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RESEARCH PAPER

Rethinking the Secondhand Supply Chain: A Technological and Sustainable Approach

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Abstract

This research investigates the complex dynamics of supply chain management (SCM) within the burgeoning secondhand market. Through a rigorous literature review, encompassing over 500 publications and a focused analysis of 54 relevant articles, this study explores the challenges, opportunities, and innovative strategies employed by businesses in this sector. A mixed-methods approach, incorporating both qualitative and quantitative techniques, was adopted to gather empirical data. Semi-structured interviews with SCM experts and a structured questionnaire survey were conducted to collect insights from companies operating in the secondhand market. Additionally, case studies of leading companies were analyzed to delve deeper into their SCM practices and the application of emerging technologies. The findings of this research highlight the critical role of technology, particularly blockchain and AI, in enhancing transparency, traceability, and efficiency in secondhand supply chains. Blockchain can be leveraged to verify product authenticity and track the product journey, while AI can optimize logistics, demand forecasting, and inventory management. Furthermore, the study emphasizes the importance of sustainability initiatives in aligning with consumer preferences and reducing environmental impact. By combining these technological advancements with sustainable practices, businesses can improve their operational performance, enhance customer satisfaction, and contribute to a more circular economy. This research provides valuable insights and practical recommendations for businesses operating in the secondhand market, enabling them to navigate the complexities of SCM and achieve sustainable growth.

Keywords: Supply Chain Management (SCM), Secondhand Market, Retail Industry, Blockchain Technology, Artificial Intelligence (AI).

Introduction

Secondhand marketplaces have been revolutionizing the retailing sector in recent times, primarily by increased consumer demands with regards to sustainability, affordability, and unique experiences for shopping. Such a trend has elevated this industry as a whole even more concerning business organizations in managing supply chain management in selling old or secondhand products, adapting to the complexity of sourcing, controlling inventory, and delivering goods amidst moving trends in the marketplace. The paper provides a critical review of the strategies and challenges in optimizing supply networks for used goods. The role of technology, environmental initiatives, and collaborative partnerships in driving operations

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efficiency and consumer trust in competitive landscapes is discussed critically. In the various different contexts of secondhand market supply chain management, some developments have been recorded in recent times [1]. For instance, Dou et al. [2] explored how blockchain technology might enable supply chains to achieve better transparency and accountability-particularly when individuals consign used goods to an online platform for resale, thus competing with suppliers of new products. It also emerged that the platform would likely use a consistent pricing strategy for new products when the income share in consignment contracts is relatively low and a dynamic pricing strategy when it is high. Also, Sihvonen and Turunen [3] searched the view of consumers with regard to the value of fashion brands in online flea markets, especially when such brands were second-hand and on sale on a flea market attached to Facebook. Efficient SCM is quintessential for the second-hand market to ensure that it attains profitability objectives, efficiency, and environmental goals.

Blockchain technology offers several specific applications within the secondhand market, particularly in tracking the provenance of goods, verifying authenticity, and facilitating secure transactions [4]. By utilizing a decentralized ledger, blockchain can provide a transparent and immutable record of a product's lifecycle, from its original manufacture to its resale, ensuring that each transaction is traceable and secure. This is especially valuable for high-value items like luxury fashion or electronics, where verifying the authenticity of secondhand goods is crucial. Blockchain can also prevent fraud by allowing buyers and sellers to trust that the product’s history and ownership details are accurate and verifiable, thus reducing the risk of counterfeit goods entering the market. Additionally, smart contracts built on blockchain can automate payments and transfers, further enhancing the security and efficiency of transactions. These applications collectively increase consumer trust and streamline operations within the secondhand market [5].

The following research considers the various challenges and new strategies that were developed in the SCM of secondhand markets with regard to sourcing, logistics, inventory, and ensuring buyer satisfaction. It points out opportunities for improvement that could be incorporated into the already existing SCM systems and also provides workable solutions. It further contributes to the greater understanding of sustainable supply chains, introducing knowledge from various segments of the secondhand market and state-of-the-art technological innovations, and will deliver actionable recommendations for businesses in this fast-growing market.

Methodology

This research employs a mixed-methods approach to comprehensively investigate the complexities of supply chain management (SCM) within the burgeoning secondhand market. A rigorous literature review was conducted using multiple academic databases, including Google Scholar, Scopus, Web of Science, and IEEE Xplore. Keywords such as "secondhand market AND supply chain management," "secondhand market AND blockchain," "secondhand market AND AI," "secondhand market AND sustainability," "secondhand market AND circular economy," and "secondhand market AND reverse logistics", “Green supply chains”, and “closed-loop” were used to identify relevant studies. A stringent selection process was applied, prioritizing recent publications with an empirical focus. To gather primary data, a combination of qualitative and quantitative methods was utilized. Qualitative Research involved semi-structured interviews with key stakeholders, including SCM managers and experts from companies operating in the secondhand market. These interviews explored the challenges, strategies, and technological innovations employed in secondhand SCM. The interview guide was developed based on a literature review and preliminary discussions with industry experts. Interviews were conducted in-person or via video conferencing and were audio-recorded to

ensure accurate transcription and analysis.

