Proceedings of the International Conference on Industrial Engineering and Operations Management

Publisher: IEOM Society International, USA DOI: 10.46254/AP06.20250215
Published: August 5, 2025

RFID-Enabled Inventory Accuracy Improvement in a Peruvian Textile Manufacturer: A Case Study

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Abstract

Inventory inaccuracy remains a critical issue in the Peruvian textile industry, driven by manual tracking and lack of real-time visibility. This study aimed to improve finished-goods inventory accuracy in a jeans-manufacturing SME through the integration of Radio Frequency Identification (RFID), Value Stream Mapping (VSM), and discrete-event simulation. A time study over 14 days supported the development of current and future-state models using Arena Simulator. RFID gates and handheld readers were incorporated in the improved design. Results showed an increase in inventory record accuracy from 85% to 95%, an 81% reduction in registration time (from 2.6 h to 0.49 h), and a 35% reduction in lead time. The intervention also enabled 100% compliance with the daily production plan. This research fills a gap in the literature on RFID implementation in Latin American textile SMEs and offers a replicable model for industries seeking sustainable improvements in operational visibility, labor efficiency, and customer service performance.

Keywords
Inventory inaccuracy, RFID, Inventory management, Supply chain, VSM

1. Introduction
Effective inventory management is crucial for supply chain performance, especially in the textile industry, where inventory inaccuracy is a persistent issue. Reports indicate that 29% of textile companies face daily challenges related to inaccurate inventory (National Council of Textile Organizations 2019), which can lead to delays, reduced profitability, and customer dissatisfaction (PwC 2020).

Radio Frequency Identification (RFID) is a technological alternative that improves inventory tracking through automated data capture using radio waves. Unlike traditional barcodes, RFID offers greater accuracy and real-time visibility. Studies show that its implementation can reduce inventory discrepancies and financial losses, although its adoption remains limited (Ben Daya et al. 2019).

This case study analyzes a textile manufacturer experiencing a 15% average inventory inaccuracy rate, resulting in delivery issues and client complaints. The current production process is mostly manual and error-prone, particularly in the tagging, sorting and packing stages.

To address this, the study proposes the use of RFID technology combined with Value Stream Mapping (VSM) to identify inefficiencies and enhance product traceability. The main goal is to improve inventory accuracy and operational efficiency.

Despite isolated success stories, peer reviewed evidence on RFID adoption in Latin American textile SMEs is virtually absent, leaving managers without benchmarks for justifying the sizeable upfront investment. Accordingly, this paper addresses the following problem statement: How can an SME jeans manufacturer lift inventory record accuracy to ≥ 95 % while safeguarding operational continuity?

The study pioneers the combined use of RFID, VSM and stochastic simulation in the Peruvian textile context, offering a novel, data driven framework for emerging economies.

1.1 Objectives

The main objective of this research is to enhance the accuracy of finished goods inventory management in a textile manufacturing company through the implementation of RFID technology. To achieve this, the study aims to review the theoretical and contextual background, analyze the root causes of the problem using industrial engineering methodologies, design appropriate improvement proposals, and evaluate their effectiveness and feasibility. The research is framed within three key areas: operations analysis using simulation tools, technological innovation in manufacturing processes, and supply chain optimization, all contributing to greater efficiency and competitiveness for the company.

2. Literature Review

2.1 Inventory Inaccuracy

Inventory inaccuracy occurs when the information recorded in the system differs from the actual physical inventory. A case study revealed a 35% discrepancy between recorded and actual stock, resulting in a 10% decrease in profits (Raman 2001). Additionally, the issue of misplaced inventory refers to products being stored in incorrect locations, making it difficult for companies to meet customer demand in a timely manner (Lee and Özer 2007).

Inventory inaccuracy is a major challenge in the textile industry, and its prevalence can vary significantly depending on various factors. As noted in a PwC (2020) report, "inventory inaccuracy is one of the main challenges faced by the textile industry". Furthermore, Kang and Gershwin (2005) point out that even small levels of inventory inaccuracy can cause significant disruptions in supply chain performance, especially in environments with high product variety and turnover.

