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Circular Logistics as Part of the Supply Chain

Dora Kolaric*, Ivan Grgačić, Matej Stoprd, Dunja Horvat

Abstract: This paper investigates circular logistics and its impact on the efficiency and sustainability of the supply chain. Key trends from 2019 to 2024 are analyzed, including the adoption of advanced technologies such as Blockchain, the Internet of Things (IoT), and artificial intelligence (AI), as well as recycling and material reuse, simplified product returns, and sustainable packaging. A qualitative analysis of secondary data, including scholarly articles and company reports, shows that the implementation of circular logistics reduces operational costs and waste, while its success depends on developed recycling infrastructure and the adaptation of business models. The study connects circular economy theory with practical examples, provides insights into the challenges and success factors in integrating circular models into supply chains, and offers guidance for future research and practical application.

Keywords: circular logistics; recycling; supply chain; sustainable packaging; sustainability

1 INTRODUCTION

Circular logistics is a comprehensive concept that has become crucial in modern supply chain management. In contrast to traditional supply chains, where products move linearly from raw materials to end consumers and often end their life cycle in landfills, circular logistics seeks to minimize waste and maximize resource use through reuse, recycling, and product regeneration [1]. This approach not only supports sustainability but also contributes to cost reduction and improved ecological efficiency, making it a strategic tool for companies seeking to optimize their operations [2]. The concept of reverse logistics flows originally emerged from the need for alternative ways of managing supply chain processes in increasingly demanding markets. The harmful effects of environmental degradation, pollution, and climate change served as tangible evidence of the inadequacy of traditional linear models. Consequently, awareness of the importance of sustainability has increased significantly in recent years. As the entire product life cycle, from raw material extraction to disposal, gained more attention, new demands arose to support the principles of sustainable development [3]. Circular logistics enables products to extend their life cycle and avoid ending up in landfills, but its definition and application have proven challenging due to its inherent stochasticity and complexity. At the same time, consumer demands have become increasingly urgent, requiring a rethinking of existing logistics networks and structures. Manufacturers and other stakeholders are forced to adopt new technologies, faster and more efficient delivery models, and greater reliance on e-commerce to remain competitive and maintain market share, particularly over the past decade [3]. Despite the growing recognition of its importance, systematic analyses of how circular logistics affect the entire supply chain remain limited, especially in specific regional contexts. The research problem therefore arises from the limitations of the traditional "take–make–use–dispose" supply chain model, which can no longer ensure long-term sustainability or competitiveness. Companies must seek new approaches that combine profitability, environmental responsibility, and responsiveness to consumer needs. Circular logistics presents one such alternative, but further research is required to determine its actual impact on supply chain efficiency and to identify the main challenges of its implementation. To address this gap, the aim of this paper is to examine the role of circular logistics within modern supply chains and to analyze its effects on business efficiency and sustainability. The specific objectives are to:

- Analyze the development of logistics in the past five years with an emphasis on circular logistics trends.
- Identify the advantages and disadvantages of circular logistics compared to traditional models.
- Examine key challenges and success factors in implementing circular logistics.
- Connect theoretical insights with practice through real-world business examples.

This study applies a qualitative-analytical method based on literature reviews, case studies, and comparisons of existing circular logistics models. The strength of this approach lies in its ability to capture the complexity of processes and highlight success factors often overlooked by purely quantitative studies. The motivation for writing this paper stems from the need to better understand how circular models can be integrated into supply chains in practice, as well as from the increasing consumer pressure that compels businesses to adapt their strategies and innovate. By answering the following research questions, the study aims to contribute to a deeper understanding of circular logistics as a driver of sustainability and competitiveness in modern supply chains:

RQ1: How does the implementation of circular logistics affect the efficiency of the supply chain in terms of cost and waste reduction?

RQ2: What are the key challenges and success factors in integrating circular logistics into a company's traditional logistics system?

H1: The implementation of circular logistics significantly reduces operational costs and the amount of waste in the supply chain.

H2: The successful application of circular logistics depends on the development of recycling infrastructure and

product return systems, as well as the adaptation of business models.

By addressing these questions and hypothesis, this research seeks to highlight the transformative role of circular logistics in creating resilient, efficient, and sustainable supply chains. The structure of the paper is organized as follows. After the introductory chapter, the second part provides the definition and theoretical framework of circular logistics, with a particular focus on its integration into supply chains, the optimization of routes in waste collection, and the challenges companies face in its implementation. The third part of the paper focuses on research into circular logistics trends as part of the supply chain and includes the research methodology, presentation of results, and discussion. The fourth part presents the conclusions of the paper, while the fifth part contains the list of references.

2 DEFINITION AND THEORETICAL FRAMEWORK OF CIRCULAR LOGISTICS

Circular logistics, as part of the supply chain, is increasingly gaining attention in the context of sustainable business and waste reduction. Circular logistics focuses on minimizing waste and maximizing resource utilization through reuse, recycling, and material regeneration. This approach not only helps preserve the environment but can also significantly improve supply chain efficiency. The implementation of circular logistics is becoming crucial for modern companies that wish to optimize their operations and align them with the principles of sustainable development [4]. Circular logistics represents an extension of the traditional logistics concept, with an emphasis on the reverse flow of products and their reuse. Unlike the linear model, circular logistics closes the loop of material movement, reducing the need for new resources and decreasing the amount of waste that ends up in landfills [5]. The connection between logistics and sustainability is also highlighted in the literature dealing with waste management and reverse logistics [6] [7]. According to Harris, sustainable development cannot be achieved without serious reforms in the ways businesses manage their supply chains [8]. Circular logistics lays the foundation for such a transformation, enabling businesses to efficiently utilize resources and respond to environmental demands and consumer pressures. The integration of this model into all stages of the supply chain, from production to the end user and the return of products after use, is essential. More efficient handling of goods in the return process is crucial due to the constant decline in product prices. The functioning of the supply chain, in addition to reducing the percentage of returned goods, also enables a faster flow of returned products. Return logistics activities include the processes a company uses to collect used, damaged, unwanted products, or those that have expired, as well as packaging from end consumers or suppliers. Reverse logistics is a relatively new concept, and services in this area are gradually developing. Once a product is returned, the company can redistribute it to maximize the product's value [9].

