

# **Improvement of OTD in A Commercial Distribution Center Applying Poka Yoke, Work Standardization and Forecast**

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## **Abstract**

Improving delivery performance is a critical requirement for distribution operations, as delays often arise from documentation errors, non-standardized procedures, and irregular demand patterns. This study proposes an integrated solution to enhance the On-Time Delivery (OTD) indicator in a logistics process by applying three complementary engineering tools: work standardization, poka-yoke mechanisms, and a multi-SKU forecasting model. Time measurements were conducted using a representative sample of 370 orders, allowing the identification of fixed and variable components in the generation of shipping guides and their optimization under a standardized workflow. Additionally, historical demand was analyzed to develop a forecasting model capable of managing highly irregular consumption, enabling better inventory availability. A simulation of 100 replications was performed to validate the improvements and evaluate their stability under operational variability. The results demonstrate a reduction in processing times, a decrease in documentation errors, and a more stable performance distribution, contributing to an overall improvement in OTD. Limitations related to data variability and manual dependencies were identified, and potential future enhancements, such as automated verification and real-time tracking, are suggested.

## **Keywords**

On-Time Delivery (OTD), Work Standardization, Poka-Yoke, Multi-SKU Forecasting, Logistics Process Improvement.

## **1. Introduction**

The wholesale distribution sector is expected to grow by 7.3% next year, increasing the need for efficient and reliable logistics operations. This study examines a major Peruvian distributor of non-strategic products that operates under a cross-docking model and serves clients across Lima and provincial regions. Despite its established operations, the company faces recurring issues such as delivery delays, inconsistent workflows, documentation errors, and limited

demand planning, all affecting its On-Time Delivery (OTD) performance. The research identifies the root causes of these problems and proposes engineering-based improvements to enhance process reliability and overall distribution efficiency

### **1.1 Objectives**

- Developing a standardized workflow that reduces fixed and variable processing times in the generation of shipping guides.
- Implementing error-proofing (poka-yoke) mechanisms that ensure accurate documentation and minimize operational mistakes.
- Designing a demand forecasting model capable of responding effectively to irregular consumption patterns to improve inventory availability.
- Enhancing overall process efficiency by integrating engineering tools that support faster, more consistent, and reliable delivery performance.

## **2. Literature Review**

The performance of wholesale distribution has become increasingly critical due to rising operational complexity and service expectations in modern supply chains. Delivery delays, documentation errors, and planning deficiencies remain the main factors affecting service reliability and On-Time Delivery (OTD) performance in distribution centers (Zhou et al., 2020). In Peru, wholesale distributors of non-strategic products face high demand variability, which, if not properly managed, leads to longer cycle times, reprocessing, and reduced customer satisfaction (Bueno et al., 2020; Singh et al., 2020).

To mitigate these issues, engineering-based tools such as work standardization, poka-yoke mechanisms, and demand forecasting have been increasingly adopted in logistics operations. Standardization reduces process variability and human error, error-proofing mechanisms prevent documentation mistakes, and forecasting models help anticipate inventory needs and reduce stockouts (Mesta Serquén, 2016; Savković et al., 2022; Chowdhury et al., 2025).

Building on these approaches, this study proposes an integrated improvement system for a Peruvian wholesale distributor operating under a cross-docking model. The methodology combines standardized workflows, poka-yoke validation, and multi-SKU demand forecasting, supported by time studies on 370 orders and a 100-replication simulation to validate performance under operational variability. Unlike prior studies focused on isolated techniques, this research evaluates the combined impact of multiple engineering tools on OTD performance.

The results show improved process stability, reduced processing times, fewer documentation errors, and enhanced forecasting accuracy. The proposed approach provides a practical, scalable, and cost-effective solution for improving delivery performance and operational efficiency in wholesale distribution environments.

## **3. Methods**

A simple but effective methodological approach was applied to analyze the operational performance gaps and identify improvement opportunities within the order fulfillment process. Special consideration was given to the reliability of the simulated results, the consistency of the modeled variables, and the ability of the proposed tools, work standardization, Poka Yoke, and Multi-SKU Forecasting, to reduce variability and support more efficient and timely order processing.

