculations were performed to determine the specific machine requirements for each process, optimizing the allocation of physical resources. By establishing clear and consistent time standards, this phase provided a framework for maintaining the gains achieved through the intervention and adapting the method to future changes in operational conditions. The emphasis on standardization ensured that the benefits of the model would extend beyond the initial implementation, offering a lasting solution to productivity challenges.

The proposed model demonstrates the effectiveness of Methods Engineering in addressing productivity challenges in retail distribution centers. Through its structured and data-driven approach, the model not only delivers significant improvements in operational efficiency but also establishes a foundation for continuous improvement and scalability. By integrating process standardization, ergonomic considerations, and time analysis, the model provides a replicable framework that can be adapted to various operational contexts within the retail sector. Its application underscores the value of aligning process optimization efforts with human-centric principles to achieve sustainable and impactful results.

3.3 Model Indicators

Specialized metrics were established to monitor and analyze performance during the case study to measure the influence of the operations management model that integrates the tools of Methods Engineering. These metrics offered a dependable foundation for analyzing the essential elements of retail distribution center operations management. This systematic methodology facilitated a comprehensive evaluation of essential performance indicators, hence ensuring precise monitoring and fostering ongoing enhancements in distribution center operational processes.

Productivity Rate
The productivity rate measures the number of orders processed per worker per hour, reflecting the efficiency of human resources in the operation. Higher values indicate improved workflow and better utilization of labor.

$$PR = \frac{Orders\ Processed}{Number\ of\ Workers \times Hours\ Worked} \tag{1}$$

Rate of Orders Delivered on Time
This indicator calculates the percentage of orders delivered to the carrier within the scheduled timeframe, highlighting the effectiveness of the dispatch process.

$$RODT = \left(\frac{Orders\ Delivered\ On\ Time}{Total\ Orders\ Delivered}\right) \times 100 \tag{2}$$

Head Count
The head count reflects the total number of operators required to perform the processes. Reductions in this metric indicate better resource allocation and improved process efficiency.

$$HC = Total\ Number\ of\ Operators\ Assigned \tag{3}$$

Cost of Logistics
The cost of logistics measures the percentage of expenses related to the order preparation and delivery processes in proportion to total operational costs. Lower percentages signify cost optimization.

$$CL = \left(\frac{Logistics\ Costs}{Total\ Operational\ Costs}\right) \times 100 \tag{4}$$

4. Validation

4.1 Validation Scenario
The validation scenario took place in a case study focused on a retail company. This company operates within a competitive market environment and has over 25 years of presence in Peru and Chile. It boasts 31 strategically located stores across Lima and other provinces, alongside two distribution centers specializing in high-volume and small-packing products. The high-volume center manages categories such as white goods, furniture, and electronics, representing 40% of the company's total sales. The main problem addressed was inefficiencies in order preparation processes, particularly in dispatching orders to transport carriers. Challenges included late deliveries, incomplete orders, and increased overtime costs, cumulatively impacting logistics expenses and service quality. The company aimed to address these issues by implementing method engineering, productivity analysis, and process standardization to enhance operational efficiency and meet customer expectations in a highly dynamic and demanding sector.

4.2 Initial Diagnosis
En la figura 2 se muestra el árbol de problemas que resume el diagnóstico realizado en el caso de estudio, enfocado en identificar las razones y causas raíz de la baja productividad en el proceso de preparación de pedidos. El análisis evidenció un desfase técnico, dado que la tasa de cumplimiento de entregas a tiempo alcanzó el 92%, por debajo del estándar de la industria del 95%. Este problema generó un impacto económico de 1.9 millones de soles anuales, equivalente al 12.09% de los ingresos de la empresa. Las causas principales incluyen pedidos no cargados a transporte por demoras (44%), pedidos incompletos (28%) y errores en el etiquetado de pedidos (12%). Entre las causas raíz se identificaron la falta de procesos estandarizados (22.3%), pedidos preparados fuera de horario (48.10%) y sobrecarga operativa manual (13.64%), así como actividades sin estandarización (37.8%) y un headcount incompleto (28.64%). Adicionalmente, errores de operador (33.56%) y la falta de supervisión a nuevos empleados (36%) contribuyeron al problema, junto con errores de entrega (43.29%) y toma de pedidos incorrecta (21.01%). Este diagnóstico destacó la

necesidad de implementar herramientas de ingeniería de métodos para mitigar las deficiencias identificadas y optimizar el proceso.

