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Artificial Intelligence in Reverse Logistics: A Systematic Literature Review

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Abstract: Objectives: This study aims to conduct a systematic literature review to examine the role of artificial intelligence in reverse logistics in the context of the circular economy and to provide a comprehensive overview of the existing literature on its implementation. **Previous work:** Although research on artificial intelligence, reverse logistics and the circular economy has expanded significantly in recent years, previous studies have mainly focused on specific technologies or individual aspects, leaving a lack of comprehensive reviews on the implementation of artificial intelligence in reverse logistics. **Approach:** A systematic literature review was conducted using the Scopus database. Following predefined inclusion and exclusion criteria, 179 journal articles were selected and analyzed. **Results:** The findings show that artificial intelligence techniques are increasingly being applied to return prediction, waste sorting and sorting, routing optimization, and product recovery decision-making. **Implications:** The findings provide valuable insights for researchers, managers, and policymakers seeking to improve reverse logistics and support the transition to a circular economy. **Value:** This study provides a comprehensive synthesis of current research, identifies key application areas and research gaps, and provides directions for future research.

Keywords: artificial intelligence; reverse logistics; circular economy; systematic literature review

JEL Classification: Q56; M11; O33

1. Introduction

With many businesses engaging in the circular economy, a recoverable and efficient industrial economy, reverse logistics has become essential to contemporary supply chains (Khan et al., 2022). Numerous detrimental environmental effects, including climate change, ocean pollution, biodiversity loss, and land degradation, were brought on by the conventional linear model. RL emerges as a crucial component of waste management systems, since it involves the planning, implementation, and control of product, material, and information flows from the point of consumption back to the point of origin, with the intention of reuse, recycling, or proper final disposal (da Silva et al., 2025a; Spirito, 2024). The primary distinction between RL and traditional waste management is that RL concentrates on recovering value from end-of-life products and garbage for reintegration into future supply chains, whereas waste

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management primarily focuses on the collection and treatment of waste that has no further use (Sandamini et al., 2025).

Global logistics and supply chain systems are facing increasing problems due to e-commerce expansion, sustainability demands, and operational complexity (Boukebbab et al., 2025). Smart logistics uses digital technologies to improve efficiency and responsiveness, whereas reverse logistics manages product returns, recycling, and waste within circular economy frameworks. A Smart Circular Economy is an industrial system that uses Digital Technologies to provide intelligent functions for the implementation of value-added circular strategies (Sartzetaki et al., 2025). Many studies have shown that integrating emerging technology with existing business practices allows organizations to improve economic, social, and environmental sustainability in the forward supply chain (John et al., 2025). Numerous studies on the circular economy have utilized Artificial Intelligence, Machine Learning, and Data Mining methodologies (Noman et al., 2022).

However, AI systems and their intelligent agents that make excellent decisions are changing the game in today's marketplaces (Subramoniam et al., 2021). AI aims to replicate the judgment and problem-solving skills of the human brain through mechanical and computational methods (Bhowmik et al., 2024). Other studies indicate that, although its efficacy varies depending on the technology used, AI offers significant advantages at every stage of reverse logistics (Alzoubi, 2025). By enhancing returns handling, monitoring the quality of reconditioned goods, streamlining routing and delivery, and more, AI has advanced RL. In addition, AI platforms can track return patterns and forecast them beforehand, helping reduce uncertainty related to the supply of used goods (or cores), which remains a major challenge in the remanufacturing sector. According to Farshadfar et al. (2024) machine learning considerably improves circular supply chain performance by enhancing supplier selection, operational optimization, and waste reduction. Machine learning-driven approaches in manufacturing, customer behavior forecasting, logistics, and waste management enable businesses to maximize resource utilization while minimizing waste. Similarly, technologies such as the Internet of Things, Artificial Intelligence (AI), Big Data Analytics, Cloud Computing, and Blockchain improve RL's traceability, automation, and sustainability (Rodrigues et al., 2025). Reverse logistics powered by AI has also shown a favorable correlation with circular economy performance (Mukherjee et al., 2024). Furthermore, AI techniques such as supervised, unsupervised, and reinforcement learning, fuzzy logic, image recognition, and neural networks are commonly used in circular economies (Noman et al., 2022). Despite the growing interest in digital technologies and circular economy research, several gaps remain in the literature. Literature studies have focused significantly on tackling blockchain technology and plastic redesign to properly exploit circular economy activities (Leal et al., 2024). However, a significant gap remains in addressing logistical challenges in waste management, as well as in artificial intelligence studies on reverse logistics (Lopes et al., 2024). Moreover, few studies have attempted to capture all aspects of the circular economy in the context of AI application during bibliometric and network analyses (Raut et al., 2025). Researching the influence of AI on reverse logistics is therefore critical for two reasons: first, there is a lack of formal examination of how AI may help with important reverse logistics activities; second, artificial intelligence is transforming entrepreneurship-related applications such as industry, company management, and innovation (Wilson et al., 2022).

