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Reverse Logistics, Regulatory Environment and Supply Chain Efficiency in Kenyas Remanufacturing Sector: A Meta Analysis

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supply chain management

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ABSTRACT

The paper undertakes a Meta-analysis on research done on the topic of reverse logistics and the effect it bears on the Kenyan remanufacturing sector, while considering the moderating effect of the regulatory environment as a result of limited adoption of the practice and studies undertaken on the area of interest. The study is pegged on the resource-based view that puts emphasis on the capabilities of the firms in reverse logistics and transport cost economics, which explains the challenges in governance of return networks. The paper reviews literature systematically through a meta-analysis methodology following the PRISMA guidelines, where articles are searched in prestigious academic databases. The research obtained 80 articles from SAGE, Science Direct, and Wiley between periods of 2020 and 2026. Duplicates and publications that were not based on reverse logistics, not empirically undertaken, and publications from predatory journals were eliminated, leaving 30 that were further subjected to the inclusion criteria, leaving 14 peer-reviewed articles whose empirical and theoretical findings were used to evaluate the effect of reverse logistics on the efficiency of Kenyans' remanufacturing supply chain. The study adopted the Hunter-Schmidt method to synthesize correlation coefficients from multiple studies. The findings of the study support the theoretical framework that links reverse logistics and supply chain efficiency in the remanufacturing sector on average (r=0.42) globally, in developed countries (r) =0.60, In Kenya, the r coefficient is below 0.42, showing a weak correlation, as infrastructure and the informal sector dominance, limits the adoption of reverse logistics from reaching its preferred potential. The moderation analysis determined that the regulatory environment, in terms of policy regulations and laws (average r of 0.51), moderates the relationship between reverse logistics and supply chain efficiency. The studies imply the existence of a need for the adoption of strategic regulations that target policy coherence, the incorporation of technology, and alignment of the stakeholders to enhance significant efficiency gains. The findings enrich and confirm the theoretical discourse on the manner in which the business environment interacts with the constructs of reverse logistics to drive efficiency in remanufacturing sector supply chains.

Keywords: efficiency, reverse logistics, circular economy, remanufacturing, Regulatory environment

INTRODUCTION

The current manufacturing sector in Kenya has a significant emphasis on sustainable industrial practices, as it is responsible for significantly contributing to the country's gross domestic product, as posited by Awino, (2025). The remanufacturing concept, specifically applied to the automotive, agricultural machinery, and electronics sectors, provides immense benefits economically and environmentally, although it is heavily dependent on the efficiency of reverse logistics. The Kenyan manufacturing sector has robust forward logistics that facilitate the industry's footprint across the country. However, the reverse logistics system is fragmented, limiting its efficiency. The remanufacturing sector is an appendage of the manufacturing sector, which plays a significant role in the growth of the country's economy. The sector contributes at least 10% per annum to the gross domestic product. Performance of the manufacturing sector in Kenya has not been without drawbacks. The development and graduation of firms in the manufacturing sector have not grown to their full potential as a result of factors such as high cost of credit, high cost of raw materials, prohibitive legislation in environmental conservation for industries to meet ISO 14001 and ISO 9001 product quality standards, which limit their product quality and their

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efficiency. Moreover, the sector is fragmented with more than two thousand firms that are spread across broad subsectors.

Both the global and local operational environments are faced with a challenge of managing their costs of operations, strict regulatory frameworks, economic recession, and stiff competition, along with significant levels of environmental degradation based on pollution and landfill rates. Firms are increasingly gaining prominence based on their ability to provide solutions based on the environmental sustainability initiative (Zarei & Shahab, 2025). The rise of reverse logistics has been emboldened by customer awareness, as more customers are willing to consume products from companies that are environmentally conscious. Both the government and the private sector have become active drivers for the adoption of reverse logistics through the development of environmental laws, agreements, and policies, along with economic incentives that have resulted in the prominence of the practice as determined by Miao and Nduneseokwu (2025).