Quantitative Research involved a structured questionnaire survey distributed to a sample of secondhand businesses. The questionnaire was designed to collect data on various aspects of their SCM practices, such as sourcing, logistics, inventory management, and sustainability initiatives. A pilot study was conducted to refine the questionnaire and ensure its clarity and reliability. Data was collected through an online survey platform and paper-based surveys.

The collected data was analyzed using a variety of techniques. Qualitative data from interviews were subjected to thematic analysis to identify recurring themes and patterns. Thematic analysis involved coding the transcripts, identifying key themes, and organizing them into a coherent narrative. Quantitative data from questionnaires were analyzed using statistical software, such as SPSS, to examine relationships between variables and assess the impact of different SCM factors on overall performance. Descriptive statistics were used to summarize the data, and inferential statistics were employed to test hypotheses and identify significant relationships.

To gain deeper insights into specific case examples, case studies were conducted on leading companies in the secondhand market. Case studies provided detailed information on their SCM practices, including the adoption of emerging technologies like blockchain and AI. Data for the case studies was collected through a combination of interviews, document analysis, and site visits.

The research methodology employed in this study ensures the validity and reliability of the findings. Triangulation was used to cross-validate data from multiple sources, such as interviews, questionnaires, and case studies. Additionally, the research adhered to rigorous data collection and analysis procedures to minimize bias and maximize the accuracy of the results.

While this study provides valuable insights into the secondhand market, it is important to acknowledge its limitations. The sample size may be limited, and the findings may not be generalizable to all contexts. Future research could explore a wider range of case studies and conduct longitudinal studies to track changes in SCM practices over time.

Literature Review

Considering the growing consumer appetite for sustainable purchasing options and the tantalization of value in secondhand goods, the secondhand market has seen exponential growth over the last decade. Parallel to this rise, supply chain management has emerged as a key player in the success and efficiency of such markets. Varied differences in efficient SCM include unpredictability of the sources, complications of assessing quality by product authenticity. The article addresses how, with innovative SCM strategies, secondhand markets are transforming product availability, customer satisfaction, and sustainability practices that add considerably to the circular economy. We explore the role of technology, logistic frameworks, and strategic partnerships in reshaping the pathways through which secondhand goods are sourced, processed, and delivered to consumers. Supply chain management is one of the major operations management approaches employed by organizations to achieve and sustain competitive advantage in today's global marketplace. Supply chain management (SCM) is important since companies realized that their ability to constantly create a competitive advantage depends on their capacity to not only make use of their internal capabilities but also to actively engage with their channel partners. Channel partners help the organizations develop innovative ideas and source out the required resources by which a strategic bundle of competencies can be developed that will go in line with both their own organizations as well as the needs of the targeted markets. In modern days, by corporate managers, it is very well acknowledged that entirely the survival and prosperity of their organizations would altogether depend upon maintaining a good relationship with both the suppliers as well as consumers.

Indeed, the most important ability that a company can have may not necessarily relate to a short-term advantage it may hold through a product or process, but rather in its ability to constantly gather and execute market-leading abilities deriving from cooperative partnerships with its supply chain collaborators [6]. Mentzer et al. [7] They deliberated on the intrinsic linkage between SCM and Marketing, how these functional areas not only shared a common goal but also gained from each other in the process. By doing so in detail, they realized how both functions help in customer value creation and integration of functions lead to the efficiency and effectiveness of organizations. The collaboration between SCM and Marketing will, therefore, enable organizations to gain strengths from each function to ensure better customer satisfaction, reduce costs, and improve their market position. Roussat et al. [8] They conceptualized a supply chain for C2C product exchanges in the sharing economy, emphasizing the strong physical mediation in a "sharing supply chain." They compared this extreme case with other forms and developed theoretical propositions, extending the concept while underlining the strategic role of dimensions of supply chains. Sumo et al. [9] Examined the economic contributions and environmental challenges of the second-hand clothes market in Africa, important for job creation and the alleviation of poverty, yet empirical research should be undertaken in view of the limitedness of the dataset. Qiu et al. [10] The vertical integrations involving the recycling platform and online secondhand platform in a supply chain are those that benefit the RSP in special market power conditions and consumer acceptance levels, providing managerial insights through game models and numerical analyses. L. Gunasekara et al. [11] Results: This paper reviewed 131 high-impact journal articles from 2012 to 2021 about returns acquisition, sorting, and disposition in circular supply chains. It pointed out the main research areas, such as coordination of closed-loop supply chain and ASD for remanufacturing. It also indicated some limitations, for example, empirical studies and practical validation were relatively scarce, and some future research directions have been suggested to help the transition to a circular economy. G. Lai,et al. [12] It investigates the incentive and consequence of an online retail platform that launches a secondary market of used products by developing a game-theoretic model characterizing the equilibrium decisions in the choice of product durability and service commission rate. The analysis showed that the platform and the stakeholder can gain from it under certain conditions. Z. Guan, et al. [13] Analyzed the block chain adoption strategy of a brand owner under new and secondhand product competition, incorporating consumers' anticipated regret: it was observed that block chain adoption improves brand image and reduces uncertainties, but it does not always improve profits earned by the brand owner. Outcomes were reasoned to be due to levels of brand image improvements and regret intensities. J. Wu et al. [14] Conducted a deep systematic review of block-chain application for anti-counterfeiting within resale luxury markets using 230 journal articles and various case studies of various luxury brands and resale platforms to highlight factors able to further boost adoption in the settings. S. Liu et al. [15] It provided an all-inclusive review of the fashion resale market of China through systematic review and meta-analysis of 69 articles and reports, identified key facilitators and barriers for both consumers and platforms, and put up valuable insights in shaping business strategies and policies to make the market more sustainable and adaptable globally. Q. Guo et al. [16] introduced block chain as the quality disclosure technology for second-hand platforms to reveal the fact that although adopting block chain generally leads to cumulative advantages over time, non-block chain platforms can still compete under circumstances such as levels of supply and demand, platform differentiation, and network effects with the benefits of block chain platforms mainly following high consumer trust and optimal supplier choices in most scenarios. J. Lichy,et al. [17] The study applied the theory of sustainable social innovation and the Consumer Styles Inventory with a view to exploring secondhand clothing consumption in Russia. New shopping orientations were discovered, and the relevance of existing ones for retail strategy and business model innovation in the direction