2.1 Integration of Circular Logistics in the Supply Chain

The implementation of circular logistics in supply chains involves the optimization of logistics systems, including product return processes. Waters and Donald emphasize the importance of logistics as a key part of the entire supply chain in their work. Traditional logistics focuses on optimizing the flow of goods and reducing costs, while circular logistics expands these goals to include sustainability and waste minimization. Modern supply chains must integrate sustainable practices such as reverse logistics, waste reduction, and recycling to meet the growing demands of the market and consumers [10]. By combining all the mentioned elements, it is possible to create sustainable supply chains that not only reduce the negative impact on the environment but also provide economic benefits through more efficient resource use and cost reduction. De Brito, Rommert, and Douwe emphasize that reverse logistics is a key aspect in supply chains when it comes to waste reduction and resource maximization [11]. In the example of urban environments, Awomeso, Taiwo, Gbadebo, and Arimoro highlight the importance of proper waste management for reducing pollution and improving the environment [12]. According to Quesada, circular logistics can also increase the value of products, as it allows materials to be recycled or reused instead of being discarded. These processes not only reduce the ecological footprint of organizations but can also bring financial benefits [13]. Rubio and Beatriz identify key challenges in managing reverse flows, including costs, the need for specialized equipment, and technical infrastructure [14]. One example of successful implementation of circular logistics is the automotive industry, which uses the return of vehicle parts for their refurbishment and reuse in the production of new cars. This reduces costs and also contributes to the reduction of CO_2 emissions and resource consumption. An integral approach to managing the municipal waste collection system involves the coordination of different sectors to ensure efficient collection, processing, and disposal of waste. According to Erdelezi, Margeta, and Knezić, such an approach allows for the optimization of operational processes and cost reduction, but it requires good infrastructure and support from local authorities [6]. By introducing modern technologies and planning methods, such as computer systems for waste tracking and analysis, it is possible to significantly improve the efficiency of the system. Ghiani, Gilbert, and Musmanno also emphasize the importance of optimizing logistics systems through planning and control, which is crucial for proper resource management in supply chains [15]. By combining these approaches, logistics systems can become more flexible and sustainable. Packaging waste represents a significant portion of total waste, and its proper management is crucial for environmental protection. Grum, in his work, emphasizes the need for developing systems that enable the recycling of packaging waste and the reduction of the amount of waste that ends up in landfills [16]. Developing legal regulations, such as the ban on single-use plastics, as well as raising awareness among consumers, are key steps toward a sustainable packaging waste management system. Marinela further emphasizes the importance of educating the population on proper waste disposal and implementing

effective recycling programs, which reduce environmental pressure and ensure the reuse of materials [17]. Packaging waste can become a valuable resource if properly managed, which is one of the fundamental principles of circular logistics. Circular logistics refers to the processes of returning products from consumers back to manufacturers so that these products can be reused, repaired, or recycled. Rogers, Lambert, Croxton, and García-Dastugue emphasize that managing the reverse flows of goods is crucial for a sustainable supply chain. This process involves complex operations related to returning products at the end of their lifecycle into the economic cycle [18]. Reverse logistics also allows companies to reduce production costs through the reuse of materials. Valle, Menezes, Reis, and Efigenio further emphasize the importance of customer service in the reverse logistics process. Customer satisfaction is a key factor for the success of recycling and reverse logistics programs, and companies must ensure efficient channels for product returns. Additionally, the development of technological solutions that enable easier tracking of products throughout their entire lifecycle helps optimize these processes [19].