## **4. Data Collection**

The system described in the article focuses on a distribution process in a logistics center, covering activities such as order reception, processing, and coordination with transporters. Similarly, the analyzed process is organized into phases including quotation, stock validation, order preparation, and issuance of the shipping guide, as shown in Figure 1, all aimed at achieving on-time delivery and customer satisfaction.

This process was modeled in Arena software (Fig. 1), representing order registration, shipment preparation, and inventory validation. A sample of 370 orders was selected from 10,344 total orders using simple random sampling with a 5% margin of error, and the model was executed with 100 replications to capture process variability. The AS-

IS model highlights decision points, error-handling mechanisms, and corrective rework paths caused by documentation or stock issues that impact overall process efficiency.

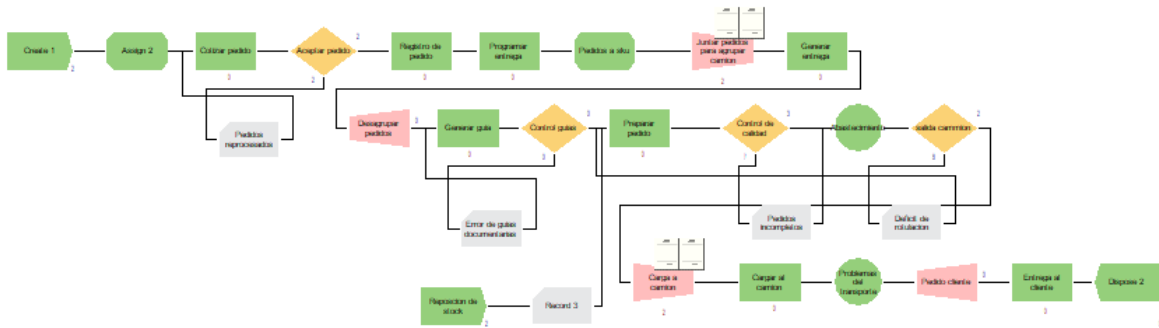


Figure 1. Simulation modeling diagram AS-IS

## 5. Results and Discussion

### 5.1 Numerical Results

The system was tested to evaluate its accuracy, responsiveness, and overall performance, using three key indicators: Documentary Accuracy Index (IPD), Logistics Matching Index (ICL), and Incomplete Orders Indicator (MAPE). As shown in the table, the As-Is model had an IPD of 79.88%, an ICL of 85.50%, and a MAPE of 20.80%. After implementing the improvements in the To-Be simulated model, these values significantly increased to 94.20% for IPD, 91.70% for ICL, and 11.00% for MAPE. The To-Be expected model aims to further improve these values, reaching 96.00% for IPD, 94.50% for ICL, and 10.50% for MAPE. The system also showed a substantial improvement in On-Time Delivery (OTD), going from 63.80% in the As-Is model to 90.30% in the To-Be simulated model, with an expected 92.00% for the future model. These results confirm that the system improvements have led to a more efficient and accurate process, enhancing overall performance in real-world conditions (Table 1).

Table 1. Simulation results

Results	As-Is	To-Be Simulated	Expected To-Be
Documentary Accuracy Index (DAI)	79.88%	94.20%	96.00%
Logistic Matching Index (LMI)	85.50%	91.70%	94.50%
Incomplete ordered indicators (MAPE)	20.80%	11.00%	10.50%
On time delivered (OTD)	63.80%	90.30%	92.00%

### 5.2 Graphical Results

The warehouse analysis (Figure 2) shows several orders being reprogrammed due to inefficiencies in the order processing system, mainly caused by documentation errors and stock shortages. These situations generate delays and operational adjustments, directly affecting delivery performance and highlighting opportunities for process improvement.



Figure 2. Rescheduled orders in warehouse

During the warehouse test, a Poka-Yoke validation checklist (Figure 3) was applied to monitor task execution. The checklist includes critical control points such as order document verification, packaging condition review, and delivery address confirmation. The partial completion of the checklist confirms compliance with the validation process and supports error prevention within the logistics flow.