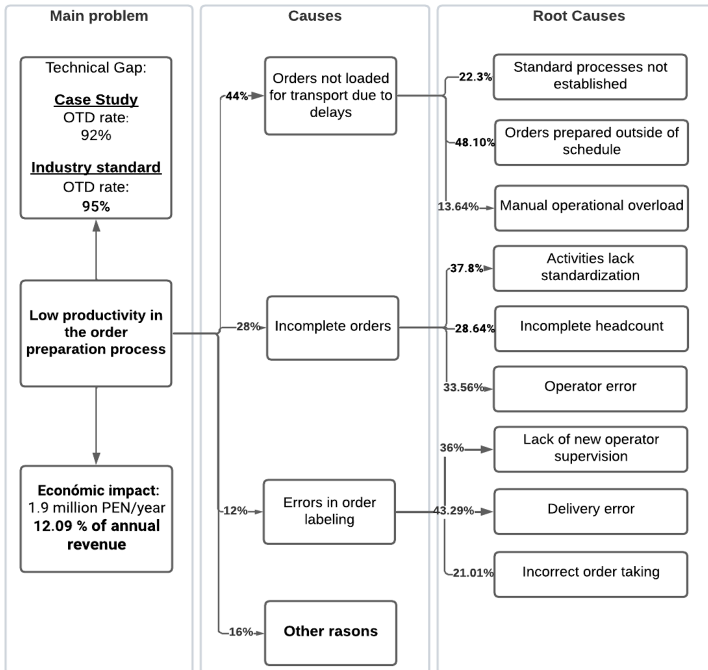

Figure 2. Problem Tree

4.3 Implementation of the model in the case study

The proposed model was implemented to improve productivity and reduce costs in the order dispatch process of a retail sector company. This model addressed critical issues such as prolonged operational times, non-standardized activities, ergonomic risks, and inefficient resource allocation. Each phase was designed to optimize performance and ensure sustainable operational improvements.

Phase 1: Project Selection

The project selection was based on the analysis of key issues in the dispatch process. In 2022, average productivity dropped to 2.84 orders/hour, and significant costs were recorded, including S/. 190,000 in overtime expenses, S/. 1,978,000 in rejected deliveries due to late shipments, and S/. 125,430 for incomplete order returns. These inefficiencies led to total losses of S/. 1.9 million due to logistic failures and a 13% sales decline in Q1 2023 compared to Q1 2022.

The dispatch process was identified as critical, as it directly impacts customer satisfaction and supply chain efficiency, representing 40% of the company's total sales. Focus was placed on the picking and dispatch flows due to their significant influence on operational performance.

Phase 2: Data Collection and Presentation

Key operational data were gathered through time studies, direct observation, and analysis of historical warehouse management system (WMS) records. Average picking times included 3.85 minutes for product extraction and 6.41 minutes when including transfers to dispatch areas. For the dispatch subprocess, workers processed an average of 24 orders per hour, but productivity varied across product categories.

Delivery compliance levels in 2022 averaged 92%, with critical months such as January (88%) and August (90%). These results highlighted the need for process improvements to address inefficiencies and standardize operational times.

Phase 3: Data Analysis

The data analysis revealed that product categories like televisions achieved a productivity rate of 36 units/hour, while more complex categories, such as furniture and mattresses, reached only 15 and 14 units/hour, respectively. These disparities were attributed to factors such as product volume, weight, and storage location. Ergonomic risks were identified, especially in the big-ticket area, where workers handled appliances exceeding 25 kg. For the dispatch subprocess, redundant activities and a lack of standardized procedures for system load closures contributed to significant delays in order preparation.

Phase 4: Ideal Method Development and Presentation

Picking Optimization

Operator tasks were redesigned, reducing responsibilities from 15 to 10 activities. A data entry operator was introduced to take over administrative tasks, allowing pickers to focus on core activities like product localization and extraction. Standard picking times decreased from 14.95 minutes to 11.13 minutes. Additionally, average operator productivity increased to 22 units/hour, representing a 10% improvement over previous years.Figure 3 illustrates the current picking process in a retail distribution center. The workflow begins with task assignments and progresses through merchandise identification, verification, labeling, and palletization. Key decision points include verifying product allocation and complement status. The process ends with dispatch preparation tasks, such as routing, barcode scanning, and system updates.