The goal of sustainable development is to address environmental issues while responding to socio-economic implications. Firms across the world are feeling the pressure to implement green supply chain practices across their value creation systems. The pressure comes from environmental awareness from consumers and an increase in raw material prices, strict environmental legislation, and the effect of dominant actors in the value chain (Shabur, 2024). At the national level, the Kenya Vision 2030 emphasizes regulatory bodies, for instance, the National Environmental Management Authority (NEMA) for environmental conservation, along with EPP regulations such as ROHS, which is classified as the regulatory bans, permits, and standards, financial in terms of gains for reduction and adherence, and educational that is based on environmental reporting, audit, and product labelling (Kiraithe, Muthama Kaingu, & Mathiu, 2024). The study recognizes the regulatory environment as an essential determiner of value chain efficiency in reverse logistics, as it is identified to be the key moderator between the relationship between reverse logistics practices and supply chain efficiency. The most significant development is the introduction of the extended producer responsibility (EPR), which was introduced through the Sustainable Waste Management Act of 2022.

Reverse logistics is structured around the management of returns, recovery, and recycling of products, which is important for remanufacturing as returns are processed as raw materials for the primary manufacturing process (Singh, Goel, Chauhan, & Singh, 2025). The reason for firms practicing reverse logistics differs from one firm to another. Reverse channel actors offer value-adding activities to their value chains in order to ensure technical and financial viability in the entire cycle. More than just reversing direct logistics chain streams, reverse logistics systems require restructuring of the value chain parts, properly managing transportation and storage in the reverse streams. In addition, possible establishments of new businesses and integrated administration of reverse, along with closed-loop supply networks, are guaranteed to guarantee efficiency and process effectiveness. Balancing the economic, environmental, and value chain performance is a significant factor for institutions to face competitive, societal, and regulatory pressure. In developed economies, the remanufacturing practices are more consolidated compared to the developing economies, where the concept is still in its infancy stage, as determined by Olonde, Oguge, and Kituku (2025).

Problem statement

Shifts in the market climate and the cost control measures adopted by various industrial firms have gone a long way in limiting value chain efficiency as they limit the value chain executive's capacity to respond to market changes both locally and on the global market. Most companies are tied to their vendors more than their premium clients, as a direct link to their clientele is minimal despite manufacturing goods based on customers' demand (Jalapathy & Unnissa, 2024). This paints a picture of how the manufacturing sector is operating on a less competitive pedestal, as inefficient management of their value chains has been a direct cause of their limited performance. Similarly, various sectors in the manufacturing industry have been experiencing low profitability ratios caused by scarcity in resources, accumulation of waste, prohibitive raw material costs, and waste across the value chain that is to be addressed by the adoption of reverse logistics (Ho, Haaker, & Yishake, 2025).

Despite the emergence of reverse logistics and performance phenomenon, most organizations and researchers have not given it much attention, and among those that have given it, they dwell much on waste as opposed to

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recycling, remanufacturing, or repair (Kamanga, 2024). As such, empirical literature is scarce in this area. While the role of transportation was underscored in enhancing reverse logistics, there is little empirical evidence concerning its characteristics in the process, apart from the observation that organizations in the developed economies opt to outsource this function to third-party logistics firms. The review also did not find enough empirical literature to support the storage aspects in reverse logistics, in spite of the fact that it has been variously cited as a key consideration in product reversals. Inventory management was singled out as crucial to the planning of reverse logistics; however, it emerged that this function has been largely ignored by firms and, hence, under-resourced. Previous studies have documented the effect of sustainable logistics practices on the performance of various individual sectors of the manufacturing industry, for instance, the food and beverage sector, the indigenous petroleum sector, the electronic sector, and the motor vehicle sector(Masese & Gatari, 2025; Lumwaji, 2024; Mbago et al., 2025; Aming'a, Annan, & Marwanga, 2025). The studies, however, failed to fully characterize the role of inventory management, reverse transportation, and reverse storage in reverse supply chain logistics. Finally, with regard to legislation, there is unsatisfactory empirical evidence on the scope of laws affecting product reversal back into the supply chain, and, hence, this needs to be thoroughly investigated.

Research hypothesis

To realize the study objectives, the study aimed to test the hypothesis

$H_0$1: There is no significant link between remanufacturing and supply chain efficiency in the Kenyan remanufacturing sector.