Datos generales			
Fecha		-- / -- / --	
Operario encargado		Cliente:	
Supervisor responsable			
N°	Actividad	Resultado	Observación
1	Verificación de documento del pedido (guía de remisión, cantidad solicitada).	✓	Se rectificó las posiciones con la OC
2	Revisión del embalaje (estado del producto y rotulado)	✓	Rotulado coincide con la guía de remisión
3	Confirmación de dirección de entrega (dirección exacta, contacto y hora programada)	✓	Se verificó con el ejecutivo de ventas que sea la dirección correcta
Firmas de conformidad			
_____		_____	
Operario		Supervisor	
Validación Poka Yoke			

Figure 3. use of the validation checklist

Processing times were analyzed prior to the TO-BE modeling using histograms (Figures 4 and 5). Figure 3 shows high variability in processing times before the implementation of Poka-Yoke and work standardization. Figure 11 demonstrates a noticeable reduction in variability after the improvements. Statistical validation using the Chi-Square and Kolmogorov-Smirnov tests yielded p-values of 0.135 and 0.0193, confirming a significant improvement in processing time performance.

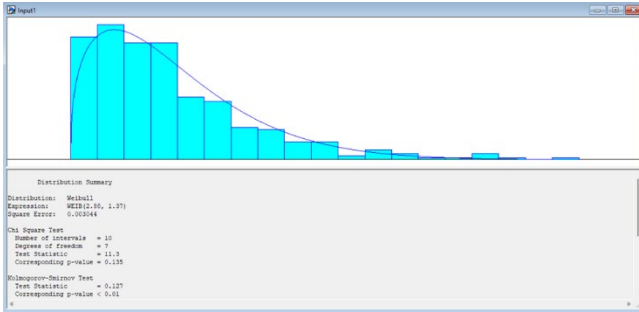


Figure 4. AS-IS guide generation

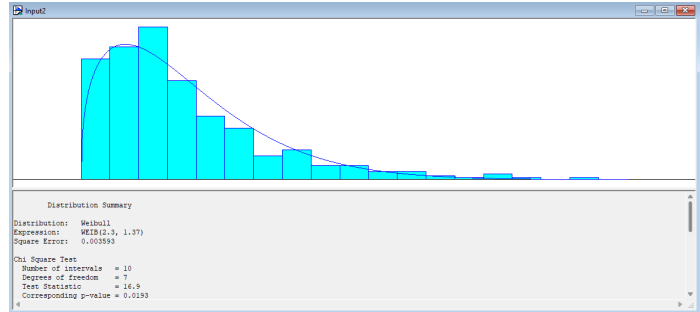


Figure 5. TO-BE guide generation

A forecasting model was applied to estimate future demand for SKU 5000232 based on historical sales data. The forecast results are presented in Figure 6, where the predicted values accurately capture demand trends and peaks over a 60-day horizon, supporting improved inventory planning and stock availability (Figure 7).

```

1. Instalar librerias necesarias
2. Importar datos desde csv
3. Limpieza de datos
4. Análisis de datos
5. Generación de reportes
6. Guardar resultados
7. Visualización de gráficos
8. Cerrar archivo
9. Salir del programa
10. Fin del programa

# Importar librerías
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
import seaborn as sns

# Leer datos desde archivo
df = pd.read_csv('datos.csv')

# Limpieza de datos
df.dropna(inplace=True)

# Análisis de datos
df.describe()

# Generación de reportes
df.to_csv('reporte.csv', index=False)

# Visualización de gráficos
df.plot()

# Cerrar archivo
df.close()

# Salir del programa
exit()
    
```