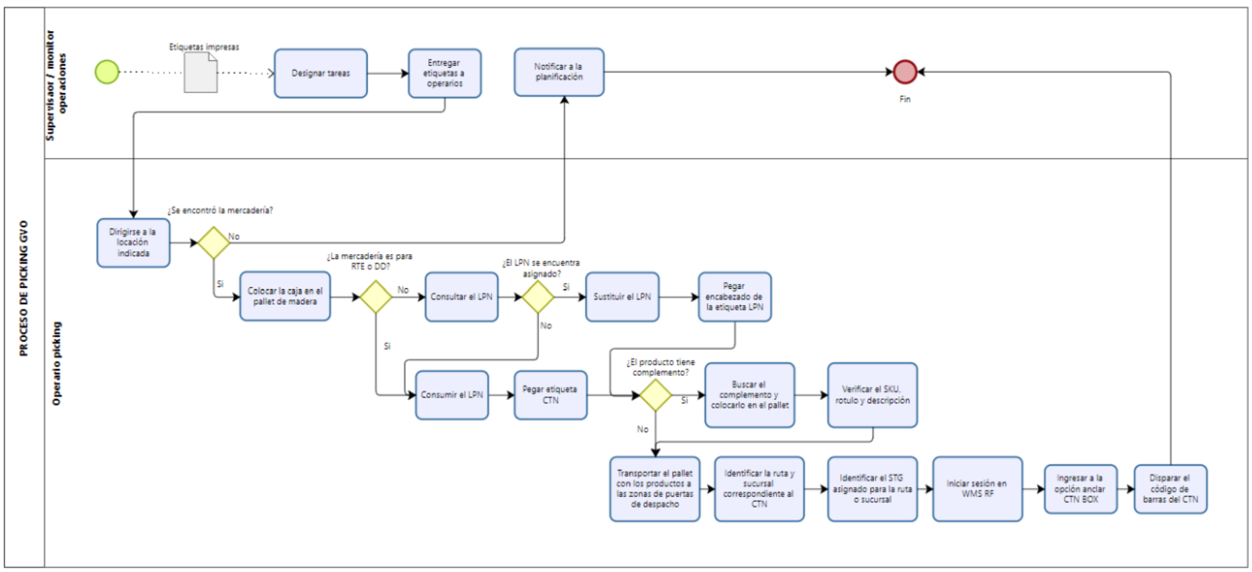

Figure 3. Current diagram of the picking process

Figure 4 shows the improved picking process, integrating enhanced workflows and reducing redundancies. Key changes include reallocating administrative tasks to a new digital assistant, optimizing product handling, and improving routing accuracy. Decision points verify product allocation and complements, while streamlined steps ensure efficient labeling, palletization, and system updates. This process improves overall productivity and minimizes errors.