2.2 RFID

RFID is increasingly perceived as a valuable tool for enhancing supply chain performance, due to its ability to provide real-time data visibility and improve inventory tracking accuracy. It is considered one of the most effective technologies to address the challenge of missing inventory in retail supply chains, primarily because of the enhanced visibility it offers (Ben Daya et al. 2019). Despite its proven benefits, including a 16% reduction in out-of-stock items and lower inventory levels across the supply chain when applied to pallets and larger packaging in Wal-Mart stores (Hardgrave et al. 2008), the implementation of RFID is still not widespread among companies (Zhang et al. 2018). Nonetheless, RFID presents a wide range of usability possibilities through new and innovative solutions, which can help reduce waste in various segments of the supply chain (Chauhan et al. 2020).

2.3 VSM

Value Stream Mapping (VSM) is a Lean Manufacturing tool that uses a flow diagram to represent the sequence of both material and information activities required to deliver a product or service to the customer. It is primarily used to identify non-value-adding activities, visualize process inefficiencies, and drive continuous improvement throughout the entire value stream (Rother & Shook 1999). The application of VSM has shown significant benefits across various industries, including lead time reduction, enhanced workflow, and cost efficiency (Abdulmalek and Rajgopal 2007; Singh et al. 2018). In comparison with other research findings, the implementation of this approach has also demonstrated a significant reduction in operational costs. For instance, in a footwear company, the application of VSM in its operations led to a monthly savings of approximately PEN 15,850.57 (Mamani 2019).

3. Methods

This study is both a qualitative and quantitative case study, aiming to gain in-depth knowledge on a specific topic. It focuses on a large-scale textile manufacturing company, allowing for detailed analysis. The scope is exploratory, as it addresses a problem that had not previously been examined within the company.

3.1 Work Model

This research was carried out in a company dedicated to the production of jeans for commercial sale. This company was chosen due to its accessibility for observing its production process and for access to its current performance indicators (Figure 1).

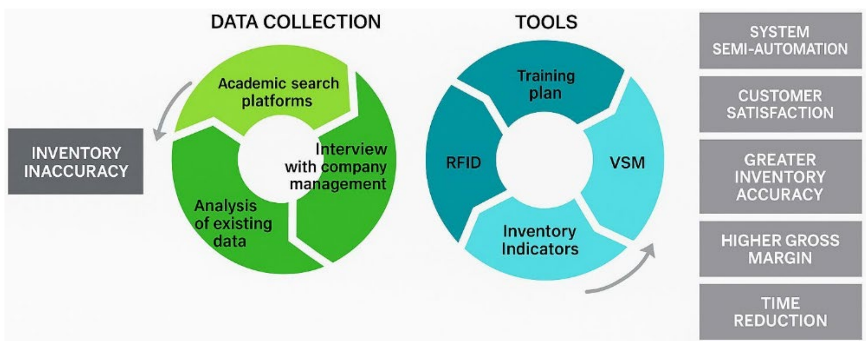

Figure 1. Solution Design for the company

3.2 Company Management Interviews and Data Collection

To collect all the necessary data from the company for this research, several actions were taken:

The real-time measurement of the inventory registration process was conducted through a 14-day plant visit carried out over the course of one month. During this visit, all activities involved in the inventory registration process were carefully observed and recorded. Additionally, production process activities were identified during the time measurements in order to analyze their efficiency.

Furthermore, the management was asked to provide inventory registration reports along with the key performance indicators used, allowing for a comparison and validation of the collected data.

4. Validation

4.1 Initial Diagnosis

Inventory inaccuracy is a significant challenge in the textile industry, according to PwC (2020), it is one of the main operational issues in the sector, and 29% of textile companies report facing it in their daily operations (National Council of Textile Organizations 2019). This issue compromises efficiency increases operational costs, and reduces customer satisfaction.