Figure 6. programming code in Google Collab

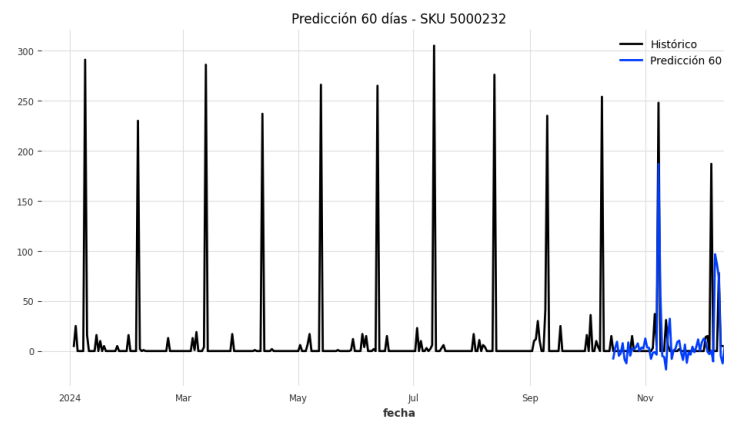


Figure 7. SKU prediction

Finally, the TO-BE simulation model was executed under the same conditions as the AS-IS model, with 100 replications conducted in Arena to ensure statistical consistency. This allowed a direct comparison between both models, validating the positive impact of the proposed improvements on operational efficiency.

In the warehouse environment shown in the image, we can observe several orders that are currently being reprogrammed. This is a direct result of inefficiencies in the order processing system, which leads to delays and adjustments. These reprogrammed orders highlight the operational challenges faced when discrepancies occur, such as errors in documentation or stock shortages. The physical representation of these issues in the warehouse underlines the importance of optimizing the workflow to reduce errors and improve delivery times, directly aligning with the objectives of the improvement proposal (Figure 8).

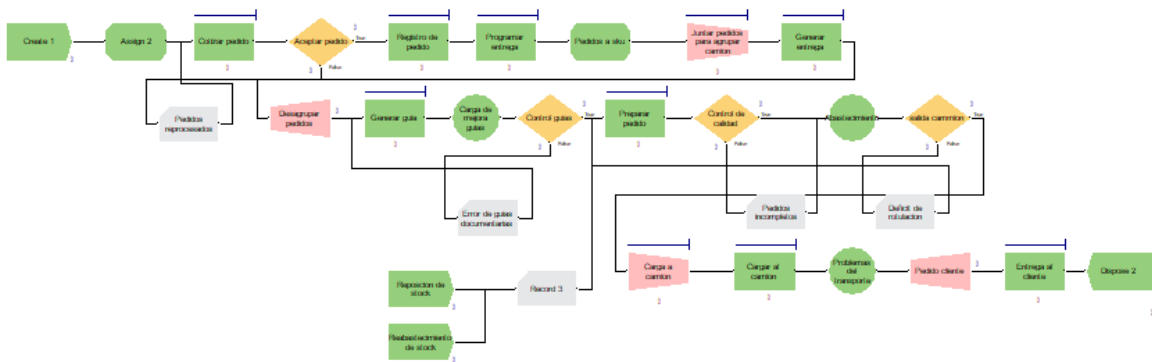


Figure 8. Simulation modeling diagram TO-BE

## 6. Conclusion

The implementation of the Poka-Yoke technique significantly reduced errors in the issuance of guides and documentary records, increasing the Documentary Accuracy Index (IPD) from 79.88% to 94.2%. The pilot test, based on a verification code developed in Python and integrated with the SAP system, automatically validated customer information before generating the guides. The Multi-SKU Forecasting tool enabled more accurate supply planning, reducing the average forecasting error (MAPE) from 20.8% to 11%, improving product availability and reducing overstocking. Process standardization helped to standardize critical activities in the transportation area, improving the Logistics Matching Index (ICL) from 85.5% to 91.7% by establishing clear procedures that favored stability and coordination in workflow. As a result, the integration of Poka-Yoke, Work Standardization, and Multi-SKU Forecasting tools improved the On-Time Delivery (OTD) indicator from 63.8% to 90.3%, optimizing supply chain efficiency. These results confirm that the combination of quality control methodologies, standardization, and advanced forecasting optimizes operational efficiency, reduces process variability, and strengthens continuous improvement, significantly contributing to the Peruvian wholesale industry by improving operational accuracy and logistics efficiency in dynamic, high-demand environments.