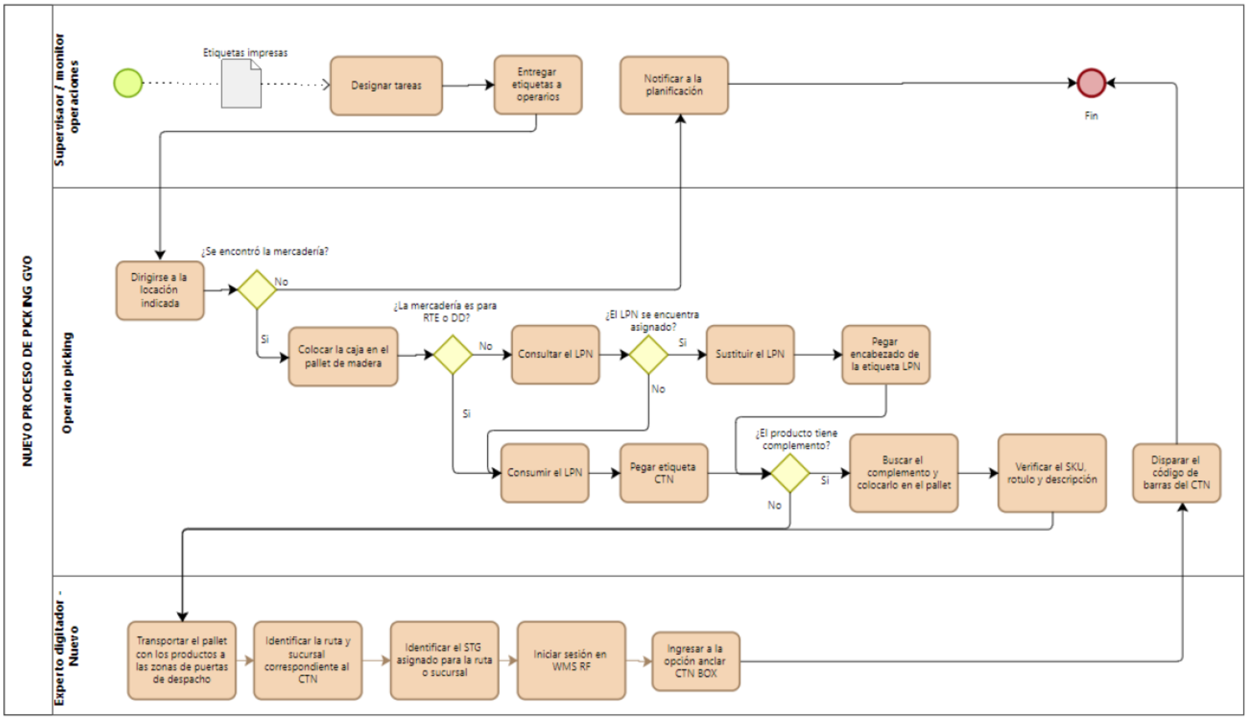

Figure 4. Diagram of the improvement of the picking process

Dispatch Enhancements

Dispatch workflows were reorganized to eliminate redundant activities and optimize the use of tools such as electric pallet jacks. As a result, average order handling times dropped to 0.73 minutes, enabling a capacity of 596 orders per day.

Figure 5 depicts the improved dispatch process, emphasizing streamlined workflows and enhanced decision points. The process begins with picking and anchoring merchandise at designated dispatch areas. Decision nodes address transport allocation, with tasks including pallet labeling, product palletization, and system-based load assignments. It concludes with loading, transport, and generating dispatch or pallet removal guides, ensuring operational accuracy and efficiency.