In the case study, the company serves multiple distribution channels, including department stores, exports, and its own retail outlets. This complexity demands a high level of inventory precision. According to internal data, the company currently has an average inventory accuracy rate of 85%, indicating a 15% inaccuracy rate. This leads to 5% customer dissatisfaction, penalties of up to 15% of total sales, and a 15% increase in labor costs. According to the ERC Community, addressing these inconsistencies could lead to a 4% to 8% increase in sales.

The main causes contributing to inventory inaccuracy include the absence of an inventory verification tool (42.5%), inadequate production processes (22.5%), lack of training for operators (19.5%), and insufficient quality control (15.5%). A root cause analysis revealed deeper issues such as the use of manual processes (78.2%), limited budget (79.8%), errors and poor resource utilization in production (53.4% and 46.6%, respectively), as well as a lack of quality control policies (66.8%) and insufficient continuous improvement efforts (33.2%) (Figure 2).

Therefore, the objective of this research is to increase the company's inventory accuracy from 85% to 95%, a 10% improvement that would bring it closer to optimal performance standards. Achieving an inventory record accuracy rate between 95% and 100% is considered an efficient benchmark to ensure customer satisfaction and enhance profitability (Villagra 2021).

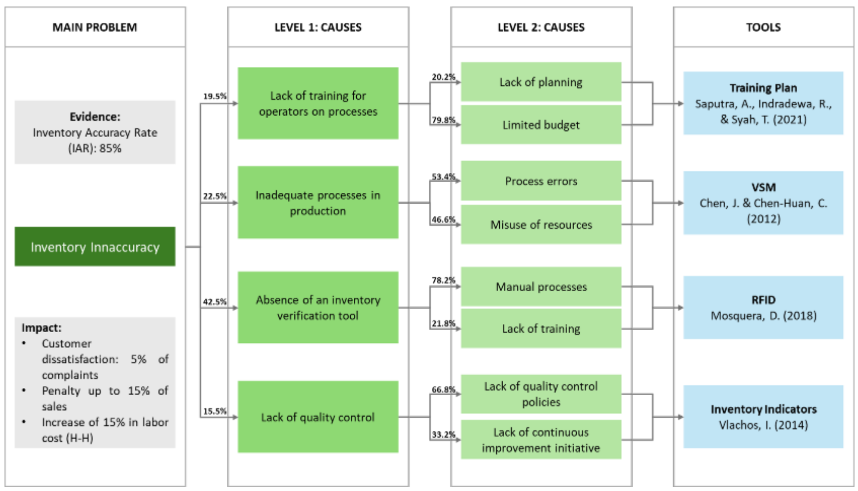

Figure 2. Problem Tree

4.2 Value Stream Mapping (VSM)

To analyze the jeans production process, time and resource data were collected and used to develop a Current State Value Stream Map. This mapping allowed the identification of stages, activities, waiting times, and inventory levels. The analysis revealed four unnecessary classification stages, each lasting one hour, which added no value to the process. Based on these findings, a Future State VSM was designed to optimize the production flow (Figure 3).

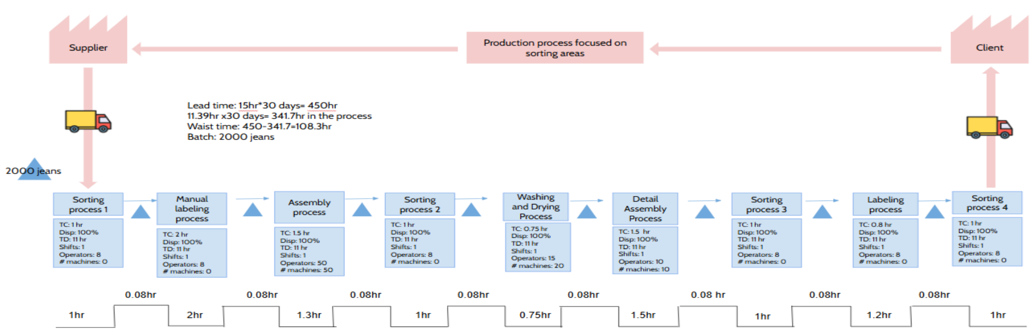

Figure 3. Actual VSM

As part of the improvement, the sequence of operations was modified: the first classification stage was moved before product labeling and part assembly, while the second stage was placed afterward. This change ensures that products reach the finished goods warehouse correctly and without rework. Additionally, the manual labeling and part assembly processes were merged, reducing the number of operators required and eliminating redundant activities (Figure 4).