## 7. Future Work

During the research, several challenges and areas for improvement were identified, which could be addressed in future investigations. To optimize logistics processes and enhance overall system efficiency, the following recommendations are proposed:

- **Transport Management:** Implement GPS tracking for route compliance and real-time alerts on deviations.
- **Transporter Performance:** Evaluate punctuality and compliance, creating continuous feedback.
- **Advanced Technologies:** Apply RPA, AI, and machine learning to automate and integrate processes.
- **Process Certification:** Certify logistics processes to reduce rework and improve service quality.

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## References

- Bueno, A. A., Godinho Filho, M., and Frank, A. G., "Smart Production Planning and Control in the Industry 4.0 Context: A Systematic Literature Review," *Computers & Industrial Engineering*, Vol. 149, p. 106774, 2020.
- Chowdhury, A. R., Paul, R., and Rozony, F. Z., "A Systematic Review of Demand Forecasting Models for Retail E-Commerce Enhancing Accuracy in Inventory and Delivery Planning," *International Journal of Scientific Interdisciplinary Research*, Vol. 6, No. 1, pp. 1–27, 2025.
- Mesta Serquén, D., "Aplicación del Método Poka Yoke para Incrementar la Productividad en el Proceso de Despacho de Producto Terminado de una Empresa Siderúrgica Callao," Bachelor's Thesis, Universidad César Vallejo, 2016.
- Savković, M., Komatina, N., Caiazzo, C., and Djapan, M., "Improving the Quality of Final Product by Poka-Yoke System on Assembly Workstation: A Case Study," *Proceedings of the 8th International Conference on Industrial Engineering (SIE 2022)*, pp. 186–190, 2022.
- Singh, J., Singh, H., and Kumar, A., "Impact of Lean Practices on Organizational Sustainability through Green Supply Chain Management—An Empirical Investigation," *International Journal of Lean Six Sigma*, Vol. 11, No. 5, pp. 1049–1082, 2020.
- Singh, R. K., and Singh, S. P., "Applications of the Internet of Things for Optimizing Warehousing and Logistics Operations: A Systematic Literature Review and Future Research Directions," *Computers & Industrial Engineering*, Vol. 149, p. 106774, 2020.
- Zhou, L., Jiang, Z., Geng, N., Niu, Y., Cui, F., Liu, K., and Qi, N., "Production and Operations Management for Intelligent Manufacturing: A Systematic Literature Review," *International Journal of Production Research*, Vol. 60, No. 2, pp. 808–846, 2021.

## Biographies

**Yajel Bellido Tumba** is an undergraduate student in the Industrial Engineering Career at the University of Lima, in the Faculty of Engineering and Architecture, Lima, Peru. I am particularly interested in professionally developing in the areas of finance, commercial sectors, and supply chain management. Outside of academics, I have supported in the teaching of engineering courses, including mechanical physics and finance. I am passionate about further developing my skills in the areas mentioned above. I am currently working on a project focused on logistics optimization and forecasting models.

**Carlos Urbina** is a professor in the Industrial Engineering Career at the University of Lima, within the Faculty of Engineering and Architecture. With years of experience in international distribution, planning, and project management, Professor Urbina brings a wealth of practical expertise to his teaching. His background in managing and planning complex international distribution projects allows him to offer real-world insights into logistics, supply chain management, and operations strategy. In addition to his academic duties, he has worked with numerous companies in the field, further enhancing his credibility as a subject matter expert. He currently teaches courses in Industrial Engineering, focusing on areas like supply chain management, logistics, and project planning, where he integrates both theoretical knowledge and practical application.

**Edilberto Ávalos** is also a professor in the Industrial Engineering Career at the University of Lima, in the Faculty of Engineering and Architecture. Alongside his teaching responsibilities, he serves as a Research Advisor and Coordinator, playing a crucial role in guiding students through their research projects and academic development. Professor Ávalos is deeply involved in fostering the university's research culture, providing mentorship to students working on theses and scientific investigations. His contributions to both teaching and research support the university's goals in advancing academic knowledge, particularly in areas related to industrial engineering, operations management, and system optimization. With his expertise and leadership, he ensures that students are equipped with the tools necessary for both academic success and professional achievement.