of sustainable and socially responsible marketing within the high-end secondhand clothing market was affirmed. J. Davies,et al. [18] The authors have explored the transformative potential of NFTs in sustainable supply chain management by using the Technology Organization Environment framework to propose how NFTs can incentivize sustainability, improve consumer engagement, offer anti-counterfeiting measures, and underpin circular business models. They also introduce a 'Mint-to-Order' strategy that ties digital tokens to physical products.

Y. Wang [19] tried to handle the credit risk of SMEs in supply chain finance with the integration of block chain technology and fuzzy neural network algorithms. It built a block-chain-based supply chain financial system based on embedding financial information into the block and used fuzzy neural networks in data processing and risk assessment. It was done by the researchers to present the outcomes of this study, which reveal effective enhancement in the risk management of a supply chain through simulation; at the same time, it confirms the implementation of these technologies. However, its integration does provide some promising improvements like efficient processing of the risks and possible weaknesses are its complexity in implementing such an advanced system and high needs for high-scale computational resources. C. Yang et al. [20] concentrated on improving chemical safety assessments in the cosmetics industry by leveraging the ChemTunes•ToxGPS® platform, which merges in silico and in vitro data within a digital ecosystem. According to researchers discussed, this platform, implemented by the Long Range Science Strategy (LRSS) program of Cosmetics Europe, allowed for the integration of experimental and predictive data, facilitating detailed toxicity predictions and safety evaluations. Its effectiveness has been demonstrated with an example of Perilla frutescent through methodologies like TTC, QSAR, structural rules, and qRAX. Although the platform does ensure streamlining of several kinesthetic workflows and in silico tools of advanced nature, challenges may exist related to the complexity of the integration of data and the requirement for continual updating to keep pace with the regulatory standards as well as scientific advancements. Z. Yihui [21] It was designed to try and solve some of the problems that have arisen with cloud data storage security, data privacy, and financial risk control, given the wide use of sensor networks. It described a system combining sensor network technology with cloud storage, embedding such security mechanisms as data encryption, access control, and identity authentication, with a real-time monitoring and analyzing module for financial risk control. The author demonstrated in the system its effectiveness by offering a user-friendly interface for configuration and monitoring, as well as flexible expansion and customization options to meet various needs. However, while the integration of these technologies strengthened data security and risk management, potential weaknesses, included the complexity of implementation and the need for continuous updates to maintain security standards. The motivation for composing this research article arises from the substantial impact that secondhand marketplaces have had on the retail sector, propelled by the changing customer desires for sustainability, affordability, and distinctive purchasing experiences. Prior research, such as the work conducted by Dou et al. on the capacity of blockchain technology to improve transparency and accountability in consignment platforms, and by Sihvonen and Turunen on the perceived worth of fashion brands in online flea markets, emphasize the intricacies and advancements in this industry. However, even with these progressions, there is still a need for a thorough examination of the SCM procedures that are unique to secondhand marketplaces. This study seeks to fill this need by consolidating current research, pinpointing obstacles, and investigating inventive approaches to enhance supply chain management in the secondhand market. Ultimately, this will contribute to scholarly discussions and provide practical guidance for companies. Thomas et al. [22] investigated how a growing second-hand market, influenced by decreased transaction costs and increased product lifetimes, could either reduce or increase demand for new goods and material consumption, depending on the availability of waste used

