

ORIGINAL ARTICLE

## Automated distribution network for inventory management in Lima

### ABSTRACT

In the consumer goods industry, distribution plays a fundamental role in ensuring operational efficiency. This research paper highlights the importance of automated distribution in inventory management in this sector. The correlational-causal study analyzes the relationship between inventory management and distribution automation, considering variables such as availability, efficiency, automation, and technological innovation. It proposes a specific solution through a quantitative, non-experimental approach, which evaluates how management is influenced by the implementation of automated distribution systems. In this region, 1,250 medium-sized companies directly benefit from automation in data collection and the integration of their systems with distributors. With a sample of 295 companies located south of Lima, a survey was conducted using a 30-item questionnaire, structured around four dimensions: automation, technological innovation, availability, and efficiency, with the aim of measuring the impact of automation on management. The results demonstrate a significant relationship between automated distribution and inventory management in the consumer goods sector. Thus, companies that increase their investment in automation and technological innovation will experience improvements in their availability and efficiency indicators. This translates into increased revenue and reduced operating costs. These factors are reinforced by the automation of information gathering and the adoption of technological advances in areas such as distribution and logistics.

**Keywords:** distribution; inventory management; automation; technological innovation.

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## INTRODUCTION

Following the crisis triggered by the pandemic, companies engaged in product distribution faced a significant impact due to the numerous restrictions imposed globally. Logistics and the supply chain, considered the backbone of business, were severely affected by factory closures, transportation limitations, and unpredictable changes in demand (Srinivas & Ganesha, 2024). These circumstances generated adverse consequences and uncertainty for organizations, making it difficult to meet their objectives due to restrictions on the movement of goods (Maleki Vishkaei & De Giovanni, 2024). In their research, Abdellah and Khalid (2024) point out that, although the supply chain has been widely modeled to optimize its processes and improve its performance, these models are weakened by disruptive events such as the pandemic, the 2008 financial crisis, or the recent semiconductor shortage. Therefore, there is a need to implement a model in which automation contributes to streamlining supply chain processes, making it more resilient.

In this context, the authors emphasize the importance of designing a new supply chain framework capable of withstanding global crises such as those mentioned above. This approach must focus on overcoming current supply chain weaknesses, as the need to strategically optimize production processes to meet customer demand is increasingly evident. In their paper, Shakur *et al.* (2024) highlights that companies have faced numerous challenges in the supply chain, both in the relationship between consumers and suppliers and in distribution, manufacturing, and the entire production chain. In this regard, organizations are expected to achieve significant improvements in inventory management, incorporating resilience, sustainability, visibility, traceability, and accountability at every stage of distribution.

In their study on supply chain disruption and the circular economy, Noora and Milla (2024) assert that this disruption began with the arrival of the pandemic. They also highlight the importance of leveraging this opportunity to transition toward a circular economy by implementing sustainable inventory management.

It is crucial to recognize that the pandemic accelerated supply chain transformations that had long been progressing slowly or stagnant. Companies were forced to adapt to a new reality to survive in a changing business environment. Medium-sized companies, in particular, which were severely impacted, need to optimize various areas of their production and distribution chains. A key innovation in this area is direct integration with product distributors.

In their research on the role of entrepreneurs in supply chain recovery during the pandemic, Kees and Robert (2024) note that authorities faced numerous challenges in restoring the chain, particularly in managing medical supply inventories. They also highlight the crucial role of entrepreneurial initiatives, which offered innovative solutions to emerging problems and helped rebuild a then-collapsed supply chain. The study focuses on entrepreneurs' response to the crisis and their ability to develop and distribute products efficiently. This research highlights the relevance of new initiatives in the market, as does the present proposal, which seeks to improve inventory management through automated processes that reduce distribution costs.

Companies across diverse industries are seeking to increase their profits by optimizing their processes and reducing costs. Shih (2020), in his scientific paper, points out the importance of adopting technologies that facilitate automation to improve inventory management and ensure the continuous flow of real-time information. Similarly, Batra *et al.* (2020), in their research on real-time inventories, highlight the need for products in warehouses to be correctly located to handle large sales volumes, which can be achieved through the use of technologies such as radio frequency identification (RFID) systems, which allow processes to be automated and streamlined.