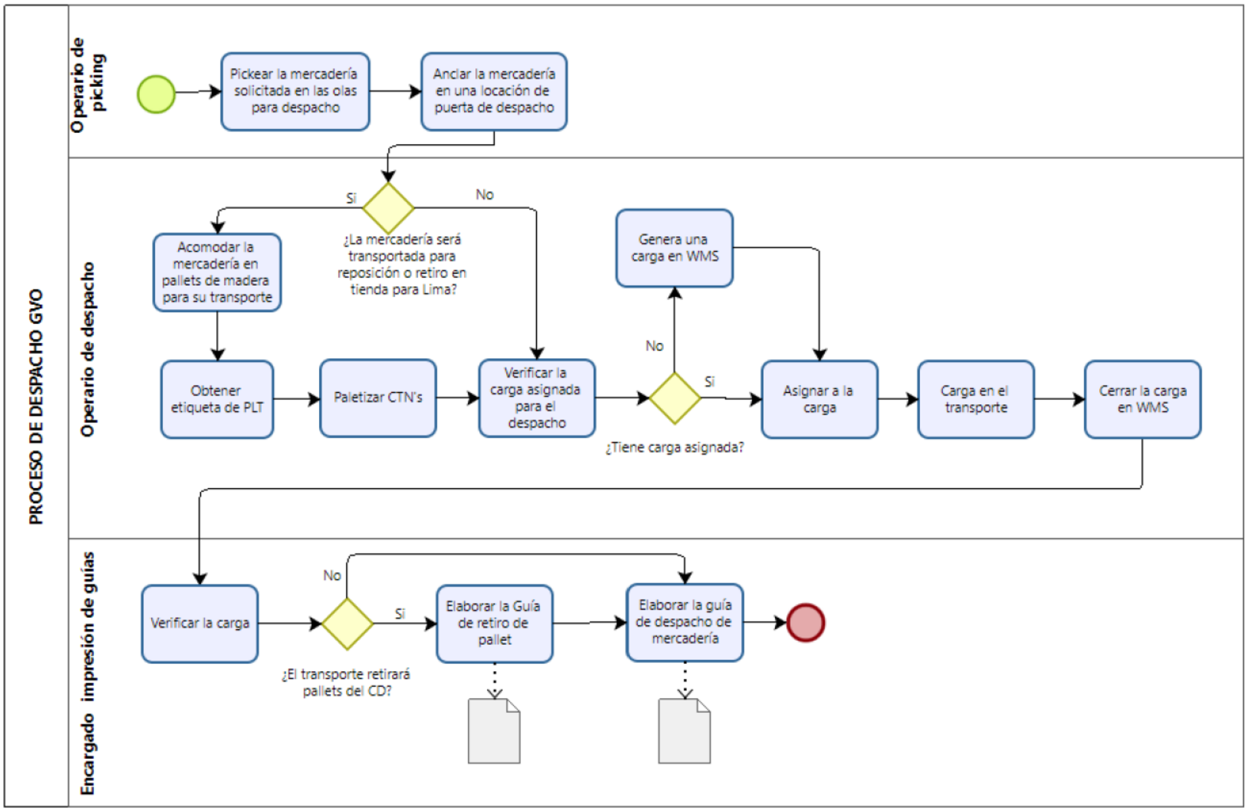

Figure 5. Diagram of the improvement of the dispatch process

Figure 6 illustrates the improved dispatch-to-transport process, highlighting efficiency and control enhancements. The workflow begins with picking and positioning goods for dispatch, followed by tasks like labeling pallets and verifying transport assignments. Key decisions ensure load accuracy and allocation, while the process concludes with loading, system updates, and generating transport or removal guides, optimizing traceability and operational performance.

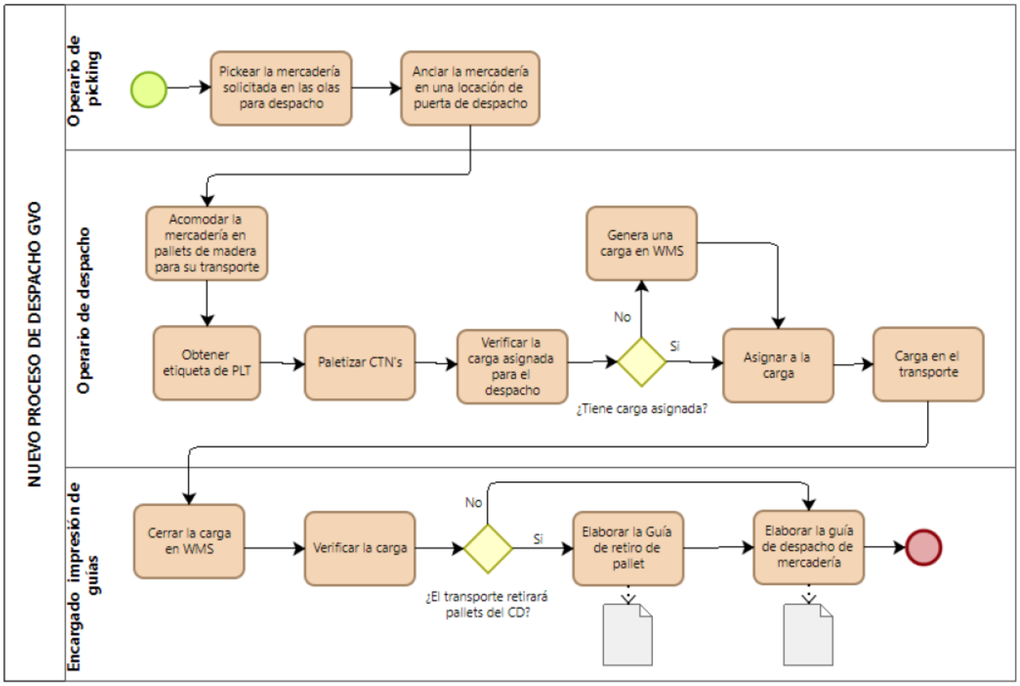

Figure 6. Improved diagram of the dispatch to transport process

Ergonomic Interventions

Ergonomic measures were implemented to reduce physical strain associated with handling heavy products. A protocol was established for active breaks, allowing workers to rest for 5 minutes after every 60 minutes of work, significantly reducing fatigue. A training program in ergonomics was introduced, covering safe loading and unloading techniques. Risk assessments showed that 60% of activities in categories like white goods were classified as high-risk. These interventions not only improved workplace safety but also increased productivity by minimizing downtime due to fatigue.