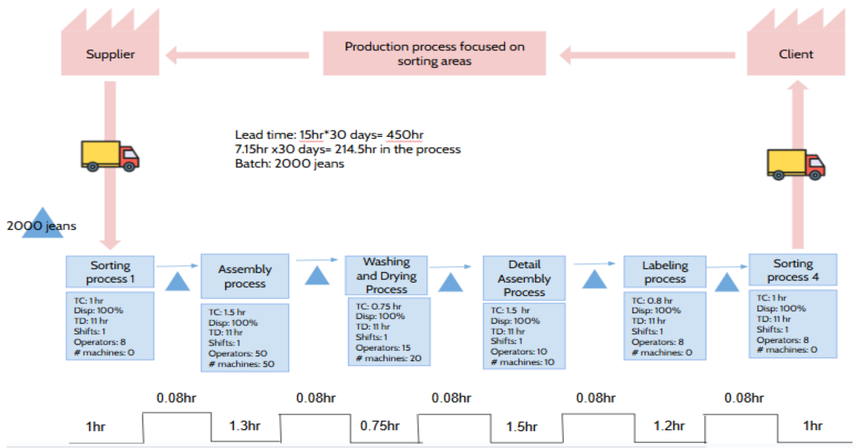

Figure 4. Improved VSM

As a result, the total process time was reduced to 7.15 hours, reflecting a more efficient workflow and improved operational performance.

4.3 Radio Frequency Identification (RFID)

To address inefficiencies in inventory management, a structured approach was adopted for the implementation of a Radio Frequency Identification (RFID)-based automation system. The primary goal was to improve inventory accuracy from its current level of 85% to 95%, a target supported by expert estimation and similar studies (Correal 2021). Achieving this improvement would enhance inventory control, reduce losses, and increase operational efficiency throughout the supply chain.

4.3.1. Simulation Model and Process Redesign

The process began with a detailed assessment of the company's current state to identify weaknesses and areas with improvement potential. The initial registration process consists of five specific stages, which are described in Figure 5:

Figure 5. Initial procedure

In terms of system design, multiple evaluation methods were used to define the appropriate statistical distribution of process times for simulation. Visual inspection showed variability that did not fit standard distributions. Although the Input Analyzer suggested a Weibull distribution, it was discarded based on practical criteria. In the end, an exponential distribution was selected following expert advice and domain knowledge.

During the data collection phase, time measurements were recorded for each key activity involved in the manual inventory registration process (Table 1).

Table 1. Time per Activity – Manual Inventory Process

Day	Generating a blank report for SKU registration	Physical identification per packed SKU and corresponding registration in the blank report.	Enter into the system	Cross-check of physical boxes vs. system records	Submit a record
1	1.41	113.4	19.9	4.28	5.7
2	1.44	124.2	19.8	4.48	5.33
3	1.49	126	22.2	4.4	4.14
4	1.42	118.8	22.3	4.05	3.15
5	1.55	111	18.4	5.33	3.8
6	1.43	112.8	19.8	4.03	3.86
7	1.55	127.8	23.4	4.85	3.21
8	1.59	121.2	21.3	6.84	4.65
9	1.54	121.8	24.1	5.57	6.97
10	1.58	117.2	22.1	4.59	4.25
11	1.45	130.8	21.4	4.95	3.19
12	1.57	127.8	25	4.7	5.15
13	1.44	115.8	21.2	4.35	3.08
14	1.45	127.8	21.6	5.83	5.66

After the site visit, the average time to complete all activities was estimated at 2.6 hours. In the simulation, the resources included one operator, the system, an RFID reader, a technical datasheet, and a record, all considered unlimited per batch. The simulated entity was defined as a batch of jeans, since the process is carried out once per day. These inputs were applied in the proposed new model shown below in Figure 6 and Figure 7.