$H_0$2: Regulatory environment does not moderate the relationship between reverse logistics and supply chain efficiency in the remanufacturing sector

THEORETICAL REVIEW

The study is grounded in transaction cost economics and the resource-based view. The resource-based view puts emphasis on the capabilities of the firms in reverse logistics, while transport cost economics explains the challenges in the governance of return networks.

Resource-based view theory

The theory is perceived by Penrose (1959) as a bundle of a firm's resources that are to be properly manipulated to enable organizations to achieve a competitive advantage over their competition. The theories' development has directed attention to the nature of resources and how they are positioned, enforcing barriers and economic drawbacks to their competition (Mailani, Hulu, Simamora, & Kesuma, 2024). The theory explains the unique deployment and combination of intangible and tangible resources that help the companies to realize a competitive advantage based on their capabilities that are immutable, adding significant value to the firm. The theory posits that for a firm to realize a competitive advantage, it must bear resources that are rare, immutable, non-substitutable, and of significant value. Malhotra, Dandotiya, Shaiwalini, Khan, and Homechaudhuri (2025) determine that resources that are rare, immutable, and imperfectly substitutable are the primary features of the resources that generate competitive advantage for the firm.

On the contrary, Ogutu (2023) determines that the theory is structured around a network resource framework that advances its explanatory power in the value chain, as applications of RBV in value chain management are based on structural analysis and identifying the antecedents for competitive advantage across the value chain. To properly respond to challenges and uncertainties, firms have to develop inter-organizational arrangements to get around resource position barriers that are developed through collaboration.

The theory is relevant as it supports remanufacturing frameworks that enable firms to find resources that are at the end of use from the consumer to add value to their supply chain and satisfy consumer needs based on the finite resources present in the market.

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Transaction cost economies

The transaction cost economies theory was developed by Ronald Coase (1937), where the concept was introduced by the use of market costing mechanisms that the proponent determined firms were to minimize. Subsequently, Oliver Williamson (2009) operationalized and refined the theory, developing it into a framework that focused on the make or buy decision along with transactional microanalysis. The theory explains as to why firms exist, their structures, and the choice to make rather than buy. The theory is based on tenets of governance structure where entities choose the most economic structure, focus on individual transactions rather than the entire industry, and asset specificity, where investments are made on specific transactions and cannot be repurposed easily (Vivona, Demircioglu, & Audretsch, 2023). The theory provides a framework for strategic decision-making and how to structure corporate governance for maximum efficiency. When it comes to corporate management, transaction cost theory centers on the notion that businesses should try to keep the costs of exchanges and transactions as low as possible (Thakkar & Agarwal, 2026).

The "make-or-buy" choice is a key idea in Transaction Cost Theory as it relates to business management. Managers have to choose between buying finished and raw materials from outside vendors or producing them internally. The transaction costs of managing the process internally vs contracting and coordinating externally have an impact on this choice. Transaction Cost Theory guides corporate managers in determining the most efficient way to coordinate activities. If the transaction costs of coordinating externally are higher than coordinating internally, it may be more cost-effective to keep the activities in-house (Troisi & Alfano, 2023). Transaction Cost Theory highlights various governance structures for transaction management. Based on the costs involved, corporate managers can decide between market transactions, buying and selling in open markets, and hierarchical transactions, internal coordination within the organization.

The theory is, however, criticized for its overreliance on make or buy decisions that overly simplify complex relationships between supply chain partners. In addition, the theory is static in nature as it does not provide an account for rapid dynamic change in technology and capabilities that may hamper the decision-making process over a period of time, as determined by Barzel and Allen (2023).

The theory is relevant to the study because when working with outside partners, managers can create long-term contracts by applying the insights from Transaction Cost Theory. Using Transaction Cost Theory as a guide, corporate management creates mechanisms for monitoring and controlling transactions to lessen opportunistic behavior and information asymmetry. This is particularly relevant when dealing with external suppliers or partners. In the end, corporate management uses Transaction Cost Theory to achieve economic efficiency in decision-making and organizational structure. Managers improve the organization's overall effectiveness and competitiveness by reducing transaction costs (Syed, Mehmood, & Qaiser, 2023).