This research focuses on the distribution of mass consumption products, specifically in the southern area of Lima. For the study, a distributor and the medium-sized businesses it supplies are considered. According to Dijisa (sf), medium-sized businesses are classified as those that place monthly orders between 5,000 and 20,000 soles. For its part, the Instituto

Nacional de Estadística e Informática (INEI, 2023) defines medium-sized companies as those with annual sales between 1,700 and 2,300 UIT. To achieve the integration of inventory information, application programming interfaces (APIs) are used, which, according to Red Hat (2023), are “un conjunto de definiciones y protocolos que se emplean para diseñar e integrar el *software* de las aplicaciones” [a set of definitions and protocols used to design and integrate application software] (par.1).

In the supply chain, it is increasingly possible to automate more processes to improve inventory management. In a scientific paper on automation and logistics management, Liu (2020) analyzes how to automate a warehouse whose needs are growing due to the increase in trade, which complicates its administration. This technological innovation is closely linked to automation, which introduces changes that optimize the production processes of companies (Organización para la Cooperación y el Desarrollo Económico [OECD], 2018). To achieve this objective, the author proposes the use of RFID technology in distribution, along with electronic records. Custodio and Machado (2020), in their study on flexibility in automation, indicate that, to automate the different points of the logistics chain, it is necessary to use a standardized framework.

Li (2022), in his research on transformation and inventory management, emphasizes the critical importance of these two aspects in companies and underlines the need to ensure stability in the supply chain. For their part, Tamer and Koklu (2021), in their paper on retail companies and automation, define inventory management as an essential process for product traceability, recording changes in sales, and loss control.

This research addresses the relationship between automated distribution of mass consumption products and inventory management

in the southern region of Lima, using as a reference the trade between a regional distributor and medium-sized companies in the sector. This study seeks to demonstrate a positive and close relationship between inventory management and automated distribution, and that companies that adopt innovative technologies and integrate with their business partners achieve significant benefits in inventory flow, improving efficiency and reducing costs.

## METHODS

This research is correlational-causal, with a quantitative rather than experimental approach. This approach is justified because the main objective is to explore and understand the relationship between inventory management and automation, coupled with the limitations of time and resources available to achieve this objective. The study was conducted on a population of 1,250 medium-sized companies within the distribution network in the southern region of Lima, using a sample of 295 medium-sized companies. The sample was determined by applying the standard statistical formula for calculating samples. This selection seeks to analyze the relationship between an automated distribution network and inventory management.

Data collection was conducted using a 30-question survey addressed to information management managers in medium-sized companies. The instrument was previously reviewed and validated by three experts in the field. A five-level Likert scale was used to measure the relationship between inventory management and automated distribution, where 1 represents “Strongly disagree”; 2, “Disagree”; 3, “neither agree nor disagree”; 4, “Agree”; and 5, “Strongly agree.” The instrument was validated using Cronbach’s alpha, the results of which are presented in Table 1. This method guarantees the reliability and internal consistency of the questionnaire used in the research.

**Table 1**  
*Result of Cronbach’s Alpha calculation.*

Reliability statistics	
Cronbach's alpha	Number of elements
.91	30

*Note.* Figure based on survey results.

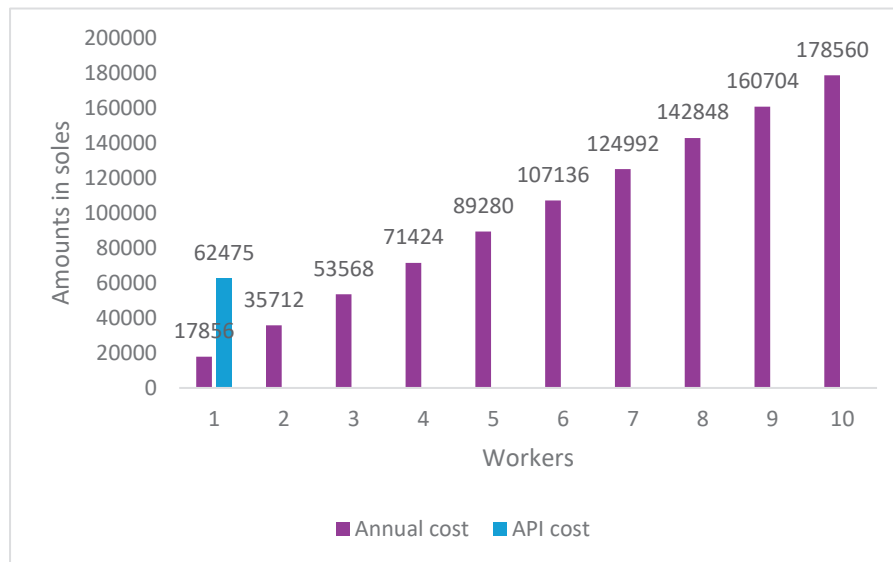
This demonstrates the instrument's high reliability, as the value obtained is close to one. It also indicates that the responses to the questions are consistent, reflecting similar opinions among respondents. This value also suggests that the margin of error due to random factors is small, which increases the reliability of the study's conclusions.

