ISSN: 2595-1661

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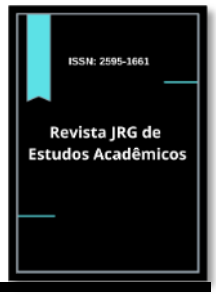

Automation and real-time tracking (IOT, RFID, and blockchain) in logistics management: a review of technological evolution and the impact on operational performance

DOI: 10.55892/jrg.v9i20.2923
ARK: 57118/JRG.v9i20.2923

Recebido: 26/01/2026 | Aceito: 03/02/2026 | Publicado *on-line*: 04/02/2026

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Abstract

This study aimed to analyze the technological evolution and the impact of integrating intelligent automation systems, based on the Internet of Things (IoT), Radio Frequency Identification (RFID), and Blockchain, on the operational performance of logistics management. The research is characterized as an integrative literature review of a qualitative and exploratory nature, grounded in the analysis of twenty scientific articles published between 2015 and 2025. The searches were conducted in the Scopus, Web of Science, IEEE Xplore, ScienceDirect, and MDPI databases, all recognized for indexing peer-reviewed and internationally relevant journals. The results showed that the combination of IoT, RFID, and Blockchain has played a decisive role in the digital transformation of logistics processes, promoting significant improvements in efficiency, traceability, and data integration. IoT proved essential for real-time data collection and communication; RFID stood out for automation and operational accuracy; and Blockchain emerged as an integrating element, ensuring transparency and reliability in transactions. Despite the observed benefits, challenges remain related to interoperability, technical standardization, implementation costs, and cybersecurity. It is concluded that the integration of these technologies represents a milestone in the modernization of logistics management, establishing itself as a strategic factor for increasing organizational competitiveness and resilience in the era of digital transformation.

Keywords: Intelligent Systems; RFID; Blockchain; Logistics Management; Automation; Operational Performance.

1. INTRODUCTION

The growing digitalization of logistics processes has driven the adoption of advanced technologies that enable automation and real-time tracking of goods and assets. The integration of systems based on the Internet of Things (IoT), Radio Frequency Identification (RFID), and Blockchain has profoundly transformed supply chain management, promoting greater visibility, efficiency, and reliability in operations. These advances have been identified as key factors in enhancing operational performance across industrial, commercial, and transportation environments, reducing costs, and improving decision-making (KUPUNARAPU, 2024; HELO; SHAMSUZZOHA, 2020).

The advancement of IoT has enabled the continuous collection of data through sensors, connected devices, and embedded systems, making it possible to monitor inventories, fleets, and product flows in real time (JARAŠŪNIENĖ; CIZIUNIENE; ČEREŠKA, 2023). At the same time, RFID technology has evolved as an essential tool for automatic identification and accurate tracking, providing significant gains in inventory accuracy and process control (BUDIYANTO; MUSLIM, 2024). The integration of these solutions creates intelligent logistics environments capable of operating with greater autonomy and responsiveness.

In recent years, Blockchain has emerged as a mechanism of integration and security among IoT and RFID systems, enabling immutable transaction records and full traceability of logistics flows (CAMMARANO et al., 2022). This decentralized technology reduces fraud, enhances transparency, and strengthens trust among supply chain stakeholders. Studies demonstrate that the combination of Blockchain and IoT leads to significant improvements in operational efficiency and reliability of transportation and storage data (VOVCHAK; VERES, 2025; A'ZAM et al., 2025).

Several empirical studies and recent reviews indicate that the integration of IoT, RFID, and Blockchain is directly associated with increased operational efficiency, reduced logistics costs, and improved customer satisfaction (HASAHATAN; MANIAH; WASKITO, 2025). Companies adopting these technologies report gains in agility, supply chain visibility, and delivery accuracy, factors that contribute to greater competitiveness and sustainability (BENDHI, 2025; AL KHATIB; ALASHEH; SHAMAYLEH, 2024).

Despite technological advances and promising results, the literature still reveals important gaps in system standardization, data interoperability, and quantitative assessment of operational impacts. In this context, the following research question arises: **How has the integration of IoT, RFID, and Blockchain contributed to the improvement of operational performance in logistics management?** Therefore, the objective of this review is to **analyze the technological evolution and the impact of integrating these technologies on the operational performance of logistics management**, identifying trends, benefits, and research opportunities. In doing so, this study contributes to advancing the understanding of the effects of digital transformation in logistics and provides theoretical support for managers and researchers interested in strategies for intelligent automation and real-time traceability (ZAINUDDIN et al., 2022; GOWRI, 2022).