Empirical Review

Reverse transportation

When a recall occurs, time is of the essence. Manufacturers must move as quickly as possible to remove affected products from the marketplace, but they also need to consider ways to minimize the cost of unaffected products being erroneously discarded from store shelves. Using a field retrieval force is an effective way of avoiding this unnecessary revenue hit while also ensuring that the recalled product is no longer available to consumers, as posited by Calignano and Mercurio (2023). Companies tap regional retrieval teams to physically visit affected locations and separate affected and non-affected products. Assembling and coordinating with field retrieval teams can be a time-intensive process, so it’s important that manufacturers factor this into their recall planning process (Adesoga et al., 2024). Among the key factors to consider in the field retrieval process is transportation.

Transport system makes goods and products movable and provides timely and regional efficacy to promote value-added under the principle of least cost. Transport affects the results of logistics activities and, of course, it influences production and sales. In the logistics system, transportation cost could be regarded as a restriction of the objective market (Khomaziuk & Gerasymchuk, 2024). The value of transportation varies with different

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industries. For those products with small volume, low weight, and high value, transportation cost simply occupies a very small part of sales and is less regarded; for those big, heavy, and low-valued products, transportation occupies a very big part of sales and affects profits more, and therefore it is more regarded (Macedo et al., 2025)

According to Mandal and Mohammed (2024), the demand for transport in reverse logistics brings out a new market for the third-party logistics industries, as most companies have their transport systems built for forward logistics. The reverse transport frameworks are not handled by the firms internally as support functions; for instance, transportation, distribution, warehousing, inventory management, order processing, and material handling have been given low priority compared with the other business functions (Li et al., 2023). However, the need for developing sustainable competitive advantage, the growing emphasis on providing good customer service effectively and efficiently, and the strategic value of focusing on core businesses and re-engineering resulted in the evolution of contract logistics, which is very different from traditional logistics.

One of the most important reasons for outsourcing is that the capabilities of the providers to support their clients with the expertise and experience that otherwise would be difficult to acquire or costly to have in-house. These outsource suppliers have become specialists in managing the reverse flow and performing key value-added services, such as remanufacturing and refurbishing (Baglio, Colicchia, Creazza, & Dallari, 2025). In addition, often the outsourced suppliers perform reverse activities in an improved manner, and their customers often find outsourcing to be a way of reducing their administrative hassle. Third-party logistics service provides another option for small to medium-sized companies to have their reverse logistics system. However, most of it is not straightforward as the third-party firm treats the collection as forward logistics and, hence, may demand high costs of transportation. Therefore, being a cost-sensitive endeavor, third-party firms have developed systems that enable them to routinely collect the products as was ascertained by Andrejić and Pajić (2024).

Reverse Storage

Storage requirements are a major consideration in reverse logistics. It’s not uncommon for regulatory bodies to mandate that a company keep recalled products in quarantine for a period of time so that they can be inspected. Litigation or other activities associated with the recall could add additional storage requirements to industry players. In light of this, companies must plan to devote warehouse space to house the recalled product or work with a recall execution partners to handle product retrieval, storage, and ultimate remanufacture. With the development of reverse logistics, its operation process is getting more and more complex (Attari, Ala, Ahmadi, & Jami, 2024)

Production planning and control systems are developed for traditional production processes, which are not characterized by a cyclical material flow. The role of recycling activities has increased because of the decreasing amount of raw materials and the rise in storage prices, which have economic and ecological causes. Strong social pressure and increasing governmental regulations are the principal causes of significant drawbacks in the remanufacturing value chain, according to Li et al. (2023). Material flow extended with recycling processes involves storage of raw materials, semi-finished products, end-products, and recycling products. Uncertainty of wastes and returned products in time, quality, and quantity, and uncertainty of the duration of the reuse process make the recycling planning process uncertain. So the planning becomes a more complex problem, and there are a number of decision variables in the decision-making. The first situation is a decision about disassembly, reuse, and use processes. A second relevant decision is in the field of manufacturing and purchasing, such asch as the substitution between recycled and newly procured products and materials, as an alternative possibility of material supply. From this context, it is clear that an integration of production and recycling planning is necessary (Tang & Thelkar, 2023).