Additionally, a cost analysis was conducted comparing the resource usage of this automated distribution network with the number of people involved in a non-automated

process. The results show that automation generates significant savings for the company. Figure 1 presents a comparative analysis of the cost associated with using APIs and the cost of the personnel responsible for manually collecting information, highlighting the economic advantages of technological implementation.

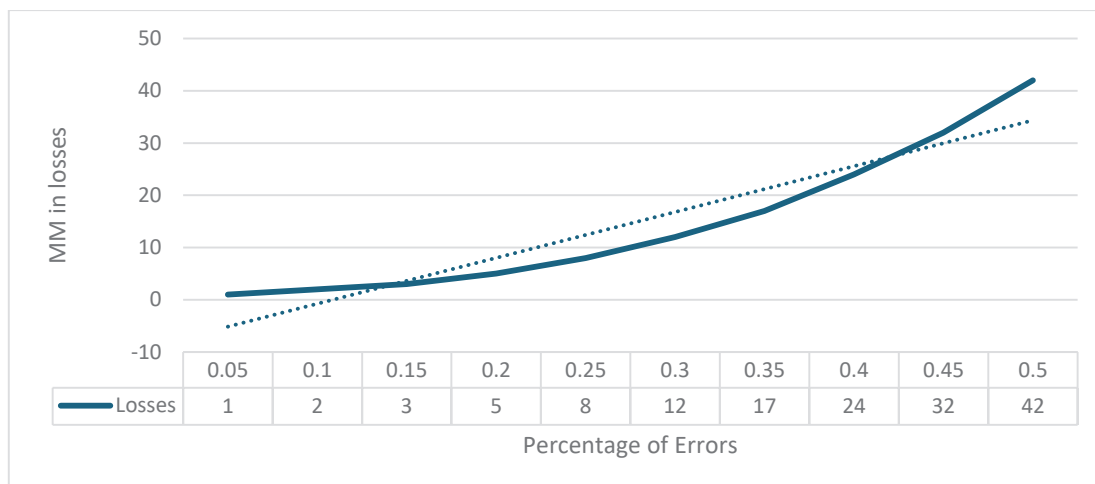
An analysis was also conducted of the number of errors generated and the associated losses suffered by the company when it does not have an automated distribution network. Figure 2 presents a detailed analysis of monetary

**Figure 1**  
*Comparison of API costs vs. workers*



*Note.* Figure comparing API manufacturing costs for inventory automation versus the cost of workers on an annual basis.

**Figure 2**  
*Losses in millions of soles*



*Note.* The figure shows the relationship between the percentage of order entry errors and the losses generated by these errors.

losses based on the percentage of errors, which provides a visual representation of the economic impact of the lack of automation on distribution processes. This analysis reinforces the importance of implementing automated systems to reduce errors and minimize financial losses.

## RESULTS

A statistical analysis demonstrates a significant relationship between inventory management and the automated distribution network. The critical chi-square value is 26.3, while the calculated chi-square value is 191.6. This relationship demonstrates that the research objectives are met. The results of the chi-square test are presented in Table 2. The chi-square value obtained, being considerably higher than the critical chi-square value, indicates that the data cannot be attributed to chance and that the confidence level is high. This reinforces the validity of the findings and supports the conclusion that distribution network automation has a positive impact on inventory management.

On the other hand, the relationship between automation and inventory management is analyzed, where the critical chi-square is 26.3 and the calculated chi-square is 140.73, which confirms this relationship and meets the research objective.

Likewise, a connection between technological innovation and inventory management is evident, with a critical chi-square of 26.3 and a calculated chi-square of 206.28, which demonstrates this association and satisfies the purposes of the study.

In non-automated distribution systems, errors resulting from manual processes require

correction. This means that the entire percentage of errors must be reintegrated into the supply chain through inventory management, which includes tasks such as data collection and confirmation to validate orders, updating distribution systems, and re-dispatching trucks. Each of these steps entails additional costs for the distribution company. Therefore, errors in non-automated distribution are frequent and economically significant.