Figure 7 presents an ergonomic risk assessment table categorized by product type, weight, and handling method. Key metrics include manual handling, transportation via carts, and the number of daily units processed. High-risk categories, such as white goods (e.g., washing machines, stoves, and refrigerators), exhibit elevated risk factors due to weight and repetitive strain, while items like televisions are classified as safe. This assessment helps prioritize ergonomic interventions to reduce workplace injuries and enhance operational safety.

CATEGORÍA		PESO - KG	T. PICKING	T. DE TRASLADO	N° UNIDADES DESPACHADAS DIARIAS	IE	DE	EM	HWP	SW	DD	JSI (FACTOR DE RIESGO)	JSI<=3.Prob.Seguro JSI>=7.Prob.Peligrosa
Línea Blanca		60	Manual	En carretilla manual	150	9.0	2.0	1.2	2.0	1.5	1.0	10.8	Peligrosa
		30	Manual	En carretilla manual	110	5.0	3.0	1.0	2.0	1.5	1.0	7.5	Peligrosa
		40	Manual	En carretilla manual	120	5.0	4.0	1.5	2.0	1.5	1.0	15.0	Peligrosa
Línea marrón		30	Manual	En carretilla manual	250	3.0	0.5	1.0	1.0	2.0	1.0	0.5	Segura
Muebles		28	Manual	En carretilla manual	45	5.0	3.0	1.0	2.0	1.5	1.0	7.5	Peligrosa
		28	Manual	En carretilla manual	95	3.0	0.5	1.0	1.0	2.0	1.0	0.5	Segura

Figure 7. Ergonomic risk assessment table by category

Phase 5: Work Analysis Development

Optimal headcount was calculated for each shift, considering a 94% real productivity rate. This analysis enabled the creation of three rotational shifts with 42 workers distributed as follows: 24 in picking and 12 in dispatch. New equipment, including electric pallet jacks (increased from 2 to 4 units), was also incorporated, further optimizing workflows.

Phase 6: Time Standardization

Procedures were standardized based on the ideal times determined in earlier phases. For example, the average time for delivering orders to carriers was reduced to 11.13 minutes, a 25% improvement over the initial time of 14.95 minutes. This reduction was achieved through the adoption of efficient machinery and the standardization of critical tasks. Overall productivity improved, surpassing 3 orders/hour on average.

Figure 8 shows the Improved Process Analytical Diagram (DAP) for the order preparation process, comparing the current and proposed methods. Activities are classified by type (operation, transport, inspection) and value-added contribution. The proposed method reduces total time from 141 seconds to 107 seconds, optimizing key steps like labeling, pallet transport, and system updates. This enhancement minimizes non-value-added activities, increasing efficiency and reducing process cycle times.

DIAGRAMA ANALÍTICO DE PROCESO - DAP								
PROCESO: Preparación de pedidos						Operación: Preparación de pedidos		
						Material: Dispensador		
MÉTODO: ☐ Actual		☒ Propuesto				Hombre: Operario		
DESCRIPCIÓN	Operación	Transporte	Inspección	Retraso	Almacenaje	Tipo de desperdicio	Tipo de segundos	Tipo de actividad
Entregar etiquetas a operarios	●					operación	30	AGREGA VALOR
Dirigirse a la zona indicada		●				operación	8	AGREGA VALOR
Colocar la caja en la paleta de madera	●					operación	18	AGREGA VALOR
Consumir/ Sustituir LPN	●					operación	15	AGREGA VALOR
Pegar etiqueta CTN/LPN	●					operación	30	AGREGA VALOR
Transportar pallet a zona de de despac		●				Transporte	12	AGREGA VALOR
Identificar ruta y sucursal de CTN			●			inspección	26	AGREGA VALOR
Identificar el STG asignado para la ruta			●			inspección	12	AGREGA VALOR
Iniciar sesión en WMS	●					operación	40	AGREGA VALOR
Ingresar a la opción CTN BOX	●					operación	60	AGREGA VALOR
Disparar el código de barra al CTN	●					operación	40	AGREGA VALOR
Acomodar los pedidos en palets de madera	●					operación	45	AGREGA VALOR
Obtener etiqueta PLT	●					operación	50	AGREGA VALOR
Paletizar CTN	●					operación	90	AGREGA VALOR
Verificar carga para despacho			●			inspección	8	AGREGA VALOR
Generar carga en WMS	●					operación	28	AGREGA VALOR
Cargar en el transporte	●					operación	50	AGREGA VALOR
Cerrar carga en WMS	●					operación	45	AGREGA VALOR
Verificar carga para despacho			●			inspección	10	AGREGA VALOR
Elaborar documentación (Guías)	●					operación	50	AGREGA VALOR
RESUMEN — Cantidad	14	2	4	0	0	20	667	
RESUMEN — Tiempo total (s)	591	20	56	0	0	667		Versión 1
RESUMEN — Tiempo AV (s)	591	20	56	0	0	667		
RESUMEN — Tiempo NV (s)	0	0	0	0	0	0		