2.2 Optimization of Routes in Waste Collection

Route optimization in waste collection becomes crucial in achieving an efficient waste management system, reducing costs, and minimizing the ecological footprint. In urban areas, with the increasing volume of waste and the complexity of collection, it is essential to find solutions that reduce unnecessary resources, time, and greenhouse gas emissions. One of the key elements of circular logistics is transportation optimization, especially in waste collection and recycling. In studies conducted, such as the one in the city of Trabzon (Turkey), route optimization helped reduce the total number of kilometers traveled by waste collection vehicles while improving system efficiency. Apaydin and Gonullu use mathematical models to identify optimal routes that reduce operational costs and the time needed for waste collection [20]. They also studied route optimization for solid waste collection in the city and demonstrated how proper route organization can significantly reduce costs and collection time [20]. Sulemana, Donkor, Forkuo, and Oduro-Kwarteng emphasize that route optimization is an important aspect of circular logistics, as it reduces fuel consumption and greenhouse gas emissions [21]. The integration of information and communication technology (ICT) into logistics systems also plays an important role in enhancing circular logistics. Asadi states that advanced ICT technologies can improve efficiency in managing reverse product flows and waste, contributing to better control and waste reduction in the supply chain [22]. These systems also help businesses better manage inventory, reduce costs, and increase efficiency. The digitalization of logistics processes enables better coordination between different stakeholders in the supply chain, facilitating product returns and recycling. For example, tracking systems and automatic ordering of products that are nearing the end of their lifecycle allow for quick responses to changes in demand and supply, reducing the risk of excess inventory and waste. Several algorithms are used for waste collection route optimization. The most commonly used are search algorithms. These algorithms enable the creation of optimal routes that consider variable factors such as traffic, distance between destinations, and vehicle capacity. Ghiani, Gilbert, and Musmanno emphasize that proper planning and optimization can significantly improve the efficiency of logistics systems, including those in waste collection [15]. Heuristic methods are often used when a quick, yet sufficiently good solution is needed for complex optimization problems. Heuristic approaches allow for the rapid evaluation of optimal routes and are frequently used in urban areas where there are a large number of collection points. Erdelez, Margeta, and Knezić suggest a combination of heuristic methods and traditional logistics approaches for better optimization [6]. The application of modern technologies, such as GPS systems and GIS (Geographic Information Systems), is crucial in tracking and optimizing routes. These systems enable real-time data collection, which helps adjust routes based on actual conditions on the ground, such as traffic delays or changes in waste volume. According to Marinela, GIS systems allow for precise route planning, reducing travel time and fuel consumption, which results in lower greenhouse gas emissions [17].

2.3 Challenges in the Implementation of Circular Logistics

Although circular logistics offers numerous benefits, there are challenges related to its implementation. Srivastava and Srivastava emphasize that reverse logistics often requires additional resources, such as specific infrastructure and technology for processing returned products [23]. The infrastructure for product return and recycling is often not sufficiently developed, making it difficult for companies to implement circular processes on a global scale. Kućar Dragičević, Butuči, and Kufrin state that in Croatia and other transitional countries, the main issues are related to inadequate waste management infrastructure and the lack of legal regulations that would encourage the implementation of circular models [24]. In addition, Potter emphasizes that companies must invest significant resources in adapting their business models in order to effectively implement circular logistics [25]. One of the main challenges in implementing circular logistics is the high initial cost. Investments in recycling technology, process optimization, and infrastructure adaptation can be significant. According to research by Frosch and Gallopoulos, the costs of implementing circular practices are often too high for small and medium-sized enterprises, which can slow down the spread of circular models [26]. The lack of universal standards and guidelines also presents a challenge. Currently, there are no globally accepted standards for evaluating the effectiveness of circular logistics practices, which can make comparison and implementation difficult. As Stahel points out, standardization is crucial for effective management of circular processes and reducing uncertainty in business operations [5]. Compatibility between different systems and technologies can also be problematic. Integrating existing logistics systems with new circular technologies often requires complex adjustments. According to research by the Ellen MacArthur Foundation, many organizations face challenges in adapting their IT systems and infrastructure to support circular practices [27]. The resistance of

organizations to change and the lack of support from employees also pose obstacles. Implementing circular logistics often requires a shift in culture and attitudes within the organization. Access to relevant data and information is crucial for the success of circular logistics. The lack of transparency in supply chains can complicate the tracking and optimization of circular processes. As Ghisellini, Cialani, and Ulgiati note, better access to information can significantly improve organizations' ability to implement circular models and track their performance [28].

3 RESEARCH ON CIRCULAR LOGISTICS TRENDS AS PART OF THE SUPPLY CHAIN

This research aims to support the mentioned theory with concrete examples and to answer the research questions and hypotheses. Circular logistics represents a significant shift in how organizations manage their supply chains, focusing on waste reduction and resource optimization. Over the past five years, this approach has become increasingly important due to global challenges related to sustainability and climate change. The goal of this research is to identify and analyze key trends in circular logistics that have emerged during the period from 2019 to 2024.

3.1 Research Methodology

The methods used in this study are based on a qualitative research approach, which is widely recognized in supply chain and logistics research for exploring complex, context-dependent phenomena. The research focuses on secondary data collected from scientific papers, books, industry reports, and other relevant sources published between 2019 and 2024, a period chosen to capture the most recent developments in circular logistics, including technological innovations, regulatory changes, and evolving consumer demands [1] [29]. The use of qualitative methods such as analysis, synthesis, description, induction, and deduction allows for a systematic examination of trends, patterns, and principles in circular logistics, providing insights that cannot be obtained through purely quantitative approaches [30]. This research is both descriptive and exploratory, aiming to document observed practices and identify new insights, gaps, and challenges in the application of circular logistics. The population consists of academic literature, industry reports, policy papers, and other credible sources addressing circular logistics worldwide. The sample was limited to sources published in the last five years (2019–2024) to ensure relevance and timeliness, while the universe includes peer-reviewed journal articles, books, official reports, and industry analyses relevant to circular logistics and supply chain sustainability [31]. The research was conducted in several steps. First, relevant sources were identified and collected from databases such as Scopus, Web of Science, and Google Scholar. Selection criteria included relevance to the topic, credibility, publication date, and focus on trends, innovations, and challenges in circular logistics. Finally, the findings were synthesized and linked to theoretical insights to draw conclusions and provide recommendations for practice [1]. The research instruments employed include literature review for comparison of sources, and analytical frameworks to facilitate the synthesis of insights and the connection between theory and practice. Data were analyzed thematically, using both inductive reasoning to derive general insights from specific observations and deductive reasoning to evaluate theoretical assumptions against the collected evidence. This structured approach ensures a rigorous examination of secondary data, enabling the identification of key trends and challenges in circular logistics and supporting actionable conclusions for modern supply chain management.