## DISCUSSION

The calculated chi-square analysis reveals that automated distribution significantly influences inventory management. The statistical tool yields a result of 191.6, which allows us to conclude that, by passing this test, the automated distribution network for mass consumption products is relevant for inventory management. Previous research, such as that by Liu *et al.* (2022), already proposed the use of a decentralized database to ensure information consistency and improve traceability in an automated manner, albeit in a different industrial sector. For its part, the IEEE, in a research paper, suggested the use of technologies such as protocol management to keep information updated in an automated manner, a proposal that coincides with what is proposed in this study (Li *et al.*, 2020).

This perspective aligns with the theory outlined in *Fundamentals of Supply Chain Theory*, which highlights that automated distribution is closely linked to the efficient handling of products from the company to the consumer, optimizing inventory management (Lawrence & Shen, 2019). Likewise, *Essentials of Supply Chain Management* emphasizes the need for agile mechanisms to detect errors in the distribution

**Table 2**  
*Chi-square test cross-tabulation*

	Chi-square tests		
	Value	df	Asymptotic Sign. (2-tailed)
Person's chi-square	191.60	4	.000
Reason for similarity	158.93	4	.000
Linear-by-linear association	126.81	1	.000
Number of valid cases	295		

*Note.* Figure based on the results of the survey relating inventory management and automated research distribution and processed by the PSPP statistical tool for calculating the chi-square test.

network, allowing for rapid responses that minimize costs (Hugos, 2024). Along the same lines, Abbasi *et al.* (2024), in their research on supply chains in sustainable environments, point out that planning energy and total costs in an integrated model increases the probability of achieving energy objectives in economic systems.

These approaches contrast with this research, which proposes an automated distribution network in which the distributor and its customers, especially medium-sized companies, share inventory information to achieve common goals in inventory management and improve supply chain management. In their scientific paper on data management in distribution and procurement based on artificial intelligence and blockchain, Zhang *et al.* (2022) highlight that technologies applied to inventory management have characteristics such as openness, automation, independence, security, modularity, and the ability to share information. These characteristics greatly benefit inventory management, and therefore, blockchain technology is positioned as a technological core for decentralized and disruptive distribution systems.

In this regard, this research paper proposes an alternative approach to data decentralization, although it is observed that the logistics industry is moving in this direction to improve its efficiency. Wang (2021), in his scientific paper on the impact of blockchain on the supply chain and efficiency, points out that technologies such as smart devices and the Internet of Things have gradually transformed and innovated logistics and inventory management. For logistics and the supply chain, the most important thing is to increase operational efficiency in inventory management. Furthermore, he highlights that, in this context, companies in the sector cannot expand their capabilities without fostering collaboration and transparency in the exchange of information. The current trend points toward the development of smart logistics, which aims to facilitate economic exchange, automation, and efficiency in services, while reducing costs.

In the scientific paper on the application of technologies such as blockchain and big data to

improve supply chain traceability and information exchange, Hader *et al.* (2022) point out that customers, accustomed to immediacy thanks to a wide variety of applications, demand that logistics companies become increasingly efficient. This is achieved through increased automation and computing in processes. However, many supply companies still suffer from deficiencies in product handling, low traceability, delays and insufficient information exchange, as well as limited automation in distribution. Technologies such as blockchain allow for the decentralization of information, which represents a significant innovation to overcome these deficits and improve product traceability.

For his part, Serzhuk (2023), in his research on technological innovation in the supply chain, highlights the importance of using information technologies in logistics, especially in inventory management. Digital technology, the basis of modernity, is presented as a promise for the development of the global economy. In the context of Industry 4.0, the use of these technologies in logistics processes has given rise to an emerging concept known as Smart Logistics, which seeks to optimize logistics information and facilitate data flow in process automation.

Analyzing the influence of automation on inventory management using the statistical tool, a chi-square value of 140.73 is obtained, which allows us to conclude that the test was successful and, therefore, automation significantly influences inventory management. However, the distributor's current automation is inefficient, a common problem in the industry, as Sadoon *et al.* (2023) points out. Furthermore, the complexity of automating processes represents an additional challenge. It is important to consider that this automation can be complemented with other technological improvements, such as warehouse management using RFID technology (Liu, 2020). Fundamentals of Supply Chain Theory emphasizes the need to automate distribution and each of the processes involved in inventory and supply chain management (Lawrence & Shen, 2019).