A dynamic decision support system for sustainable supplier selection in circular supply chains has already demonstrated the potential of integrating machine learning with decision-making techniques such as the best-worst method and fuzzy inference systems (Alavi et al., 2021). Nevertheless, the development of manufacturing processes, food supply chains, and e-waste management still requires additional attention within AI-driven circular economy research (Noman et al., 2022).

The supply of used goods (or cores) and return uncertainty are currently major problems for the remanufacturing sector. In order to lower risk in reverse supply chain uncertainty, AI platforms can track return patterns and forecast them beforehand. Smart logistics uses digital technologies to improve efficiency and responsiveness, whereas reverse logistics manages product returns, recycling, and waste within circular economy frameworks. Reverse logistics powered by AI showed a favorable correlation with CE performance (Mukherjee et al., 2024).

RL emerges as a crucial component of waste management systems, since it involves the planning, implementation, and control of product, material, and information flows from the point of consumption back to the point of origin, with the intention of reuse, recycling, or proper final disposal (Silva et al., 2025). Many studies on the circular economy have utilized Artificial Intelligence, Machine Learning, and Data Mining methodologies (Noman et al., 2022). According to Farshadfar et al., (2024) machine learning considerably improves circular supply chain performance by enhancing supplier selection, operational optimization, and waste reduction. Machine Learning-driven approaches in manufacturing, customer behavior forecasting, logistics, and waste management enable businesses to maximize resource utilization while minimizing waste.

Some research shows that technologies such as the Internet of Things, Artificial Intelligence (AI), Big Data Analytics, Cloud Computing, and Blockchain improve RL's traceability, automation, and sustainability (Rodrigues et al., 2025).

The primary distinction between RL and traditional waste management is that RL concentrates on recovering value from end-of-life products and garbage for reintegration into future supply chains, whereas waste management primarily focuses on the collection and treatment of waste that has no further use (Sandamini et al., 2025). RL emerges as a crucial component of waste management systems, since it involves the planning, implementation, and control of product, material, and information flows from the point of consumption back to the point of origin, with the intention of reuse, recycling, or proper final disposal (Spirito, 2024). The results indicate that, although its efficacy varies depending on the technology used, AI offers significant advantages at every stage of reverse logistics (Alzoubi, 2025). By enhancing returns handling, monitoring the quality of reconditioned goods, streamlining routing and delivery, and more, AI has advanced RL. AI aims to replicate the judgment and problem-solving skills of the human brain through mechanical and computational methods (Bhowmik et al., 2024).

According to Noman et al., (2022) literature study, AI techniques such as supervised, unsupervised, and reinforcement learning, fuzzy logic, image recognition, and neural networks are commonly used in circular economies. The study also discovered that the development of the manufacturing process, the food supply chain, and e-waste management requires additional focus.

Many studies have shown that integrating emerging technology with existing business practices allows organizations to improve economic, social, and environmental sustainability in the forward supply chain (John et al., 2025).

Literature studies have focused significantly on tackling blockchain technology and plastic redesign to properly exploit circular economy activities (Leal et al., 2024). Table 1 is a summary of some literature studies and the studied reverse logistics methods.

By addressing the present fragmentation of research across technology and sustainability domains, this study adds to the body of literature by offering an organized and thorough synthesis of the role of artificial intelligence in reverse logistics within the circular economy. Additionally, it provides a basis for the creation of integrated, data-driven frameworks for sustainable supply chain management by highlighting important topic areas and research needs.