3.2 Research Results

In the last five years (2019–2024), circular logistics has undergone significant transformations, driven by the growth of e-commerce, increasing sustainability demands, and the adoption of advanced technologies. Recent studies highlight that reverse logistics has become a key area for reducing costs, enhancing operational efficiency, and improving customer satisfaction [36, 37, 39]. Based on an extensive literature review and supported by case examples, six key trends have been identified as shaping circular logistics globally. The selection of specific technologies was based on their proven relevance to circular logistics and their potential to address key challenges such as supply chain transparency, efficiency, resource optimization, and waste reduction. These technologies were chosen because they represent the most widely implemented innovations in reverse logistics, offering measurable improvements in operational performance and sustainability outcomes. The following are some of the key trends that have shaped reverse logistics globally:

1) Impact of Disruptive Technologies on Information Management (2019): Blockchain has increasingly been used to manage logistics, utilizing RFID chips to track the entire supply chain from manufacturers to sellers. This technology enables seamless exchange of goods and information, high security, transparency, and tracking among all participants. Customers can view the history of purchased items and track them through the supply chain [29, 30]. Blockchain can revolutionize reverse logistics management, accelerate processes, increase efficiency, and improve partner connectivity through digital platforms, thereby reducing barriers and encouraging innovation without additional costs. ShipChain, a blockchain-based solution, enables global cargo tracking with encryption and data accessibility limited to involved participants. This technology allows for better tracking of product history, generating reliable freight invoices, and reducing costs. The Internet of Things (IoT) provides clear visibility in storage and sharing of information between departments, enabling tracking, planning, and control of all processes with RFID technology and wireless sensors. The Smart Reverse Supply Chain (SRSC) allows for an intelligent combination of various systems, such as recycling and supply chain management systems, using advanced IT systems to manage product information throughout the entire lifecycle [31-33]. An example of successful Blockchain implementation in circular logistics is the introduction of this technology by De Beers in 2019. De Beers, a well-known diamond manufacturer, uses Blockchain to track diamonds throughout the entire supply chain, ensuring transparency and product

authenticity. All diamonds are tracked from the raw material stage to finished products, allowing customers to verify the history of their diamonds and ensure they are not linked to illegal activities [34, 35].

2) Recycling and Material Reuse (2020): IKEA (Ingvar Kamprad Elmtaryd Agunnaryd) is a Swedish company founded in 1943. Today, it is one of the largest global corporations in furniture retail, and in addition, it engages in real estate sales and operates restaurants within its stores. IKEA stands out as a leader in environmental conservation, implementing measures such as introducing eco-friendly bags, reducing water and electricity consumption, and using ecological materials [36]. By 2030, the company plans for all plastic in its production process to be made from renewable or recycled materials. Additionally, it aims for all wool in its products to come from responsible sources, and the cotton it uses to be sustainable, either recycled or grown with reduced resource use. In 2020, IKEA focused on recycling or incinerating 91% of the waste from its stores for energy use, while promoting more sustainable materials and LED lighting [37, 1].

3) Sustainability and Environmental Awareness (2021): In 2021, there was an increasing focus on sustainability in circular logistics. Companies began implementing strategies to reduce waste, recycle returned products, and use environmentally friendly packaging. H&M implemented textile recycling systems in 2021. H&M encourages customers to donate old clothing items at their stores, where the collected textiles are sorted and recycled into new products. H&M expanded its textile recycling program, known as "H&M Garment Collecting". Customers are invited to donate old clothes at H&M stores worldwide. The donated textiles are collected, sorted, and recycled based on their material and quality. The collected garments can be processed in various ways, including recycling into new textile fibers or converting them into industrial materials. H&M uses advanced technologies for sorting and recycling textiles. For example, the company has invested in material recognition technologies, which allow for more efficient separation and recycling. These technologies enable the recycling of fibers that would otherwise be unrecyclable, such as blends of different materials. The company aims that by 2030, all of their products will be made from recycled or sustainable materials. This includes using recycled fibers and materials from sustainable sources. H&M also plans to significantly increase the amount of textile they recycle compared to the amount they collect. H&M actively educates its customers about the importance of recycling and sustainability. The company organizes campaigns and events in its stores to raise awareness among consumers and encourage them to participate in recycling programs. H&M also provides information on how to properly dispose of old clothing and which materials are suitable for recycling [38] [39].

4) Simplified Product Returns (2022): An example is ASOS, known for its simple return policy, which offers a user-friendly interface with numerous filters and clarity to make shopping as easy as possible. The return policy allows for the return of unused and undamaged products within a specified period, with a refund. The customer simply repackages the product in its original packaging, fills out the return form, and follows the detailed instructions on the store's website. The return packaging is designed for easy reuse. ASOS also has a donation system in place, allowing customers to send clothing and footwear donations via DPD delivery service at no additional cost. This service collects donations at the time of order delivery, further simplifying the process. This efficient circular logistics system saves time and money and is focused on customer care and socially responsible activities [9, 40-42].