Figure 8. Improved Process Analytical Diagram

5. Results

In Table 1, the validation of the proposed model based on Methods Engineering is presented, highlighting significant improvements. The productivity rate increased by 40.85%, rising from 2.84 to 4.00 orders per hour-man. Additionally, the percentage of orders delivered on time improved to 96.1%, surpassing the initial target. The headcount was optimized, reducing from 50 to 36 operators, representing a 28% decrease while maintaining operational efficiency. Furthermore, the logistics cost was reduced by 35.29%, demonstrating the effectiveness of the model in streamlining resource utilization and lowering expenses. These results reflect the model's capacity to address critical inefficiencies in the order preparation process, balancing operational performance with cost reduction and quality enhancement. By integrating structured methodologies and operational improvements, the model successfully resolved key challenges and delivered measurable benefits, emphasizing its applicability in similar industrial contexts.

Table 1. Results of validation of the proposed model

Indicator	Unit	As-Is	To-Be	Results	Variation (%)
Productivity rate	Pedidos/Hour-Man	2.84	3.20	4.00	40.85%
Rate of orders delivered on time to the carrier	%	92.0%	95.0%	96.1%	4.46%
Head count	operators	50	35	36	-28.00%
Cost of logistics	%	1.7%	1.0%	1.1%	-35.29%

6. Conclusions.

The study reveals significant advancements in optimizing productivity and efficiency in retail distribution centers by employing a structured model based on Methods Engineering. Key findings demonstrate a 40.85% increase in productivity rate, from 2.84 to 4.00 orders/hour-man, and an improvement in on-time delivery rates, rising from 92.0% to 96.1%. The headcount was reduced by 28%, from 50 to 36 operators, while logistics costs decreased by 35.29%. These improvements stemmed from process standardization, ergonomic interventions, and workflow redesign, addressing critical inefficiencies in order preparation and dispatch processes. By integrating ergonomic principles, safety was enhanced, reducing fatigue and injury risks, particularly in high-risk product categories such as white goods.

This research underscores the importance of enhancing operational efficiency in retail distribution centers, which play a pivotal role in supply chain performance. In an increasingly competitive market, improving productivity and reducing costs while maintaining service quality are vital for sustaining customer satisfaction and profitability. The integration of ergonomic measures not only mitigates physical strain on workers but also aligns with broader goals of workplace safety and employee well-being. Furthermore, the use of data-driven decision-making and time standardization ensures that the proposed model delivers replicable and sustainable results.

The study contributes significantly to the field of Industrial Engineering by providing a replicable framework for addressing productivity challenges in distribution centers. Its systematic approach integrates ergonomic principles, workflow optimization, and continuous improvement strategies, bridging gaps in the existing literature regarding operational inefficiencies in retail logistics. This model is particularly relevant for organizations seeking to enhance their adaptability and competitiveness in dynamic market conditions. Moreover, the emphasis on quantitative metrics allows for precise monitoring and evaluation of improvements, ensuring that interventions are both effective and scalable.

Final observations highlight the necessity of adopting comprehensive strategies that combine human-centric approaches with technological advancements to optimize operational processes. While the proposed model demonstrates substantial improvements, future research could explore the integration of advanced technologies such as automation and IoT to further enhance efficiency. Additionally, studies could focus on the long-term impacts of ergonomic interventions on worker health and productivity. Expanding the application of this model to other industries and operational contexts could provide valuable insights, fostering the development of adaptable and resilient logistics systems.

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