goods and the relative value of used versus new products. Van Boeckholtz et al. [23] examined the secondhand clothing supply chain from the Netherlands to Ghana, revealing that while Dutch companies emphasized their sustainability and circularity through various certifications and statistics, these representations failed to address the complex, lived realities of clothing interactions in Ghana, thus underscoring the need for more nuanced considerations in the global North's discourse. Norris et al. [24] introduced a special issue by exploring themes from the study of secondhand clothing economies, showing how the evolution of this global industry linked market dynamics, materiality, and morality, while highlighting the complexities of commodification, market variations, and the need for further research on value extraction and associated issues of reciprocity, power, and inequality. Chen et al. [25] developed a text analytics framework to assess secondhand sellers' reputations on e-commerce platforms by integrating domain ontology with topic modeling, demonstrating that this method surpassed traditional models and offered a practical tool for improving buyer decision-making and online secondhand market development.Norris et al. [26] highlighted how the complex dynamics of used clothing trade in India revealed the tension between ethical aspirations and the realities of informal economies, power, and corruption.Hasan et al. [27] demonstrated that consumer values in secondhand fashion varied between the mass market and luxury sectors, revealing that mass-market platforms overlooked key values like ownership transfer, which impacted their performance compared to luxury counterparts.Datta et al. [28] revealed that establishing secondhand marketplaces for durable goods allowed lower-income consumers to access expensive products at reduced prices, potentially boosting market growth and GDP by encouraging product replacement and increasing overall consumption.Ek Styvén et al. [29] Perceived sustainability, economic motives, and the desire to dissociate themselves from conventional consumption drive the attitude of UK consumers in purchasing second-hand clothing on peer-to-peer sharing platforms, while past experience strengthens the effect of perceived sustainability.Waldman et al. [30] argued that durable goods manufacturers like United Shoe, IBM, and Xerox adopted lease-only policies to eliminate the secondhand market, and it analyzed the implications of this strategy for antitrust policy and its relationship to existing literature. Bae et al. [31] This demonstrates features designed to ensure safe transactions and an enjoyable experience by users were the most influential ones that drove the adoption of online secondhand resale platforms, while high-tech innovations- such as virtual reality and machine learning- had minimal effect, suggesting the given industry growth was more driven by practicality and user friendliness rather than by the use of cutting-edge technology. Table 1 shows studies measuring progress towards circular economy:

Table 1. Studies measuring progress towards circular economy

REf	Aim	Method	Result	Limitations
[32]	To create indicators that measure how well companies apply Circular Economy principles across environmental, economic, and social dimensions.	Using expert input, feedback, and case studies to develop and test the indicators.	Testing with three Brazilian companies showed that data on economic and social impacts was hard to find, which makes it tough to fully track Circular Economy benefits.	Limited availability of data on social and economic impacts makes it difficult to comprehensively assess CE benefits.
[33]	To assess opportunities for improving material efficiency in a medium-sized manufacturing company through supply chain	The study used deterministic calculations and simulations to evaluate material efficiency strategies within the company and its supply chain.	Improving supply chain material efficiency was crucial but needed to be combined with efforts to return waste and used products to the economic cycle for greater impact.	The deterministic nature of simulations may oversimplify the complexity of real-world material flows and supply chain dynamics.

	optimization and Circular Economy measures.			
[34]	To analyze how 143 companies implemented Resource Efficiency Measures (REMs) and the challenges they faced with business model changes.	The study grouped REMs into supply, demand, and life cycle measures, linking them to business model changes and common barriers like market, organizational, and technological hurdles.	Finding all types of REMs faced challenges, regardless of complexity, with specific patterns of barriers tied to different business model changes.	Insufficient empirical data; the study relies heavily on self-reported measures, and it lacks external validation in real-world applications.
[35]	To explore material efficiency improvements and barriers in Swedish manufacturing companies, focusing on waste segregation.	Reviewing company practices, identified barriers, and analyzed strategies for improving material efficiency.	It found potential for better waste segregation, with key barriers being internal, like budget and communication issues, and noted a lack of effective material efficiency strategies.	Limited focus on external factors, such as regulatory or market conditions, that could affect material efficiency.
[36]	To propose a Circularity Measurement Toolkit (CMT) for assessing circular practices in manufacturing SMEs.	The toolkit was developed from a literature review, verified using a Delphi study, and validated through a case study in a manufacturing SME.	It introduced a practical tool that helps SMEs measure their circularity and identify actions to improve their adoption of Circular Economy practices.	The toolkit's practical applicability may be constrained by differences in industry types and varying levels of circularity awareness.
[37]	To explore opportunities for circularity in the consumer goods sector by leveraging digital intelligence and redistributed manufacturing (RDM).	The study used a mixed-method approach, combining a multi-case study with qualitative analysis and Discrete Event Simulation to evaluate circular scenarios.	It found that digital intelligence and redistributed manufacturing enable circular business models, while simulations can quantify the impact of circular activities on supply chain performance.	The study's reliance on simulations may limit its generalizability to real-world scenarios, particularly for companies with different operational structures.
[38]	To propose a roadmap for transforming linear business models into circular ones in manufacturing firms.	The study used a multiple case study approach, analyzing the transformation journeys of eight companies.	It provided a step-by-step process for circular business model transformation, helping companies achieve sustainability goals across environmental, social, and financial dimensions.	Limited to a small number of case studies, reducing the generalizability of the findings to broader industrial applications.
[39]	To present technological elements based on sustainable manufacturing principles for implementing a circular economy.	The study identified 6R-based technological elements and applied them in a case study to demonstrate life cycle cost benefits.	It highlighted the importance of 6R technologies for achieving economic, environmental, and social benefits, showcasing life cycle cost advantages through a practical case study.	The case study approach limits the study's applicability to industries beyond the one analyzed; broader testing is needed for validation.
[40]	To assess the viability of using product-service systems (PSS) to extend the lifetime of passive products and reduce	The study documented five product cases, using life cycle assessment (LCA) and life cycle costing (LCC) to quantify	The findings showed a 45-72% reduction in environmental impact and an 8-37% cost decrease, demonstrating that PSS can be both financially	The scope is limited to passive products, and the study does not account for potential complexities in other product types or

	environmental impact.	environmental and economic outcomes from repair or refurbishment.	attractive and environmentally beneficial for companies.	industries.
[41]	To review and classify existing Circular Business Models (CBMs) to identify the most promising ones for practical adoption.	The study conducted a systematic literature review of 283 articles, identifying CBM archetypes, classification methods, challenges, decision-support tools, and research areas.	The review found that Product-Service Systems and 3R-based models are the most common, with the Business Model Canvas being the most widely used classification framework, and sustainability challenges being frequently discussed.	The classification system may not fully capture the dynamic and evolving nature of circular business models, particularly in emerging sectors.