5) Integration of Artificial Intelligence (AI) (2023): In 2023, artificial intelligence (AI) became crucial for improving return processes in circular logistics. AI tools are used to optimize return routes, predict return patterns, analyze the causes of returns, and enhance operational efficiency. Amazon Robotics uses AI and robotics to improve its warehouse operations, including the returns process. AI algorithms in Amazon Robotics systems are used to optimize robot routes within the warehouse. These algorithms analyze real-time traffic and warehouse schedule data to determine the most efficient routes for robots transporting products, including returned items. This allows for faster and more efficient robot movement, reducing the time needed to process return shipments and increasing overall productivity. AI systems in Amazon Robotics are also used to automate the sorting of returned products. Warehouse robots are equipped with advanced sensors and cameras, allowing them to identify the type and condition of returned products. AI then analyzes this data to direct products to the appropriate locations for further processing, improving the speed and accuracy of sorting. AI also helps in predicting return volumes and planning resources. By analyzing historical return data, AI can predict return patterns and optimize warehouse capacities, robot allocation, and labor deployment. This allows Amazon to enhance its warehouse processes and reduce downtime caused by return processing. Amazon Robotics integrates its AI systems with other technologies, such as the Internet of Things (IoT) and Warehouse Management Systems (WMS). This integration enables real-time monitoring and management of return processes, as well as automatic adjustment of operations based on the current needs of the warehouse. By improving the speed and accuracy of processing returned products, AI and robotics help enhance customer experience. A faster return process reduces waiting times for customers, while more accurate sorting reduces the number of incorrect returns and exchanges, increasing customer satisfaction. Automation through AI and robotics significantly reduces the costs of circular logistics. It decreases the need for a large number of human workers, reduces errors, and increases efficiency, leading to a reduction in overall operational costs. This allows Amazon to offer more competitive prices and better service to customers [43, 44].

6) Sustainable Packaging and Circular Logistics (2024): In 2024, the trend of sustainable packaging and packaging management continues to expand within circular logistics. Companies globally are investing in eco-friendly materials and strategies to reduce waste, contributing to the sustainability and efficiency of their operations. Apple significantly advanced its sustainable packaging initiatives in 2024 through the "Environmental Progress Report" program. Apple introduced packaging using 100% recycled aluminum

for the casings of its products, including MacBook and iPhone devices. This material reduces the need for new raw materials and lowers the overall environmental footprint of production. Additionally, Apple uses recycled plastics and other materials for packaging, including recycled paper products for boxes and inserts, thus reducing the use of virgin materials. Apple has drastically reduced the size of its product packaging to cut CO_2 emissions associated with transportation. Smaller packaging allows for better space optimization in warehouses and transport vehicles, reducing the number of required shipments and greenhouse gas emissions. Apple has also optimized packaging design to use fewer materials without compromising product protection. The company employs advanced technologies, including AI and data analytics, to optimize packaging. These technologies help analyze demand and logistics patterns to improve packaging efficiency and reduce waste. For example, Apple uses AI to forecast and plan packaging needs in real time, allowing packaging to be tailored to specific market requirements and minimizing material surplus. Apple has introduced innovations in packaging design, including biodegradable materials and compostable options for packaging accessories like chargers and headphones. The company is researching new materials that can naturally decompose in the environment, further reducing the environmental footprint of packaging. As part of its "Environmental Progress Report" program, Apple regularly publishes reports on its packaging sustainability progress, including data on CO_2 emissions reductions, the amount of recycled materials used in packaging, and success in waste reduction. These reports allow customers and investors to track the company's progress toward its sustainability goals [45, 46].

Together, these trends demonstrate a shift towards more efficient, sustainable, and customer-focused reverse logistics strategies, driven by technological innovation and evolving consumer and environmental demands. By linking these observed practices with theoretical insights, this study establishes a stronger foundation for understanding circular logistics beyond individual company cases, highlighting the interplay between theory and practice in modern supply chains. Also, the study connects theoretical insights with practical applications, providing a foundation to analyze trends, challenges, and success factors in circular logistics. The methodology ensures that the selection of case studies and examples is justified, relevant, and directly linked to the research objectives, namely: to assess the impact of circular logistics on supply chain efficiency, to identify key challenges in its implementation, and to explore innovative solutions for sustainable operations.

3.3 Discussion

The research conducted on the trends of circular logistics from 2019 to 2024 confirmed everything previously supported by expert literature. The study was carried out using secondary data sources, specifically through non-financial reports from the companies mentioned and other verified sources. By combining case examples with theoretical frameworks, this research contributes to closing the gap between conceptual models of circular logistics and their real-world application. Through theoretical research, the following answers to the research questions and hypotheses were reached:

RQ1: How does the implementation of circular logistics affect the efficiency of the supply chain in terms of cost and waste reduction? The study indicates that circular logistics improves efficiency through multiple mechanisms. These include resource optimization, long-term cost savings, reduced operational management expenses, increased product durability, recycling and reuse, enhanced transparency, and compliance with regulatory frameworks [47, 42]. This confirms hypothesis H1, which posits that circular logistics reduces operational costs and waste. The theoretical basis for this finding aligns with the principles of the circular economy, emphasizing resource recirculation and the reduction of environmental impact [46]. While the initial implementation may involve higher costs, the long-term benefits, such as lower material expenditure and reduced waste management costs, generally outweigh these investments.

RQ2: What are the key challenges and success factors in integrating circular logistics into a traditional logistics system within a company? The study identified both operational and organizational considerations. Key challenges include organizational culture change, integration complexity, initial investment costs, supply chain complexity, and adherence to regulatory frameworks [39]. Success factors, supported by theoretical models of sustainable supply chain management, involve the adoption of innovative technologies, collaboration with partners, employee training and education, systematic monitoring and reporting, implementation of incentives, and the use of financial instruments to support transitions [44, 29]. These findings confirm hypothesis H2, emphasizing that successful circular logistics requires developed recycling infrastructure, efficient product return systems, and adaptive business models. Well-established infrastructure ensures effective material and product processing, while adaptive business models facilitate the integration of circular practices into daily operations, supporting waste reduction, resource optimization, and long-term sustainability goals [1].