2. METHODOLOGY

The present study is characterized as an integrative literature review of a qualitative and exploratory nature, with a descriptive and analytical approach. This design was chosen because it allows the identification, synthesis, and critical analysis of the existing scientific production on the topic *Automation and Real-Time Tracking (IoT, RFID, and Blockchain) in Logistics Management*, aiming to understand the technological evolution and its impacts on the operational performance of organizations. The research was conducted in systematized stages, beginning with the definition of the problem, the formulation of the research question, and the establishment of the criteria for searching and selecting studies. The guiding question that directed the review was: **"How has the integration of IoT, RFID, and Blockchain contributed to improving operational performance in logistics management?"**

Based on this question, descriptors and Boolean combinations were defined for the searches, encompassing the following terms: *"Internet of Things" OR "IoT" AND "Radio Frequency Identification" OR "RFID" AND "Blockchain" AND "logistics management" OR "supply chain" OR "operational performance."* The searches were conducted between September and November 2025, covering articles published from 2015 to 2025. To ensure breadth, recency, and scientific rigor, internationally recognized databases responsible for indexing peer-reviewed journals were selected. These included **Scopus (Elsevier)**, **Web of Science (Clarivate Analytics)**, **IEEE Xplore Digital Library (IEEE)**, **ScienceDirect (Elsevier)**, and **MDPI (Multidisciplinary Digital Publishing Institute)**.

These databases were chosen for their multidisciplinary coverage and relevance in the fields of engineering, information systems, and logistics management, ensuring access to high-quality and up-to-date publications.

The review included articles published between 2015 and 2025, studies available in Portuguese and English, publications in peer-reviewed journals, and works addressing the integration of IoT, RFID, and Blockchain applied to logistics management or supply chain operations. It also included literature reviews, empirical, and theoretical studies focusing on operational impact, traceability, automation, or logistics performance. Excluded from the review were duplicate works across databases, technical reports, dissertations or unpublished theses, articles that addressed these technologies in isolation without direct relation to logistics or operational performance, and studies without full-text availability for reading and analysis.

After the initial search, the results were subjected to manual screening and analysis of titles, abstracts, and keywords. Potentially eligible articles were read in full and assessed for their relevance to the theme and methodological rigor. The selected studies were classified according to the year of publication, type of study (review, empirical, or theoretical), technologies discussed (IoT, RFID, Blockchain), and reported impacts on operational performance. Data analysis was conducted in a qualitative, interpretative, and comparative manner, aiming to identify patterns, convergences, and gaps in the results presented by the literature. To ensure the reliability and consistency of study selection, all stages followed a predefined search and classification protocol. In cases of doubt regarding the inclusion of a given article, it was retained in the sample and its relevance discussed during the analysis. After applying the eligibility criteria, twenty articles were selected as relevant to compose the analytical corpus of the review.

The data were organized into a synoptic table containing information on authors, year of publication, objective, methodology, technologies employed, and main findings. Based on this systematization, a comparative discussion of the results was developed,

emphasizing the contributions of emerging technologies (IoT, RFID, and Blockchain) to enhancing efficiency, traceability, and the integration of logistics processes. Despite the methodological rigor adopted, this review presents limitations inherent to its bibliographic nature. The study was restricted to publications available in the selected databases, which may have excluded relevant works not indexed or published in other languages. Furthermore, as this is a qualitative analysis, the results should not be interpreted as generalizable, but rather as a critical and analytical synthesis of the existing scientific literature on the subject.

3. RESULTS AND DISCUSSION

This section presents and discusses the main findings obtained from the analysis of the twenty selected articles, aiming to understand how the integration of the Internet of Things (IoT), Radio Frequency Identification (RFID), and Blockchain has contributed to improving operational performance in logistics management. The literature review revealed that, over the past decade, there has been a significant increase in scientific production focused on the application of these emerging technologies in logistics management and supply chain contexts. This progress is directly linked to the expansion of **Industry 4.0** and the growing demand for **traceability, efficiency, and digital integration** across supply chain networks. Overall, the studies converge in indicating that automation and real-time tracking enhance **process visibility**, **reduce operational errors**, and **increase agility in decision-making** (Kupunarapu, 2024; Helo & Shamsuzzoha, 2020).

The analyzed literature shows that the **Internet of Things (IoT)** constitutes the **core pillar of the digital transformation in logistics**, serving as the foundation for real-time data collection and integration. Smart sensors and connected devices enable continuous monitoring of environmental conditions, product location, equipment status, and fleet performance. According to Jarašūnienė, Ciziuniene, and Čereška (2023), the use of IoT in warehouses and distribution centers enables **dynamic inventory monitoring**, reducing losses and increasing demand forecasting accuracy. This connectivity also enables **predictive logistics management**, allowing potential failures to be identified in advance and optimizing operational flows.