In Table 2, we mention the studies in Cooperating for advancement towards a circular economy.

Table 2. Cooperating for advancement towards a circular economy

Ref	Aim	Method	Result
[42]	To analyze critical success factors for circular economy adoption using Upper Echelons Theory in companies from Brazil and Scotland.	Conducted two exploratory case studies and tested four research propositions.	Proactive companies manage critical success factors better, with top management's sustainability focus playing a key role.
[43]	To investigate how the B-Corp Certification System can raise awareness in businesses about stakeholder commitment within the framework of the circular economy.	It analyzed case studies to explore the role of stakeholders in two circular economy scenarios.	B-Corp certified companies, especially in recycling and waste management, contribute significantly to circular economy development by engaging stakeholders and fostering industrial symbiosis.
[44]	To analyze the implementation of the circular economy in the pulp and paper industries of Portugal and Spain, comparing their environmental performance.	A comparative index based on environmental indicators was developed to compare the circular economy performance of the pulp and paper sector in both countries between 2011 and 2015.	In 2015, Portugal's pulp and paper sector outperformed Spain's by 26% in circular economy implementation, though the gap has been narrowing over the last five years.

Table 3 mentions the studies which mentioned barriers to circular economy implementation.

Table 3. Barriers to circular economy implementation

Ref	Aim	Method	Result	Barriers
[45]	To investigate how companies recognize and manage paradoxical tensions arising from the pursuit of circular economy goals in corporate sustainability.	A multiple case study approach was used, focusing on three manufacturing sectors in Italy: paper production, textile/clothing, and leather.	Companies adopted both defensive and proactive strategies to manage tensions, with one company exploiting a significant opportunity in the process	Daddi et al. (2019) discovered that effective management might facilitate new company prospects.
[46]	To identify the barriers and opportunities of the circular economy in	A deductive, positivist approach was used, with a survey questionnaire	The study identified key barriers, opportunities, and benefits of circular	Kumar et al. (2019) investigated various obstacles and identified that significant impediments to

	the manufacturing sector from socio-political, economic, legal, and environmental perspectives.	distributed to over 200 manufacturing companies in the UK and EU, yielding 63 responses.	economy implementation for manufacturing companies in the UK and EU across socio-political, economic, legal, and environmental dimen	Circular Economy (CE) implementation pertained to costs (such as investment and elevated scrap material expenses), absence of incentives (including tax benefits or financial assistance), insufficient public awareness, lack of suitable partners, and unavailability of requisite systems or technology.
[34]	To analyze the implementation of Resource Efficiency Measures (REMs) in relation to Business Model Changes (BMCs) and the barriers that affect their implementation.	The study examined 143 cases of REMs using a framework that categorizes supply side, demand side, and life cycle measures, linking them to various types of BMCs and associated implementation barriers.	The study found that all types of REMs and BMCs faced a range of barriers, but no clear evidence supported the idea that complex REMs face more barriers, with different barriers affecting each BMC type.	Diaz Lopez et al. (2019) investigated the implementation hurdles for various resource efficiency methods and identified numerous pertinent technical obstacles due to the incomplete development of technologies for the circular economy. Examining the obstacles to enhanced material efficiency
[35]	To investigate material efficiency improvement opportunities, barriers, and strategies in Swedish manufacturing companies, focusing on increasing waste segregation into high-quality circulated raw material.	The study analyzed material efficiency practices, identified barriers at two levels, and reviewed strategies used by large global manufacturing companies.	The study found significant potential for improving material efficiency through better segregation, identified internal barriers, and highlighted the lack of effective material efficiency strategy implementation in the companies studied.	Shahbazi et al. (2016) identified a diverse array of obstacles, encompassing economic, organizational, and technological impediments. The absence of a comprehensive material efficiency plan, extending beyond the firm level, was apparent; the authors advocated for the implementation of such a strategy and the enhancement of waste fraction value by sorting.
[47]	To investigate the challenges faced by a manufacturing firm when implementing a circular business model and the solutions adopted to overcome them.	A case-based research design was used, applying literature-identified challenges as lenses for data analysis.	Successful implementation of a circular business model requires collaboration across organizational functions and stakeholders, along with alignment between external conditions and the business model.	Sousa-Zomer et al. (2018) identified obstacles including stakeholder participation, budgetary and organizational constraints, and knowledge requirements.