H1: The implementation of circular logistics significantly reduces operational costs and the amount of waste in the supply chain. This hypothesis is confirmed both in theory and practice. According to [46], sustainable business models based on the principles of the circular economy enable cost reduction through recycling, reuse, and product life-cycle extension. This leads to lower demand for new resources and reduced waste management costs. Govindan and Hasanagic [47] further emphasize that the implementation of circular logistics not only decreases waste but also enhances supply chain efficiency by optimizing resources and reducing operational risks. Thus, it is evident that circular logistics can generate long-term financial and environmental benefits.

H2: The successful application of circular logistics depends on the development of recycling infrastructure and product return systems, as well as the adaptation of business models. The theoretical framework also confirms this hypothesis. Kirchherr, Reike, and Hekkert [48] stress that the circular economy cannot function without supportive

infrastructure that enables efficient collection, sorting, and recycling of products. In addition to infrastructure, the adaptation of business models is crucial for sustainability, as it allows the integration of reverse product flows into everyday operations [36]. Companies that have adapted their models, such as those adopting the "product-as-a-service" system, have demonstrated greater resilience and competitiveness in the market. This confirms that both infrastructure and business model adaptation are essential prerequisites for the successful implementation of circular logistics.

Overall, the results corroborate both hypotheses and provide theoretical support for the benefits and requirements of circular logistics. At the same time, they contribute to the literature by addressing the gap between theory and practice. Specifically, the study illustrates that the implementation of circular logistics is not merely an operational adjustment but a strategic approach requiring alignment between technology, infrastructure, organizational culture, and business processes to achieve sustainable supply chain performance. In doing so, this paper contributes to filling the gap in existing research by providing empirical evidence on how circular logistics trends are operationalized in global corporations, thereby enhancing our understanding of the transformative role of circular logistics in modern supply chains.

4 CONCLUSION

Circular logistics offers significant potential for improving ecological sustainability and business efficiency in supply chains. The integration of circular logistics flows, recycling, and material reuse are key to reducing the ecological footprint and increasing economic benefits. Although there are challenges in implementation, advanced technologies and examples of best practices show that sustainability can be achieved through circular logistics. Developing infrastructure, applying new technologies, and aligning legal regulations with the principles of a circular economy are essential steps that companies and governments must take to encourage the further adoption of circular logistics. Through this approach, it is possible to create sustainable and profitable supply chains that will meet the challenges of the 21st century. Route optimization in waste collection is crucial for achieving efficiency, reducing costs, and minimizing the ecological footprint in waste management systems. The use of advanced algorithms, heuristic approaches, and technologies such as GIS enables significant improvements in system efficiency. However, for successful implementation, operational and social challenges must be overcome, and circular logistics practices must be integrated into waste management systems. The future of circular logistics within the supply chain represents a key step towards more sustainable and ecologically friendly business operations. As global pressures to reduce waste and CO_2 emissions increase, more and more organizations are adopting the principles of the circular economy to improve the efficiency of their operations, reduce their ecological footprint, and create added value. These trends include optimizing recycling, reusing materials and products, and integrating closed loops into logistics operations. Given global trends and the need to reduce ecological footprints, circular logistics will become an increasingly important component of successful business models in the future. Implementation can help organizations adapt to these changes and achieve long-term benefits for their operations and the environment. The research questions and hypotheses highlight the importance of understanding these elements to achieve success in circular logistics and allow for further research in this field. However, this study has several limitations. First, the research relies primarily on secondary data and non-financial company reports, which may limit the comprehensiveness and generalizability of the findings. Second, the focus on selected case examples may not fully capture the diversity of circular logistics practices across industries and regions. Third, the analysis concentrates on the period from 2019 to 2024, so trends outside this timeframe were not explored. Future research could address these limitations by conducting primary data collection through surveys, interviews, or field studies to capture a broader range of organizational experiences with circular logistics. Comparative studies across different industries and countries could provide deeper insights into contextual factors affecting implementation. Additionally, longitudinal studies could examine the long-term impacts of circular logistics adoption on both operational efficiency and sustainability outcomes. Research could also explore the integration of emerging technologies, such as artificial intelligence, blockchain, and IoT, in greater depth to evaluate their potential for optimizing circular supply chains. Circular logistics represents a critical step toward more sustainable and ecologically responsible business operations. Its implementation can help organizations adapt to increasing environmental pressures, reduce waste and CO_2 emissions, and create long-term value. By addressing the research questions and testing the hypotheses, this study contributes to a better understanding of the drivers, challenges, and success factors in circular logistics, while highlighting avenues for further investigation to support sustainable and profitable supply chains in the future.