Table 1. Specific AI methods and applications from the literature

Technology Category	Specific AI Methods	Applications	Sources
Analytical AI	Data analysis, decision-making optimization	Enhanced all four RL processes (network design, collection, warehousing, processing).	Ziad Alkalha et al., (2025)
Machine Learning	Supervised, unsupervised, reinforcement learning; ANN, decision trees, random forests.	Return forecasting, route optimization, waste classification, network design, and resource allocation.	(Filho et al., 2025; Giungato et al., 2024; A. F. S. da Silva et al., 2025b; Yu et al., 2021)
Deep Learning	CNN, LSTM networks	Social media sentiment analysis for disposition decisions.	(Shahidzadeh & Shokouhyar, 2022)
Predictive Analytics	Forecasting models	Return predictions, demand forecasting.	(Al-Daradkah, 2024; Cortes-Pellicer et al., 2025a).
Computer Vision	CNN-based visual recognition	Product identification, quality control, sorting	(Habazin et al., 2025).
Decision Support Systems	AI-powered DSS	Resource allocation, logistics planning	(Al-Daradkah, 2024).
Fuzzy Methods	Fuzzy logic systems	Addressing uncertainty in RL applications.	(A. F. S. da Silva et al., 2025b)
Agent Technology	Multi-agent systems	Network performance improvement	(Wadhwa & Madaan, 2006)
Graph Theory	Optimization algorithms	Waste collection route optimization	(Yu et al., 2021)

Source: Authors

What is noticeable is a significant gap in addressing logistical challenges in waste management, and also in artificial intelligence studies on reverse logistics (Lopes et al., 2024).

A dynamic decision support system for sustainable supplier selection in circular supply chains successfully integrates machine learning, the best-worst technique, and the fuzzy inference system (Alavi et al., 2021). There is a research gap in the current CE literature since few studies have tried to capture all aspects of CE in the context of AI application during their bibliometric and network analysis (Raut et al., 2025). Researching the influence of AI on reverse logistics is critical for two reasons (Wilson et al., 2022): First, there is a lack of formal examination of how AI may help with important reverse logistics activities. Second, artificial intelligence is transforming entrepreneurship-related applications such as industry, company management, and innovation.

For these reasons, this study aims to answer the following research questions:

Q1: How is Artificial Intelligence used in the main processes of reverse logistics within the circular economy model?

Q2: What are the main application areas and contributions of Artificial Intelligence in improving reverse logistics performance?

2. Research Methods and Conditions

This study was based on the methodology of a systematic literature review to examine the role of artificial intelligence in reverse logistics in the context of the circular economy. This is known as a rigorous research method that synthesizes knowledge in a transparent, systematic, and structured way (Guzmán et al., 2023; Kitchenham, 2004). Data were retrieved from the Scopus database, a reliable and broad database for covering the public domain. In the initial search, the keywords (“artificial intelligence” OR AI OR “machine learning” OR “deep learning”) AND (“reverse logistics” OR “closed loop supply chain” OR remanufacturing OR recycling) were used, resulting in 3,150 documents without applying filters.

A screening procedure was used to guarantee quality and applicability. The following restrictions were used to refine the data set: document A screening procedure was used to guarantee quality and applicability. The data collection was modified by limiting the subject area to management and related subjects, the language to English, and the document type to journal articles. Following this filtering procedure, 179 articles made up the final sample. To identify trends and key research clusters based on title and abstract data, the selected papers were examined using descriptive and thematic analyses, supported by bibliometric mapping (VOSviewer).

3. Research Results and their Discussion

The examination of the 179 papers that made up the study's final sample shows that the number of studies is rapidly increasing, particularly in recent years. This is consistent with research on artificial intelligence, sustainability, and the circular economy. There is growing interest in using technology to address social and environmental issues, particularly in terms of waste reduction and resource efficiency (Khan et al., 2022; Noman et al., 2022). Scholars concur that digital technology plays a critical role in facilitating circular supply chains (Mukherjee et al., 2024; Rodrigues et al., 2025). Figure 1 shows the map of keywords exported from the VOSviewer software.