Green supply chains (GSCs) represent an evolution from traditional linear supply chains, integrating environmental considerations into the entire supply chain, from sourcing raw

materials to delivering products and services to customers. GSCs aim to minimize the environmental footprint by optimizing energy consumption, reducing waste, and lowering greenhouse gas emissions. The integration of green supply chain management (GSCM) practices into the circular economy is vital, particularly for second-hand markets, where the reduction of new production is balanced with the reuse of existing products [48]. In the context of second-hand markets, GSCs support sustainability by facilitating the movement of pre-owned goods through eco-friendly methods. For instance, sustainable transportation methods, energy-efficient warehousing, and ethical disposal of non-reusable materials are critical in minimizing the ecological footprint of second-hand supply chains [49].Research suggests that companies implementing GSCM practices not only enhance their environmental performance but also improve operational efficiency and customer satisfaction, thereby fostering long-term sustainability [50].Abbasi et al.[51] analyzed the optimization of logistics management and green closed-loop supply chain design during the COVID-19 pandemic, focusing on balancing costs and carbon emissions under various regulatory restrictions, and provided insights for managers on the impact of different policies on supply chain efficiency and emissions reduction.

Reverse logistics (RL) is the process by which companies recover products from customers for purposes such as refurbishment, recycling, or disposal. In the circular economy, reverse logistics plays a critical role, particularly in second-hand markets where products are intended to be reused or repurposed. RL involves a series of activities such as product return, repair, remanufacturing, recycling, and disposal, each of which contributes to reducing waste and conserving resources [52].

Within second-hand markets, RL enables the extension of product life cycles by facilitating the flow of returned goods back into the market, thereby reducing the need for new production [53]. For instance, companies like IKEA have started implementing RL practices to retrieve used furniture, which is then repaired or repurposed for resale, supporting the principles of the circular economy. In fact, reverse logistics has been found to be highly cost-effective, while simultaneously reducing the environmental impact associated with new product manufacturing [53]. Incorporating studies on reverse logistics into the analysis helps underscore its significance in achieving circularity in second-hand markets.The integration of green supply chains, reverse logistics, and closed-loop supply chains into the circular economy framework is critical for enhancing sustainability, particularly within second-hand markets. These concepts align closely with the three pillars of sustainability—environmental, economic, and social (Carter & Rogers, 2008). For instance, GSCs reduce the environmental impact of production and distribution, RL helps minimize waste, and CLSCs maximize resource efficiency. Together, these supply chain innovations promote long-term sustainability by facilitating the continuous use and recycling of materials.Through the lens of second-hand markets, the circular economy offers a sustainable alternative to the traditional linear economy, which is based on a take-make-dispose model. By rethinking how products are managed at the end of their life cycle, companies can significantly reduce their environmental footprint while simultaneously creating economic value through new business models based on reuse and refurbishment. Research indicates that companies adopting circular economy practices, especially those that incorporate these advanced supply chain models, often see improved financial performance and enhanced brand loyalty due to their commitment to sustainability [54].

Results and Discussion

The market for secondhand goods has grown exponentially over the past ten years, driven by both increased consumer demand for sustainable purchasing options and an attraction to securing value from pre-owned goods. In this context, the supply chain management (SCM)

plays a critical role in determining whether success and efficiency will be achieved in these markets. Efficient SCM in the flow of the second-hand business has quite evidently faced big challenges. Adding to them would be quality assessment and establishing authenticity. This paper focuses on how innovative SCM strategies are really changing second-hand markets by assuring the availability of products, elevating customer satisfaction, and broader sustainable practices that contribute significantly to the circular economy. We are going to explore technologies, logistics, and partnerships that are rewriting circuits in sourcing, processing, and also delivery of second-hand products to buyers.

With the continued growth of the secondhand market, fed by heightened consumer interest in both sustainability and value, businesses operating in this sector confront some unique challenges not ordinarily seen in traditional retailing. The unpredictability of supply, the variabilities in product quality, and the complexity of managing logistics across diverse inventories add to how companies operate. Also, product authenticity and transparency, more so for high-value goods, make the management of secondhand supply chains even more complex. In addressing these issues, businesses have now started embracing new technological solutions and strategies that better their efficiency, customer trust, and sustainability in general. Results presented hereafter give insight into the challenges and technological advances that are changing SCM in this evolving sector

Figure 1 illustrates the primary challenges faced by businesses in managing the supply chain of secondhand markets. The chart highlights four key obstacles: unpredictable supply sources, quality assessment, product authenticity, and logistics complexity. The most significant challenge, as depicted in Figure 1, is unpredictable supply sources, which accounts for 30% of the total challenges. This unpredictability arises because secondhand markets are characterized by very irregular availability of products largely held dependent on the donations of consumers, returns, or unscheduled consignment sales. Unlike typical supply chains, where companies can predict demand and thereby control production level, secondhand markets run on an inconsistent flow of products. This inconsistency leaves companies having to adjust in relation to managing fluctuating levels of inventories and find ways to deal with the possible stock shortages or overflows. Consequently, it has become one of the biggest operational challenges to sustain a stable and predictable supply of used products.