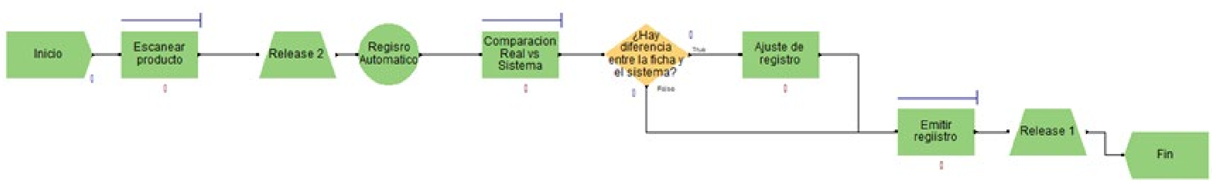

Figure 6. Updated Inventory Registration Flow

Once the simulation was run, the process time was reduced to 21 minutes. To validate the feasibility of the proposal, a scenario comparison was conducted using Arena software, where Scenario A represented the original process and Scenario B the improved one.

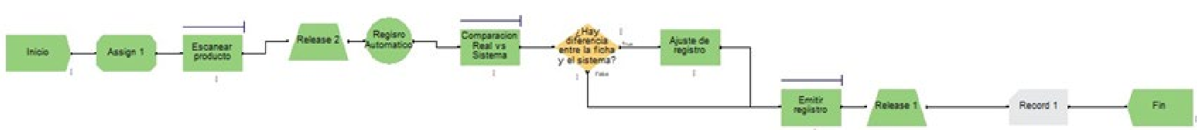

Figure 7. Improved Process with Record Module

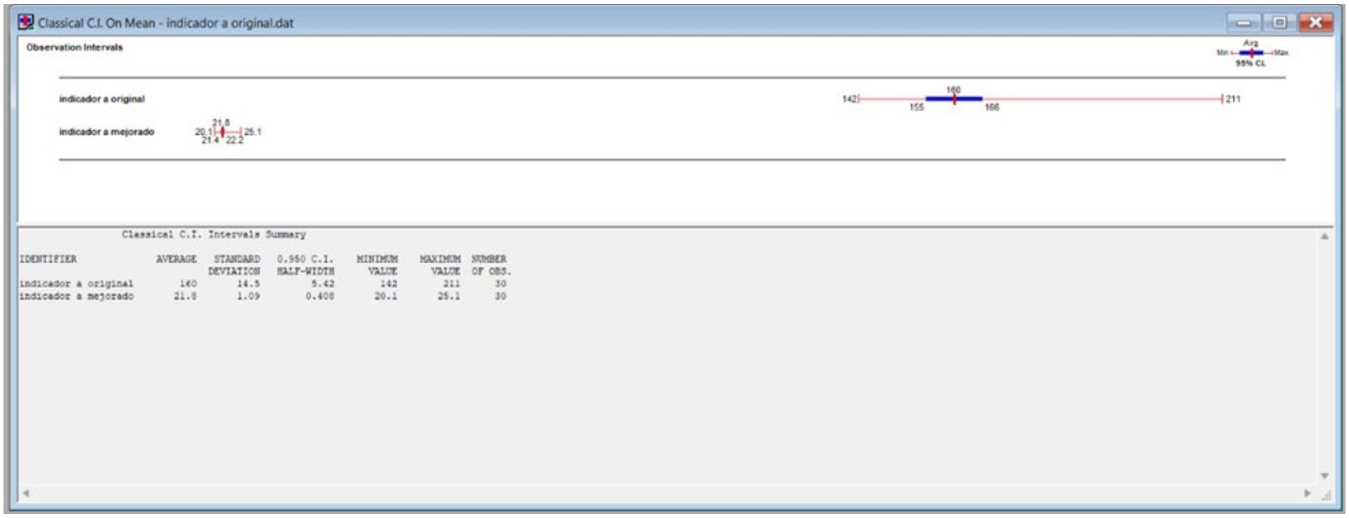

Figure 8. Scenario Comparison

The manual process took an average of 2.6 hours, while the simulated RFID model reduced it to 21 minutes. Arena's comparison of both scenarios (replicated 30 times) showed a statistically significant improvement, confirming the viability and impact of the proposed solution (Figure 8).

4.3.2. Implementation Strategy and Investment Estimation

Following the positive simulation results, a phased implementation strategy was defined to ensure operational continuity and ease of adoption. The rollout will begin in pilot areas, enabling system testing, staff training, and gradual process adjustment. After successful validation in pilot zones, the RFID system will be deployed across the entire organization.

The RFID system includes the acquisition and installation of the following components:

- RFID tags
- RFID gates and antennas
- Handheld RFID readers
- Printers
- Integration with the existing information system

The **total estimated investment** for the complete RFID system is PEN 99,052.08, which includes hardware, software integration, and supporting tools (Table 2 and Table 3).

Table 2. Estimated Implementation Total Costs

Description	Total Cost ($)
RFID system cost	10,138
Information system cost	6,400
Additional costs	820
Total ($)	**17,358**

Table 3. RFID System Implementation Budget

Estimated Budget	Quantity	Time	Unit Cost (PEN)	Total Cost (PEN)
RFID Implementation				**99,052.08**
Project Manager	1	120	52	6,240
Interns	5	240	8,75	10,500
Antenna Impinj Far-Field	1	-	2,163.10	2,163
RFID Gates	1	-	15,455.84	15,455.84
Handheld RFID readers	1	-	12,405.92	12,405.52
RFID Tags	30	-	521.73	15,651.82
Printer	1	-	7,303.3	7,303.30
Installation	-	-	29,332.11	29,332.11

This amount represents approximately 91% of the total projected investment in operational improvements. Despite the high initial cost, the system is expected to generate long-term benefits, such as improved traceability, enhanced warehouse control, and significant reductions in processing time.