Likewise, in Supply Chain Management Revised, the authors highlight that the uncertainty associated with certain products in inventory management makes automation essential to streamline decision-making in the face of unforeseen situations (Sunil *et al.*, 2024). In their research paper on the role of artificial intelligence in the supply chain and its impact on operational efficiency, Ahmad *et al.* (2024) address the strategies and implications of implementing artificial intelligence in supply chain management. They propose a Technology-Organization-Environment (TOE) framework to develop this strategy, along with an AI-based technological infrastructure. The authors highlight that this technology inherently streamlines inventory management, increasing its responsiveness. Furthermore, automation enables greater flexibility and efficiency in logistics operations.

In his scientific paper on process automation in the port industry, Bottalico (2022) points out that automation is a sensitive topic that generates debate, especially among workers affected by its implementation. This is due, in part, to the reduction in the number of employees required when it was introduced in the 1960s. However, technological innovation does not necessarily imply a decrease in the demand for labor. Evidence shows that, as new technologies are adopted in various industrial sectors, the number of workers continues to increase, and there are even staff shortages in some areas. The author highlights that, in the years following the pandemic, discourses on robotization in the logistics chain have emerged, mainly due to the costs associated with human labor. However, the author argues that robotization does not imply the replacement of humans by machines, but rather offers new conditions for workers to perform their tasks more efficiently with the support of technology.

In their research on supply chain, inventory management, and innovation to build a resilient food supply chain, Joshi *et al.* (2023) indicate that approximately 30 percent of food production is lost due to deficiencies in supply chain management. The authors highlight the need for immediate action by producers to develop more resilient supply chains, which requires greater investments

in research and innovation to improve inventory management in this sector. For their part, Risambessy and Wairisal (2023), in their scientific paper on the supply chain, transformational leadership, and innovation, highlight that innovation in this area is crucial to overcoming logistical challenges. The implementation of advanced technologies, along with innovative strategies and adequate risk management, allows companies to improve their efficiency and effectiveness in distribution. The authors emphasize that a distribution network with transformational leadership and an innovative approach represents a significant competitive advantage, since there is a direct relationship between leadership, customer satisfaction, innovation, and performance in logistics processes.

When analyzing the influence of technological innovation on inventory management using a statistical tool, a chi-square value of 206.28 is obtained, which allows us to conclude that the test is passed and, therefore, innovation significantly influences inventory management. This finding aligns with the research by Espinoza (2021), in which a relationship between continuous innovation and process improvement was established. Furthermore, this result coincides with that reported by Wang *et al.* (2023), who point out that automation in the logistics chain has been driven by technological advances. In their scientific paper on investments in digital technologies in the textile sector, Špiler *et al.* (2023) indicate that these investments have allowed companies to become more sustainable and competitive. The authors highlight that the adoption of technologies such as cloud computing, energy management, automation, robotics, and machine learning have had a significant impact on the digital transformation of these companies, generating competitive advantages, improved risk management, and increased efficiency in the supply chain and inventory management.

In Essentials of Supply Chain Management, Hugos (2024) points out that, in inventory management, high levels of innovation are sought, especially in electronic products, which requires greater efficiency in their management. Furthermore, the author highlights that today's

businesses demand innovation to customize functions in inventory management and the supply chain. Some companies specialize in specific areas of this field, offering solutions that allow for better management of the complexity inherent in these processes.

In his research paper on digital transformation and its role in promoting business resilience, Browder *et al.* (2024) identify five key technological capabilities for companies to overcome crises, such as those generated by the pandemic. These capabilities include virtual access, virtual collaboration, data-driven decision-making, the ability to reprogram processes, and assisted decision-making. All of these technology-centric skills are essential for addressing challenges and ensuring operational continuity.

This research contrasts with this study, which shows that supply chain companies faced multiple problems due to restrictions imposed at various levels. In this context, technological adoption becomes essential to overcome these limitations, and technological innovation plays a crucial role in this process. In their scientific paper on Industry 4.0, procurement, and the supply chain, Delke *et al.* (2023) highlight critical areas that must adapt for this new era, such as purchasing and supply management. They also mention the need to develop specialized talent, such as systems innovation explorers, to drive a technological revolution in the sector. The authors emphasize the importance of smart working for efficient supply chain management within the framework of digital transformation.