Figure 1. Overcoming SCM Challenges in the Secondhand Market

The authenticity of the product stands as the second considerable problem, which comprises 25% of the total. It is common in the markets that deal with expensive or, say, branded items, such as luxury products and electronics. Since the businesses operating in the secondhand market do not have direct links with the manufacturers, most of them are not able to verify the authenticity of the products they deal in. When counterfeit items are inserted into the supply chain, this can lead to devastating reputational damage to a company and total loss in customer trust. Still, managing such a problem has made some businesses look towards blockchain technology-being an immutable record-for example, signifying that the origin and history of a product are traceable; however, large-scale deployment of such technologies is still in progress. Product authenticity is an area of concern that businesses will have to deal with in relation to the increasing market. Quality evaluation is another challenge, emerging at 25 percent of the total problems companies encounter. Since their products are quite old compared to, for instance, new goods, secondhand items differ significantly in respect to their condition and usage. Ensuring that such merchandise meets expected quality standards is essential for meeting the expectations of customers and minimizing return rates. Inspection and categorization of used items are time and resource intensive and expensive. Each item requires individualized handling, which increases operational complexity and impacts the overall efficiency of the supply chain. Addressing this challenge will require innovative solutions, such as the implementation of AI-powered quality assessment tools that can automate inspections and improve accuracy. Finally, logistics complexity accounts for 20% of the challenges. The logistics of managing secondhand goods are inherently more complicated than those of new products. Each commodity in a secondhand supply chain may have special needs for handling, storage, and transportation, adding layer upon layer of complexity into the logistics process. The secondhand markets are also decentralized, meaning goods can originate from many different places and must find their way to distributed customers-the whole process calls for advanced logistical planning that guarantees deliveries in time and at low cost.

Figure 2 shows implementation rates of the technological solutions used in SCM for the secondhand market. A bar chart is used to outline the three main technologies that businesses have adopted: blockchain for transparency, dynamic pricing, and AI for inventory management. Figure 2 presents the most implemented technology: blockchain for transparency, implemented by 40% of companies. Blockchain technology has turned into a very important tool for enterprises in the secondhand market, especially regarding the problem of authenticity. Blockchain can provide a decentralized and immutable ledger that will help to track the history and ownership of secondhand goods via business, making the entire supply chain transparent. This is quite beneficial for high-value products such as luxury goods and electronic items where there is need to authenticate a product. The adoption of the blockchain has been very instrumental in developing consumer trust and reducing the risks of a high counterfeit good risking the chain of supply.

The second most common technology, implemented by 35% of companies, is dynamic pricing. Dynamic pricing strategies enable companies to adjust prices in real time based on market demand, supply levels, and consumer behavior. In the context of the secondhand market, where product availability can be inconsistent, dynamic pricing helps businesses optimize their pricing strategies to remain competitive and maximize profitability. This technology is particularly useful in balancing stock levels, allowing companies to respond to changes in supply and demand efficiently. Lastly, AI for inventory management has been implemented by 25% of companies. AI-driven inventory management systems allow businesses to predict demand, manage stock levels, and optimize the sourcing process more effectively. For the secondhand market, where inventory is highly variable and unpredictable, AI can help streamline the process of matching supply with customer demand. By using AI algorithms to analyze past sales data and market trends, businesses can make more informed decisions about

sourcing and stocking, which improves overall efficiency and reduces waste.

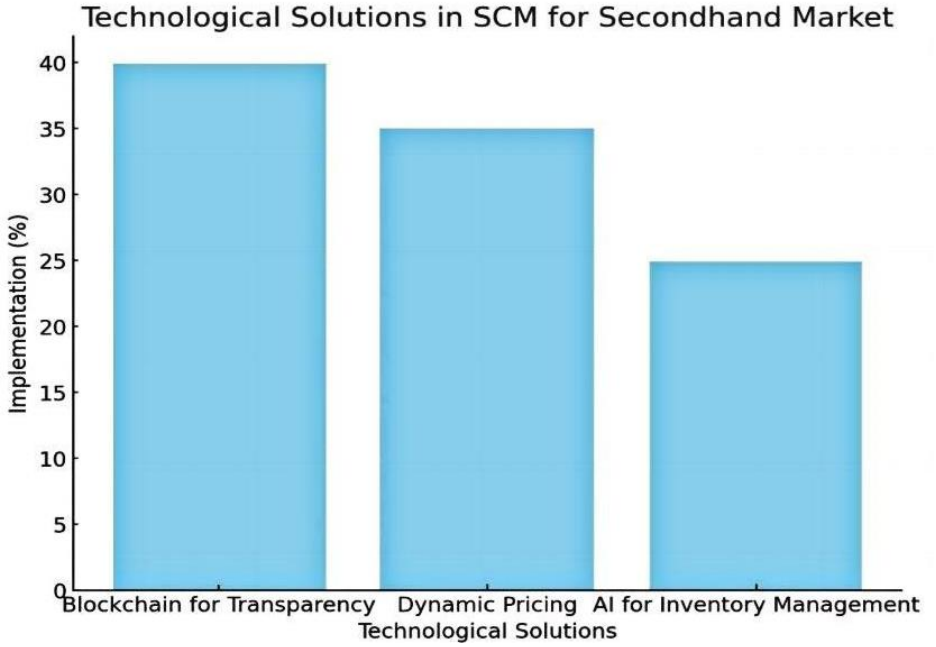

Figure 2. Technological Innovations in Secondhand Market Supply Chain Management

Table 4 illustrates the impact of various supply chain management (SCM) strategies on customer trust and satisfaction in the secondhand market, highlighting the effectiveness of Blockchain for Authenticity, AI for Logistics, and Sustainability Efforts. Each strategy shows a distinct influence on how customers perceive the reliability and overall experience of purchasing secondhand goods.