5 REFERENCES

[1] Geissdoerfer, M., Savaget, P., Bocken, N. M. P., & Hultink, E. J. (2017). The Circular Economy – A new sustainability paradigm? *Journal of Cleaner Production, 143*, 757–768. https://doi.org/10.1016/j.jclepro.2016.12.048

[2] Genovese, A., Acquaye, A. A., Figueroa, A., & Koh, S. C. L. (2017). Sustainable supply chain management and the transition towards a circular economy: Evidence and some applications. *Omega, 66*, 344–357. https://doi.org/10.1016/j.omega.2015.05.015

[3] Alkandi, I., Alhajri, N., & Alnajim, A. (2025). Green Supply Chain Management, Business Performance, and Future Challenges: Evidence from Emerging Industrial Sector. *Sustainability, 17*(1), 1–36. https://doi.org/10.3390/su17010029

[4] Rosen, M. A. (2017). The Future of Sustainable Development: Welcome to the European Journal of Sustainable Development Research. *European Journal of Sustainable Development Research, 1*(1), 1–2. https://doi.org/10.20897/ejosdr.201701

[5] Stahel, W. R. (2019). *The Circular Economy*. London: Routledge. https://doi.org/10.4324/9780429259203

[6] Erdelez, A., Margeta, J., & Knezić, S. (2007). Integralni pristup upravljanju sustavom prikupljanja komunalnog otpada. *Građevinar, 59*(6), 505–516. (in Croatian)
[7] Wright, R. E., Richey, R. G., & Tokman, M. (2011). Recycling and reverse logistics. *Journal of Applied Business and Economics, 12*(5), 9–20.
[8] Harris, J. M. (2003). Sustainability and Sustainable Development. *International Society of Ecological Economics*, 1–12.
[9] Krpan, L., Furjan, M., & Maršanić, R. (2014). Potencijali logistike povrata u maloprodaji. *Tehnički glasnik, 8*(2), 182–191. (in Croatian)
[10] Waters, D. (2003). *Logistics: An Introduction to Supply Chain Management*. Palgrave Macmillan.
[11] De Brito, M. P., Rommert, D., & Simme Douwe, P. F. (2005). Reverse logistics: A review of case studies. In *Distribution logistics* (pp. 243–281). Springer. https://doi.org/10.1007/978-3-642-17020-1_13
[12] Awomeso, J. A., Taiwo, A. M., Gbadebo, A. M., & Arimoro, A. (2010). Waste disposal and pollution management in urban areas: a workable remedy for the environment in developing countries. *American Journal of Environmental Sciences, 6*(1), 26–32. https://doi.org/10.3844/ajessp.2010.26.32
[13] Quesada, I. F. (2003). The concept of reverse logistics. A review of literature. In *Annual Conference for Nordic Researchers in Logistics*, 1–15.
[14] Rubio, S., & Beatriz, J.-P. (2014). Reverse Logistics: Overview and challenges for supply chain management. *International Journal of Engineering Business Management, 6*, 6–12. https://doi.org/10.5772/58826
[15] Ghiani, G., Gilbert, L., & Musmanno, R. (2004). *Introduction to Logistics Systems Planning and Control*. John Wiley & Sons. https://doi.org/10.1002/0470014040
[16] Grum, Đ. (2013). Gospodarenje ambalažnim otpadom i zaštita okoliša. *Sigurnost, 55*(1), 37–44. (in Croatian)
[17] Marinela, B. (2009). The Concept of Waste Management. *Analele Universităţii din Oradea, Fascicula: Protecţia Mediului, 14*, 669–673.
[18] Rogers, D. L. D. M., Kelly, L. C., & Garcia-Dastugue, S. J. (2002). The returns management process. *The International Journal of Logistics Management, 13*(2), 1–18. https://doi.org/10.1108/09574090210806397
[19] Valle, P. O., Menezes, J., Reis, E., & Efigenio, R. (2009). Reverse logistics for recycling: The customer service determinants. *International Journal of Business Science and Applied Management, 4*(2), 1–17. https://doi.org/10.69864/ijbsam.4-1.35
[20] Apaydin, Ö., & Gonullu, M. T. (2007). Route optimization for solid waste collection: Trabzon (Turkey) case study. *Global NEST Journal, 9*(1), 6–11. https://doi.org/10.30955/gnj.000388
[21] Sulemana, A., Donkor, E. A., Forkuo, E. K., & Oduro-Kwarteng, S. (2018). Optimal Routing of Solid Waste Collection Trucks: A Review of Methods. *Journal of Engineering, 2018*, 1–8. https://doi.org/10.1155/2018/4586376
[22] Asadi, S. (2011). Logistics system: Information and communication technology. In *Logistics Operations and Management: Concepts and Models* (pp. 221–245). https://doi.org/10.1016/B978-0-12-385202-1.00012-8
[23] Srivastava, S. K., & Srivastava, R. K. (2006). Managing product returns for reverse logistics. *Journal of Physical Distribution & Logistics Management, 36*(7), 524–546. https://doi.org/10.1108/09600030610684962
[24] Kučar Dragičević, S., Butuči, J., & Kufrin, J. (2006). Zbrinjavanje otpada u Republici Hrvatskoj - postojeće stanje. *Arhiv za higijenu rada i toksikologiju, 57*(3), 263–266. (in Croatian)
[25] Potter, C. (2022). *The Circular Economy: The Next Step in Sustainable Living*. Laurence King Publishing.
[26] Frosch, R. A., & Gallopoulos, N. E. (1989). Strategies for manufacturing. *Scientific American, 261*(3), 144–153. https://doi.org/10.1038/scientificamerican0989-144
[27] Ellen, F. M. (2015). *Towards a Circular Economy: Business for an Accelerated Transition*. Ellen MacArthur Foundation.
[28] Ghisellini, P., Cialani, C., & Ulgiati, S. (2016). A review on circular economy: the expected transition to a balanced interplay of environmental and economic systems. *Journal of Cleaner Production, 114*, 11–32. https://doi.org/10.1016/j.jclepro.2015.09.007
[29] Kshetri, N. (2018). Blockchain's roles in meeting key supply chain management objectives. *International Journal of Information Management*, 39, 80–89. https://doi.org/10.1016/j.ijinfomgt.2017.12.005
[30] Queiroz, M. M., Telles, R., & Bonilla, S. H. (2019). Blockchain and supply chain management integration: A systematic review of the literature. *Supply Chain Management: An International Journal, 25*(2), 241–254. https://doi.org/10.1108/SCM-03-2018-0143
[31] Farouk, M., & Darwish, S. M. (2020). Reverse Logistics Solution in e-Supply Chain Management by Blockchain Technology. *Egyptian Computer Science Journal, 44*(1), 22–34.
[32] Shah, S., Dikgang, G., & Menon, S. (2019). The Global Perception of Industry 4.0 for Reverse Logistics. *International Journal of Economics and Management, 4*, 103–107.
[33] Shah, S., Rutherford, R., & Menon, S. (2020). Emerging Technologies of IoT Usage in Global Logistics. In *International Conference on Computation, Automation and Knowledge Management (ICCAKM)*, Dubai, United Arab Emirates. https://doi.org/10.1109/ICCAKM46823.2020.9051530
[34] De Beers Group. (2022). *De Beers Group Introduces World's First Blockchain-Backed Diamond Source Platform at Scale*. Retrieved from https://www.debeersgroup.com/media/company-news/2022/de-beers-group-introduces-worlds-first-blockchain-backed-diamond-source-platform-at-scale (Accessed 18 September 2024).
[35] Saberi, S., Kouhizadeh, M., Sarkis, J., & Shen, L. (2018). Blockchain technology and its relationships to sustainable supply chain management. *International Journal of Production Research, 57*(7), 2117–2135. https://doi.org/10.1080/00207543.2018.1533261
[36] Lacy, P., & Rutqvist, J. (2016). *Waste to Wealth: The Circular Economy Advantage*. Springer. https://doi.org/10.1057/9781137530707
[37] IKEA. (2020). *IKEA*. Retrieved from https://www.ikea.com/us/en/this-is-ikea/ (Accessed 18 September 2024).
[38] H&M Group. (2022). *H&M Group Sustainability Disclosure 2021*. Retrieved from https://hmgroup.com/wp-content/uploads/2022/03/HM-Group-Sustainability-Disclosure-2021.pdf (Accessed 18 September 2024).
[39] Seuring, S., & Muller, M. (2008). Core issues in sustainable supply chain management – A Delphi study. *Business Strategy and the Environment, 17*(8), 455–466. https://doi.org/10.1002/bse.607
[40] ASOS. (2022). *ASOS Annual Report 2022*. Retrieved from https://asos-12954-s3.s3.eu-west-2.amazonaws.com/files/1816/6807/7015/ASOS_AR2022_Interactive_3November.pdf (Accessed 18 September 2024).