4.4 Training plan

An effective training plan requires careful planning and execution. In this case study, a needs assessment identified the Finished Goods Warehouse as a critical area for improvement, with training aimed at the operators working in that department.

The plan was designed by the Human Resources team and included detailed content, delivery methods, a session timeline, necessary resources, and assigned responsibilities. The implementation required financial resources, printed materials, qualified trainers, and designated time for sessions. Training facilitators were carefully selected to ensure clarity and effectiveness in knowledge transfer.

The training program lasted approximately two months and involved key stakeholders, including managers, supervisors, HR personnel, and system specialists. The evaluation phase included performance reviews and multiple-choice tests, which helped reinforce the concepts taught.

As a result, 68% of the 25 trained operators demonstrated effective knowledge retention. These outcomes were derived from participant evaluations and surveys. Continuous follow-up is recommended to track progress and identify areas for improvement in future training cycles.

4.5 Inventory Indicators

The implementation of indicators followed a structured process. First, key operational areas were identified based on their relevance to company objectives. Measurement systems were then put in place to collect the necessary data for calculating and analyzing the indicators.

Once the data was gathered, the results were analyzed to identify performance trends and variations. These insights were communicated to team leaders and upper management during regular meetings. For each area, the most relevant indicators were selected, and realistic targets were defined in alignment with the organization's strategic goals.
To quantitatively monitor the jeans production process and evaluate project outcomes, the following key performance indicators (KPIs) were established:

- Daily Production Plan Fulfillment: Measures the percentage of the daily production target (2,000 jeans/day) achieved.

$$\frac{\text{Total produced jeans per day}}{\text{Daily production target}} \times 100$$

- Inventory Record Accuracy (IRA): Assesses the reliability of inventory data versus the actual physical count. The target is to reach at least 95%.