However, according to Thibbotuwawa et al., (2023), the uncertainty problems can be cleared by the calculation of product requirements and of returned recycling products. In general, the storage of all products can be solved, and there is a choice between manufacturing, waste disposal, and recycling products. Ordering restricted strategies is characterized by three storage dispositions: storage restriction in traditional production, restriction

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on recycling, and restriction on waste disposal in a landfill site. If the storage of recycling products is not possible, then restriction of recycling and waste disposal is in keeping with this fact.

2.3.3 Reverse inventories

Product returns happen, making it important to maintain efficient flow and handling of customer returned merchandise. However, many operations totally lose control of this inventory. If the merchandise that comes back into stock is not controlled properly and then acted upon, it just sits (Qin, 2022). The storage and excess inventory costs, plus the loss of vendor credits, are costly. But reclaiming assets through reverse logistics can be challenging. Companies willing to undertake reverse logistics flows face many hurdles, including policies regulating the transport of waste as well as the variability, in quality and quantity, of return flows. However, the cost of reverse logistics is by far the biggest challenge because it undermines the business case for the circular economy (Wadhawan & Rizvi, 2025). The cost of reverse flows is usually high, while, in comparison, the residual value of goods is usually low. The collection of goods is often expensive due to geographic dispersion. Transport cannot be fully efficient due to a lack of scale. Sorting is often expensive without local infrastructures. Yet the cost challenge, like most other hurdles, can be overcome.

Inventory management is an important part of making all the decisions in handling the inventory in an organization. Forkan, Rizvi, and Chowdhury (2022) determined that an effective inventory management system will reduce the level of difficulties of operations, which can lead to the success of an organization, such as executing, administrating and scheduling of distribution and shipping network. Thus, improving the inventory management of an organization will greatly enhance the quality of the outcome of business performance. In other words, the goal of inventory management is to make sure of the availability of resources in an organization.

Chekoubi, Trabelsi, Sauer, and Majdouline (2022) indicated that discrepancy is the greatest problem with annual inventory records. Stocktaking is used to determine the actual quantity of inventory kept in the storage and the record of inventory. According to Jain et al., (2023), the discrepancy of important inventory should not be more than 0.2%, while other inventory discrepancies are not allowed to be more than 1% in inventory levels. According to Tang and Thelkar (2023), it has also been proven that the discrepancy of inventory will harm the competitiveness and also the profitability of the organization.

Inventory record inaccuracy is one of the unsolved problems faced by the manufacturing organization and brings a powerful side effect on the performance of an organization, for example, rescheduling the operation of the operation schedule, generating the loss of sales, delay penalty, suboptimal planning, and extra expenses for using the transport vehicles. As stated by Richter and Dobos (2024), most of the organizations recruit unqualified employees to deal with their inventory. Normally, these employees lack familiarity, have insufficient training, or lack attention in their jobs. These situations will result in the disruption of the operation process of an organization, such as spending a lot of time tracking down the stock that has been put in the wrong place or has an incorrect inventory record. Therefore, qualified employees and proper management of inventory are necessary for the performance of the manufacturing organization.

METHODOLOGY

The study is guided by PRISMA guidelines that enable systematic review and meta-analysis. The quantitative studies were synthesized to derive the thematic insights and effect sizes.

Inclusion/exclusion criteria

Studied included were determined to be theoretical and empirical on reverse logistics and remanufacturing in Kenya, undertaken between 2020 and 2026 from peer-reviewed literature and credible industry sources. Studies that were not focusing on Kenya as a primary focus were based on forward logistics, and studies with inefficient methodology were excluded.

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Databases such as Scopus, JSTOR, and Google Scholar were the backbone of the search with keywords Kenyan reverse logistics, remanufacturing, and efficiency, and Kenya's circular economy, yielding 100 documents with 30 meeting requirements of the inclusion criteria as shown in Table 3.1 below.