In his research on the challenges and applications of digital technology in the mining industry, Onifade *et al.* (2023) highlight the need to rethink roles within this sector to improve efficiency and performance. The use of digital technology is a key indicator of technological innovation that increases productivity in mines, as it optimizes processes, reduces human error, and minimizes the risks associated with this industry. This approach resonates with the present research, which highlights automation as a solution to counteract human error in inventory data collection. This problem is not limited to the logistics industry but

also affects sectors such as mining and other areas where manual processes are prone to errors that increase production costs.

In their paper on digital transformation for a resilient supply chain, Ghobakhloo *et al.* (2023) establish a strong relationship between Industry 4.0 and supply chain resilience. Stakeholders involved in distribution must adopt digitalization strategies to implement new practices in this area. Industry 4.0 contributes to the supply chain by focusing on data management, process automation, communication, monitoring, and visibility. This approach demonstrates that, in an industry with new paradigms, technological innovation and automation go hand in hand to achieve greater efficiency in the supply chain. However, it is important to note that the adoption of new technologies and automation are rarely fully implemented throughout the entire chain; rather, it is a constant evolution in each of its processes.

In his scientific paper on innovation in the field of logistics management, Kustrich (2023) points out that current conditions in this field are of considerable relevance, highlighting integration into distribution processes as one of the most crucial aspects. To achieve this, it is essential that companies in the sector adopt technologies such as the Internet of Things, artificial intelligence, blockchain, digitalization, and automation. These tools will play a fundamental role in the efficiency and flexibility of logistics management, since the digital administration of the supply chain absolutely requires the automation of its processes. The use of blockchain, for its part, facilitates the decentralization of logistics information, which reduces costs and increases visibility in operations. Furthermore, collaboration with business partners increases the efficiency of the supply chain, as pointed out by Syamsuddin *et al.* (2024) in their research on the application of blockchain in the global supply chain.

In his study of the digital revolution in supply chain finance and the challenges it faces in developing strategic innovations, Supriadi *et al.* (2024) analyzed the impact of implementing digital technology in this area. Their research results demonstrate that digitalization improves the efficiency of supply chain financial

operations by automating processes and facilitating decision-making. Technologies such as artificial intelligence, machine learning, blockchain, and big data contribute significantly to achieving efficiency and resilience in the logistics sector.

Among the limitations identified in the research is the fact that the surveys conducted with data officers in companies could be improved if the information were obtained directly from their internal reports. However, this is complicated by the security levels maintained by each company in the sample. With this information, obtained directly, other variables could be considered in addition to those presented in the study, which could provide a different approach to this branch of inventory management. For example, the level of technological adoption could be evaluated as a relevant variable, since each company could present different results in terms of automation depending on this factor. Similarly, it is possible to explore new variables and approaches to deepen research on inventory management.

## CONCLUSIONS

Based on the analysis carried out in this research, it was determined that the automated distribution network significantly influences the inventory management of mass consumption products in medium-sized businesses in the southern Lima area during 2023. This relationship was validated by the chi-square test of 191.6, which exceeds the critical value of 26.3, confirming the connection between inventory management and automated distribution. Decentralized information is essential for distributors and medium-sized businesses to achieve stronger and mutually beneficial integration. The protocols used in this integration are key, as they facilitate the flow of information from medium-sized businesses to distributors, allowing for more efficient management of product distribution.

Likewise, it was established that automation has a direct impact on consumer goods inventory management in medium-sized businesses in the southern Lima area in 2023. This was corroborated by a chi-square of 140.73, which also exceeds the critical value of 26.3, in relation to the availability of real-time

inventory information. Although distribution in the consumer goods industry still has areas for improvement, this situation is common in the sector due to its complexity. Therefore, it is necessary to advance the automation of the most relevant distribution processes, taking advantage of the new technologies that are continually emerging. Automation can be complemented with other projects that optimize different stages of the supply chain, with the aim of reducing product delivery times.

Finally, it was found that technological innovation significantly influences consumer product inventory management in mid-sized businesses in the southern Lima area in 2023. This finding is supported by a chi-square of 206.28, which exceeds the critical value of 26.3, in relation to the distribution region and real-time inventory information. Continuous innovation is closely linked to process improvement in distribution companies and across the industry in general. Automation, supported by emerging technologies, is transforming various aspects of the distribution chain, with the aim of optimizing delivery times for consumer products.

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#### Conflict of Interest

The author has no conflicts of interest to declare.

#### Author Contributions

Frank Harry Rojas Ore (lead author): conceptualization, research, writing (original draft, review, and editing).