$$\frac{\text{Total jeans in physical coun}}{\text{Total jeans in system}} \times 100$$

- Inventory Registration Duration: Evaluates the efficiency of the inventory registration process.

$$\frac{\text{Total registration time}}{\text{Number of processed batches}} \times 100$$

- Customer Complaint Rate: Measures product quality and customer satisfaction. The goal is to keep it below 1% annually.

$$\frac{\text{Complaints per order}}{\text{Total orders}} \times 100$$

This implementation was carried out over the course of one month by a dedicated team working in coordination with the plant manager. As a result of the project, the company achieved notable improvements:

- 100% fulfillment of the daily production plan
- 95% inventory record accuracy
- 86.03% reduction in registration time
- Anticipated reduction in customer complaints

These results reflect the successful application of engineering tools, teamwork, and a strong commitment to continuous improvement. The company remains dedicated to regularly monitoring and adjusting its KPIs to ensure ongoing performance optimization.

5. Results and Discussion

Table 4 shows that the four proposed indicators were successfully achieved through the implementation of the RFID system, Value Stream Mapping (VSM), training plans, and performance measurement tools.

A clear example of this success is the inventory record accuracy, which reached 95%, meeting both internal goals and industry expectations. Additionally, inventory registration time was reduced by 81%, from 2.6 hours to just 0.49 hours. The production process also benefited from a 35% reduction in total lead time by eliminating non-value-adding activities. Finally, the training program resulted in a 68% effective assimilation of the content delivered to the operators.

Table 4. Comparative summary of As-Is, To-Be and implementation results

Tool	**Indicator**	**As – Is**	**To – Be**	**Results**	**Variation**
RFID	Inventory Record Accuracy (IRA)	85%	95%	95%	12%
VSM	Production Cycle	11.39h	7.9h	7.40h	-35%
Training plan	% Regular Calification	-	87%	68%	-21%
Inventory Indicators	Registration Duration	2.6h	0.49h	0.49h	-81%

6. Conclusion

The investigation demonstrates that embedding Radio Frequency Identification within a lean-driven redesign of the finished-goods flow elevates inventory record accuracy from 85 % to 95 %, trims registration time by 81 %—from 2.6 h to 0.49 h—and compresses total lead time by 35 %, while daily production plan compliance reaches 100 % and overall plant productivity rises 33 %. These outcomes, validated through discrete-event simulation and confirmed after a pilot deployment, reveal tangible operational and financial gains, including a benefit–cost ratio of 5:1, that resonate strongly with the pressing needs of Peruvian textile small and medium enterprises facing manual, error-prone controls. The study therefore underscores the strategic importance of real-time visibility technologies in emerging economies, where limited capital and volatile demand often constrain competitiveness, and it highlights that thoughtful integration with Value Stream Mapping and targeted training mitigates typical socio-technical barriers to adoption. By quantifying the combined impact of RFID, lean diagnostics, and stochastic modelling in a Latin American context, the research closes a documented gap in the inventory-inaccuracy literature, extends prior findings centered on large retailers, and offers a reproducible analytical framework for scholars evaluating digital interventions in high-mix, high-volume environments. Moreover, the work contributes conceptual clarity by linking inventory precision to customer-service metrics and environmental stewardship, thereby reinforcing the discourse on sustainable operations management. Future inquiries may explore scalability under multi-product scenarios, longitudinal effects on worker engagement and carbon footprint, and interoperability with blockchain-enabled traceability or machine-learning demand forecasting. Comparative assessments across sectors such as pharmaceuticals, food and beverage, or automotive components will enrich external validity, while life-cycle cost analyses and hybrid sensing architectures may sharpen the economic and ecological case for pervasive RFID adoption. Additionally, longitudinal monitoring of energy consumption during warehouse operations and the inclusion of worker health metrics can illuminate hidden benefits, guiding policymakers and practitioners toward holistic, resilient supply-chain transformations in industry.

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