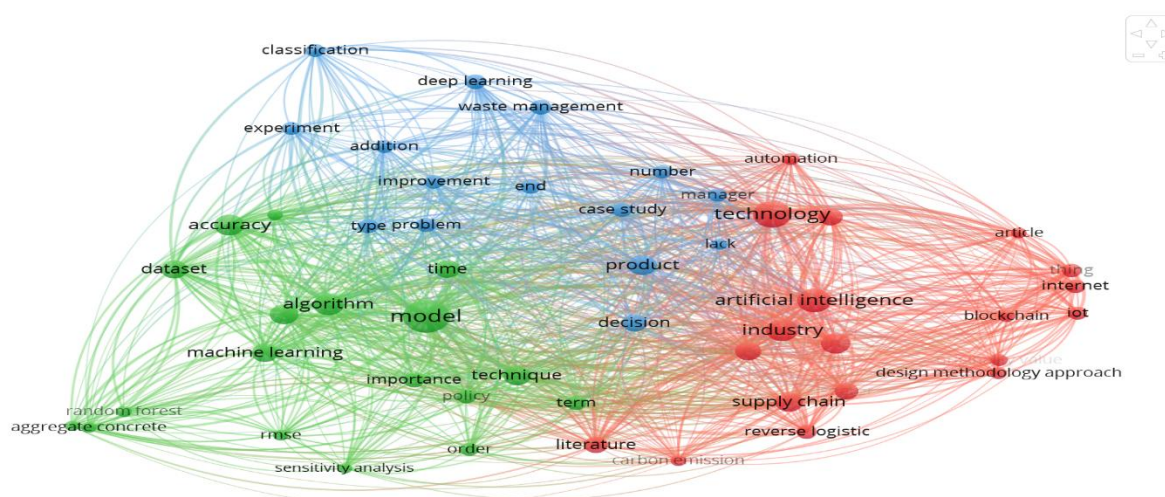


Figure. 1. Maps of the keywords

This map is created in VOSviewer following these steps: create, create maps based on text data, read data from bibliographic database files, Scopus, choose fields: abstract and title fields, binary counting, minimum number of occurrences: 10, number of terms to be selected: 52.

Table 1. Main clusters of keywords from Vosviewer

Cluster 1	Cluster 2	Cluster 3
article	accuracy	addition
artificial intelligence	aggregate concrete	case study
automation	algorithm	classification
blockchain	combination	decision
carbon emission	dataset	deep learning
circular economy	importance	end
design methodology ap	machine	experiment
industry	machine learning	improvement
integration	model	lack
internet	order	manager
iot	policy	number
literature	rac	problem
originality value	random forest	production
reverse logistic	rmse	type
sector	sensitivity analysis	waste management
supply chain	technique	
sustainability	term	
technology	time	
thing		

Source: Authors

Main Areas of Application of AI in Reverse Logistics are waste management and material recovery, optimization of logistics networks, decision-making, intelligent systems, predictive analytics, and return forecasting. In reverse supply chains, machine learning is specifically utilized to forecast product returns and manage uncertainty (Al-Daradkah, 2024; Cortes-Pellicer et al., 2025a). To increase productivity and save operating expenses, deep learning techniques are being used more frequently to automate trash identification and classification procedures (Habazin et al., 2025). Transportation routes, collection systems, and the logistics network's overall performance are all enhanced by optimization algorithms and AI-based decision support systems (Alkalha et al., 2025; Yu et al., 2021). By evaluating product conditions and economic viability, AI also helps with decisions about reuse, recycling, and reproduction (Alzoubi, 2025; Wilson et al., 2022).

3.1. Barriers and Challenges in AI-Driven Reverse Logistics

Even though the literature highlights the many benefits of using AI in enabling reverse logistics, at the same time, several obstacles are constantly identified that slow down the deployment, implementation, and operational integration to promote the circular economy. Although AI technologies show facilitation for increasing productivity, automation, and sustainability, businesses still face many organizational, technological, financial, and infrastructural difficulties (Cortes-Pellicer et al., 2025a). Of course, the main obstacle is related to the high cost of implementing AI because it requires significant investments, cloud platforms, data storage systems, etc. This is especially evident in developing countries and small and medium-sized organizations with more financial constraints (Leal et al., 2024; Sandamini et al., 2025).