Table 4. Impact of SCM Strategies on Customer Trust and Satisfaction

SCM Strategies	Customer Trust (%)	Customer Satisfaction (%)
Blockchain for Authenticity	90	92
AI for Logistics	85	88
Sustainability Efforts	75	78

Among the strategies that have the highest influence on customer trust and satisfaction, Blockchain for Authenticity tops with 90% assurance in customer trust and 92% in customer satisfaction. This reveals the essence of transparency and authenticity verification, specifically in markets that deal with high-value items or branded ones. It will enable a business to trace the product through its whole life cycle, ensuring customers are able to trust in the authenticity of their purchase. By providing an immutable record of ownership and product history, blockchain has proven to be a powerful tool in enhancing customer confidence, which in turn leads to higher satisfaction.

Next come AI for Logistics, which establishes 85% customer trust and 88% customer satisfaction. This approach uses artificial intelligence in such a way that logistics are optimized to guarantee speedier and more reliable deliveries, efficient tracking of orders, and an overall good inventory management system. In the marketplace, where the availability of a product and timely delivery is important, AI plays a very vital role in improving the operational efficiency that leads directly to a better customer experience. With AI-driven systems, consumers appreciate the precision and speed that help meet the expectations that it should be available for purchase, or at least deliverable within a certain timeline threshold.

Lastly, Sustainability Efforts depict a relatively lower but still reasonable impact on customer perceptions, with 75% customer trust and 78% customer satisfaction. As more people

are formed around environmental sustainability, many consumers would go for businesses that incorporate eco-friendly practices into their operations. While this is not an instant way to influence customer perception, like blockchain or AI technologies, sustainability initiatives do really well with customers who consider ethical and eco-sensitive purchases. It encourages businesses to create a much better connection with the eco-conscious consumer by promoting recycling, reducing waste, and minimizing their carbon footprint, which is very valuable in terms of nurturing long-lasting loyalty and overall satisfaction.

The findings of this study underscore the significant role that advanced supply chain management (SCM) strategies play in enhancing customer trust and satisfaction within the secondhand market. Technologies like blockchain for authenticity and AI-driven logistics solutions have emerged as critical tools for overcoming the unique challenges posed by the secondhand sector, such as unpredictable supply sources and the need for product authenticity verification. When compared to existing research, our results align with the broader consensus that transparency and operational efficiency are crucial in maintaining a competitive edge. In particular, blockchain's ability to provide traceability and reduce counterfeit risks has proven to be instrumental in fostering consumer trust, especially for high-value goods like electronics and luxury items. Similarly, the use of AI to streamline logistics processes helps businesses meet delivery expectations and manage inventory more efficiently, resulting in higher customer satisfaction. Both technologies are transforming how secondhand businesses operate, enabling them to meet the growing demands of a market that values both reliability and convenience. In addition to technology-driven solutions, sustainability efforts also play a crucial role in shaping customer perceptions, albeit to a slightly lesser extent compared to blockchain and AI. The alignment of sustainability initiatives with the circular economy resonates well with environmentally conscious consumers, who are increasingly seeking eco-friendly alternatives to traditional retail. The integration of these sustainable practices contributes significantly to customer loyalty and satisfaction in the long term. Compared with other industry patterns, it can be seen well that while transparency and logistics optimization can benefit an operation immediately, sustainability is a key differentiator that could further enhance a company's brand and attract an increasingly green-conscious consumer segment. In general, successful businesses that synthesize these strategies will better position themselves to enhance their competitiveness and foster customer loyalty in the increasingly dynamic secondhand market.

Conclusion

This research has shed light on the evolving landscape of supply chain management (SCM) within the burgeoning secondhand market. The increasing consumer demand for sustainable, affordable, and unique products has propelled this sector into the spotlight. By leveraging technological advancements, such as blockchain and AI, businesses can significantly enhance transparency, traceability, and operational efficiency. These technologies enable the verification of product authenticity, streamline logistics processes, and optimize inventory management.

Furthermore, sustainability initiatives play a crucial role in building long-term customer loyalty and addressing environmental concerns. By integrating sustainable practices into every stage of the supply chain, businesses can align with the growing demand for eco-friendly products and contribute to a more circular economy.

To capitalize on these opportunities and overcome the challenges identified in this research, stakeholders in the secondhand market should prioritize the following: Technology adoption, sustainability integration, collaborative partnerships, and consumer education.

We need to invest in blockchain and AI solutions to improve supply chain visibility, reduce fraud, and optimize operations. We must incorporate sustainable practices into every stage of

the supply chain, from sourcing to end-of-life management. It takes into account fostering strong partnerships with suppliers, logistics providers, and technology companies to create a robust and efficient supply chain network. It's worthy to educate consumers about the benefits of secondhand shopping and the importance of ethical consumption.

Future research should delve deeper into the following areas:

- Consumer Behavior: Explore consumer preferences and motivations for purchasing secondhand goods to tailor SCM strategies accordingly.
- Emerging Technologies: Investigate the potential of emerging technologies, such as the Internet of Things (IoT) and augmented reality (AR), to further enhance supply chain operations.
- Cross-Border Trade: Analyze the challenges and opportunities of international trade in secondhand goods, including customs regulations, logistics, and cultural differences.
- Social Impact: Assess the social and economic impacts of the secondhand market, particularly in terms of job creation and poverty reduction.

By embracing these strategies and encouraging ongoing research, the secondhand market can thrive while contributing to a more sustainable and equitable future.

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