[41] ASOS. (2024). *ASOS Returns Policy*. Retrieved from https://www.asos.com/payments-and-deliveries/returns/?country=hr (Accessed 18 September 2024).
[42] Rogers, D. S., & Tibben-Lembke, R. (2001). An examination of reverse logistics practices. *Journal of Business Logistics, 22*(2), 129–148. https://doi.org/10.1002/j.2158-1592.2001.tb00007.x
[43] Amazon. (2023). *Amazon Introduces New Robotics Solutions*. Retrieved from https://www.aboutamazon.com/news/operations/amazon-introduces-new-robotics-solutions (Accessed 18 September 2024).
[44] Waller, M. A., & Fawcett, S. E. (2013). Data Science, Predictive Analytics, and Big Data: A Revolution That Will Transform Supply Chain Design and Management. *Journal of Business Logistics, 34*(2), 77–84. https://doi.org/10.1111/jbl.12010
[45] Apple. (2024). *Apple Environmental Progress Report 2024*. Retrieved from https://www.apple.com/environment/pdf/Apple_Environmental_Progress_Report_2024.pdf (Accessed 18 September 2024).
[46] Bocken, N. M. P., Short, S. W., Rana, P., & Evans, S. (2014). A literature and practice review to develop sustainable business model archetypes. *Journal of Cleaner Production, 65*, 42–56. https://doi.org/10.1016/j.jclepro.2013.11.039
[47] Govidan, K., Soleimani, H., & Kannan, D. (2015). Reverse Logistics and Closed-Loop Supply Chain: A Comprehensive Review to Explore the Future. *European Journal of Operational Research, 240*(3), 603–626. https://doi.org/10.1016/j.ejor.2014.07.012
[48] Kirchherr, J., Reike, D., & Hekkert, M. (2017). Conceptualizing the circular economy: An analysis of 114 definitions. *Resources, Conservation and Recycling, 127*, 221–232. https://doi.org/10.1016/j.resconrec.2017.09.005

Authors' contacts:

Dora Kolaric
(Corresponding author)
Sveučilište Sjever,
Trg dr. Žarka Dolinara 1, 48000 Koprivnica, Croatia
dokolaric@unin.hr

Ivan Grgačić
Sveučilište Sjever,
Trg dr. Žarka Dolinara 1, 48000 Koprivnica, Croatia
ivgrgacic@unin.hr

Matej Stoprd
Sveučilište Sjever,
Trg dr. Žarka Dolinara 1, 48000 Koprivnica, Croatia
mastoprd@unin.hr

Dunja Horvat
Sveučilište Sjever,
Trg dr. Žarka Dolinara 1, 48000 Koprivnica, Croatia
dunjhorvat@unin.hr