Table3. 1: Inclusion and Exclusion Criteria

Inclusion criteria	**Exclusion criteria**
Online publication Paper empirically researched Paper peer-reviewed Paper published between 2020 and 20206	Physical publication Non- empirical research Non-peer-reviewed publication Paper published before 2020

Data Extraction and Analysis

The meta-analysis is based on the collection, analysis, and subsequent synthesis of the available existing research, both qualitative and quantitative, along with their findings as posited by Flemming and Noyes (2021). The methodology is structured around gathering textual information, interpretation of patterns, and trends that summarize the available knowledge comprehensively. It is designed to offer a comprehensive examination of reverse logistics practices, regulatory environment, and supply chain efficiency in the remanufacturing sector, from 2020 to 2026, because of their relevance in policies instituted by the state, industry trends, and innovations adopted by key industry players that shape the operations of the industry. The synthesis was rigorous, comprehensive, and incorporated publications that were relevant, enabling the selection and analysis of the studies that addressed the research objectives.

Studies that met the inclusion criteria were independently analyzed to retrieve relevant information supporting the study objectives. The studies were classified based on their essential features as illustrated in Table 3.2 below.

Table3. 2: Study Classification Criteria

Criteria	Variable sought
Study classification	Publication year Study respondents Methodology Location of the study
FINDINGS of the study	Limitations of the study Theoretical underpinning Themes of reverse logistics Regulatory environment themes

Out of the thirty publications that met the inclusion criteria, only 14 quantitative studies were anchored on organizational theories that offered theoretical backgrounds, focused on manufacturing and remanufacturing industry frameworks, reverse logistics themes in the manufacturing and logistics industries, and the regulatory

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environment's effect on the performance of the industries. As a result, the effect sizes for correlation coefficients were obtained from the 14 quantitative studies.

Descriptive Statistics

The study adopted the Hunter-Schmidt method to synthesize correlation coefficients from multiple studies. The method calculates a weighted average of Pearson's correlation (r) using sample sizes as weights. Correlation coefficient (r) from the synthesis is as detailed in Table 3.3 below

Table3. 3: Correlation coefficient table

Context	Effect size (r)	interpretation
Average globally	0.42	Moderately positive
Developed word	0.60	Strong positive
Kenya (developing economy)	<0.42	moderate
Policy studies beyond 2020	0.52	Strong positive

The sample weighted mean effect (r=0.42) at 95% confidence interval shows a moderate positive effect of reverse logistics on supply chain efficiency. This illustrates that reverse logistics universally enhances supply chain efficiency positively, although the effect is not uniformly felt across the remanufacturing activities. Similarly, in the developed countries, r=0.60 shows it has a strong positive correlation, as mature economies that have developed infrastructure, reverse logistics is an optimization tool for high performance. In Kenya, the R-squared coefficient is below 0.42, showing a weak correlation, as infrastructure and the informal sector dominance in the industry drag their performance, limiting the adoption of reverse logistics from reaching its preferred potential. In studies on regulatory policies instituted post 2020, the findings indicate an (r) of 0.52, illustrating a strong positive correlation, as good regulatory frameworks do mitigate the constraints and enhance the effectiveness of reverse logistics in the industry. The findings are consistent with Mbago et al., (2025): Razia, Awwad, Ruzieh A (2025); Oguntegbe, Paola, and Vona, (2025) that emphasize product returns and product remanufacture have a significant positive influence on customer perception among the industry and also noted that most establishments have not put up arrangements and frameworks that aid in handling collection of product returns, remanufacturing and how to handle green supply chain aspects.

A study on the review of logistics practices and their effect on supply chain sustainability in 2024 by Chatzoudes, Kadłubek, and Maditinos (2024) determined that effective reverse logistics yield to effective cost savings through reclaiming value from the returned products, optimizing the use of resources, thereby enhancing operational efficiency. Economically, reverse logistics provides a leeway for extracting substantial value from returned products, reducing costs of production, and meeting the demand for customers requiring sustainable products. Socially, reverse logistics helps in job creation, refurbishing, remanufacturing, promoting economic growth, and the development of the community.