Furthermore, data needs to be both qualitative and accessible, as decision-making relies on large volumes of data that need to be reliable.

This requires standardized data and the involvement and integration of stakeholders in waste management and reverse supply chains (Lopes et al., 2024; Sandamini et al., 2025). High levels of uncertainty in return flows, product conditions, timing, and inventory changes are characteristics of reverse logistics systems. For many companies, interoperability issues between blockchain applications, IoT systems, AI platforms, and organizational databases continue to be major limitations (Cortes-Pellicer et al., 2025a; Leal et al., 2024).

The challenges become more pronounced if they are combined with the lack of qualified and trained human resources for these processes. There are several studies that highlight the lack of workers with advanced programming, analytical, and AI management skills in many firms. Implementation processes are further slowed down by resistance to technological change, doubts about the reliability of artificial intelligence, and concerns about automation that could replace human work (Leal et al., 2024; Sandamini et al., 2025).

3.2. Future Research Directions

The reviewed literature provides some useful suggestions for further research on how to study the incorporation of artificial intelligence into reverse logistics to facilitate the circular economy. What remains important is the creation of conceptual frameworks that can link AI with Industry 4.0 technologies, including IoT, blockchain, cloud computing, digital twins, robots, and Big Data analytics. Future research should focus on understanding how these technologies can function as interconnected and interdependent ecosystems (Leal et al., 2024; Rodrigues et al., 2025). To address the above-mentioned challenges, future research could also be based on AI techniques that can increase managerial trust, transparency, and inclusiveness because many machine learning and deep learning models function as black-box systems (Lopes et al., 2024). Of course, the understanding and knowledge of these systems require further empirical studies in industrial case studies, longitudinal evaluations, and actual operational testing (Cortes Pellicer et al., 2025). Moreover, several studies recommend expanding the study to specific industrial sectors and waste streams. Areas including food waste, bio-waste, pharmaceutical waste, healthcare logistics and e-waste are still relatively unexplored, even though most of the current literature focuses on municipal solid waste, manufacturing waste and e-commerce returns (Sandamini et al., 2025; Leal et al., 2024). Also, areas worth further study are the social and human aspects of integrating AI into reverse logistics, which should be investigated in future studies because, in the studies to date, limited attention has been paid to workforce transformation, employee adaptation, digital skills, and human-AI collaboration (Rodrigues et al., 2025). To increase trust in the use of AI in reverse logistics, it also remains very important to measure sustainability performance and long-term effects of adoption.

Thus, the creation of assessment frameworks and standardized sustainability indicators continues to be a key research priority (Rodrigues et al., 2025).

4. Conclusions

This literature review makes an important contribution to the literature on the role of artificial intelligence in the circular economy through reverse logistics. Despite the many differences in the focus of the study, researchers agree that by significantly increasing operational efficiency, AI plays a crucial

role in enabling circular supply chains. Research on this topic has shown a growing trend of studies, disciplinary and geographical diversity in the distribution of publications. Many reverse logistics operations, such as return prediction, waste separation and classification, distribution optimization, and decision-making for product recovery, rely heavily on machine learning and deep learning technology.

These results are consistent with previous research showing how AI can improve operational performance and reduce uncertainty in reverse supply chains (Al-Daradkah, 2024; Alkalha et al., 2025; Cortes-Pellicer et al., 2025b; Habazin et al., 2025; Wilson et al., 2022). These findings also have managerial implications. They demonstrate how AI can improve decision-making, optimize reverse logistics processes, and increase resource efficiency, all of which can be crucial indicators for managers and policymakers. These implications help businesses leverage digital technology to improve sustainable performance and accelerate the transition to circular business models.

There are still limitations that need to be considered, even if this study provides an important synthesis of research trends and core areas of study of AI in reverse logistics. It is a study that relies only on secondary data and does not distinguish between research conducted in developed and developing countries. Future research may need to pay close attention to these limitations. The literature would benefit from more empirical testing and a greater concentration of studies conducted in poorer countries. In addition, much research continues to focus on technology, with less attention paid to managerial, organizational, and policy implications.

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