In parallel, **RFID technology** has become an essential tool for **automation and automatic product identification**. Budiyanto and Muslim (2024) emphasize that the combined use of RFID and IoT **enhances inventory accuracy, reduces verification time, and improves efficiency in shipping and receiving operations**. However, Jarašūnienė, Ciziuniene, and Čereška (2023) note that although efficiency gains are evident, **the lack of standardization in communication protocols and device integration remains a challenge** for full adoption of this technology. This divergence among authors highlights that the benefits of automation are only fully realized when supported by **interoperable infrastructures and integrated data management systems**.

At a more advanced level, **Blockchain technology** emerges as an innovation capable of ensuring **security, transparency, and immutability of information** exchanged among different logistics agents. Cammarano et al. (2022) argue that Blockchain, by acting as a distributed and tamper-proof ledger, enables products to be tracked from their origin to the final consumer, ensuring the authenticity of information. Other studies reinforce that the **integration of Blockchain and IoT** enhances **end-to-end traceability** and significantly reduces fraud and communication failures in logistics data (Vovchak & Veres, 2025; A'zam et al., 2025). This technological integration

strengthens **trust among suppliers, carriers, and customers**, becoming a **strategic competitive advantage** in increasingly complex and interdependent global supply chains.

Overall, the results show that the integration of IoT, RFID, and Blockchain **directly impacts three fundamental dimensions of operational performance**: efficiency, reliability, and sustainability. Efficiency is associated with **reducing costs and processing times**, reliability results from **improved traceability and data accuracy**, and sustainability is reflected in **resource optimization and waste reduction**. Hasahatan, Maniah, and Waskito (2025) confirm that companies adopting these technologies report **significant reductions in operational costs**, **greater reliability in data communication**, and **substantial improvements in logistics efficiency**. Similarly, Bendhi (2025) and Al Khatib, Alasheh, and Shamayleh (2024) demonstrate that real-time traceability provided by these systems **enhances logistics performance, sustainability, and customer satisfaction**, reinforcing the strategic value of digitalization.

However, the literature also reveals **persistent challenges and gaps**. The main obstacle lies in the **lack of technical standardization and interoperability among systems** developed by different providers, which hinders seamless data integration across platforms. Moreover, **implementation and maintenance costs** remain significant barriers, particularly for small and medium-sized enterprises. Another recurring challenge concerns **cybersecurity and the protection of sensitive data**, as increased connectivity expands the attack surface and system vulnerabilities (Zainuddin et al., 2022; Gowri, 2022). The recurrence of these gaps suggests that technological advancement has not always been accompanied by equivalent progress in **digital governance, process standardization, and data regulation**. Future research could contribute by proposing **collaborative models of technological integration**, **interoperability frameworks**, and **quantitative indicators** capable of more precisely measuring the combined impacts of these technologies on logistics performance.

Finally, the analysis of the reviewed publications indicates a growing trend of studies focused on the **integration of IoT, RFID, and Blockchain with Artificial Intelligence (AI) and Big Data Analytics**, expanding the possibilities for **predictive analysis, route optimization, and demand forecasting**. This evolution suggests that the future of logistics management is increasingly linked to the formation of **intelligent and collaborative digital ecosystems** capable of processing data in real time and enabling autonomous decision-making. In summary, the results of this review demonstrate that the convergence of IoT, RFID, and Blockchain not only **transforms operational processes** but also **redesigns the logistics management model**, making supply chains more connected, transparent, sustainable, and efficient. The evidence reinforces that the integrated adoption of these technologies represents an **irreversible path toward greater competitiveness and resilience** in logistics within the context of global digital transformation.

4. CONCLUSION

The present study analyzed the technological evolution and the impact of integrating the Internet of Things (IoT), Radio Frequency Identification (RFID), and Blockchain on the operational performance of logistics management. The integrative literature review revealed that these emerging technologies play a decisive role in the digital transformation of logistics processes, promoting significant gains in efficiency, traceability, and data integration.

The findings indicated that IoT serves as the technological foundation responsible for the real-time collection and communication of information, while RFID enhances automation and operational accuracy. Blockchain, in turn, acts as an integrating element, ensuring data transparency and reliability. Together, this technological triad has substantially improved organizations' operational performance by reducing costs, mitigating failures, and enhancing data-driven decision-making.

Despite these advances, challenges remain related to technical standardization, interoperability, implementation costs, and cybersecurity, factors that limit large-scale adoption, particularly among small and medium-sized enterprises. These gaps highlight the need for digital governance strategies and empirical studies that more precisely measure the combined effects of these technologies on specific logistics performance indicators.

It is therefore concluded that the integration of IoT, RFID, and Blockchain represents a milestone in the evolution of contemporary logistics management. When applied synergistically, these technologies not only optimize operational processes but also redefine the very structure of supply chains, making them more connected, transparent, and sustainable. Real-time automation and tracking thus stand as fundamental pillars of organizational competitiveness and resilience in the era of digital transformation.

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