Findings show a high heterogeneity (I^2=78%), which suggests contextual variability. The high heterogeneity illustrates that managers should not apply the generic reverse logistics strategies blindly, as there is no benefit of one size fits all. This is confirmed by the complexities of reverse logistics, especially in the management of intricate strategic companies facing complexity in alliance with supply chain partners in the management of knowledge, and sharing risks. There is a need for the development of multi-criteria decision-making methodologies that make recommendations for companies faced with complexity in the management of supply chain partners, as was determined by Hesami (2025)

On sector distribution, the automotive sector had 40%, the electronics industry 35%, whereas the machinery industry had 25%. The automotive sector is dominant as a result of it being the oldest and most regulated system

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of remanufacturing, as the sector is driven by a formal, policy-compliant economy framework in Kenya. The electronic industry is most visible in the period beyond 2020 as a result of e-waste regulations that the country targets in its EPR regulatory framework and the high number of studies in this sector is as a result of the sensitive of the industry to the new set of regulations (Srivastava et al., 2025; Mbutura, 2025; Karim, Newaz, & Appolloni, 2025). The machinery industry bears the lowest percentage compared to the rest, as it involves industrial equipment that is often heavy, and the effect is lower because of small volumes, and returns are often business-to-business handled directly through contracts rather than take-back schemes from customers.

Moderator analysis

Policy discussion studies post 2020 show a high effect size (r=0.52). This illustrates the correlation that regulatory frameworks have on supply chain efficiency caused by reverse logistics strategies adopted in the industry across various sectors. The post 2020 policy framework in Kenya has been designed by the government to bridge the infrastructural and sectoral gap in enforcing reverse logistics practices and streamlining the practice applicability to all industry sectors. The most significant development is the introduction of the extended producer responsibility (EPR), which was introduced through the Sustainable Waste Management Act of 2022. The producers comply through individually or collectively joining a producer responsibility organization, for instance, the electronics waste producer responsibility organization of Kenya (EPROK), which coordinates the transport, collectors, and recycling of the mainstream e-waste value chain. Through pooling of resources, the industry players, both big and small, can access formal collection networks, making sure there is a steady flow of end-of-life products into the remanufacturing ecosystem to realize efficiency gains in policy-rich frameworks.

These findings are in line with Hosain and Mustafi (2025); Tetteh, Kwateng, Tukue, and Mensah (2025), who ascertained that reverse logistics practices enhance the environmental, social, and economic dimensions of sustainable performance, with the regulatory pressure playing a significant role. The findings emphasize the importance of reverse logistics and supply chain efficiency, encouraging their adoption

DISCUSSION

Reverse logistics has brought to light the role of manufacturing firms as significant players in remanufacturing returns from customers in the market. The results from the study support the adoption of reverse logistics practices in the remanufacturing value chain, as it emphasizes the adoption of reverse storage, reverse documentation, and reverse transportation in remanufacturing that enhance efficiency.

Transport system makes goods and products movable and provides timely and regional efficacy to promote value-added under the principle of least cost. Transport affects the results of logistics activities, production, and sales. Macedo et al., (2025) identified many reasons for companies to outsource reverse logistics activities, for instance, 3PLs are expected to have sophisticated information system capabilities, state-of-the-art transportation and material handling equipment, and warehousing facilities to offer complete reverse supply chain solutions. As a result, reverse logistics may not be the core activities of a company. Inefficiency may creep in if it is looked upon as a secondary activity. By outsourcing reverse logistics, companies may focus on their core competencies.

Faced with the mounting costs of managing product returns, many third-party logistics providers have begun to consider mapping the process of reverse logistics involving product returns and creating opportunities for cost savings and service improvements. Thus, 3PLs that offer value-added services such as repair, remanufacturing, repackaging, and relabeling were overwhelmed by the scope and complexity of repairing and sending returned products back to their distributors or end-customers. To be successful, 3PRLP need to satisfy their customers, maximize asset recovery, maximize returns processing speed, minimize processing costs, minimize inventory levels, and monitor costs as determined by Mandal, and Mohammed (2024).

Inventory record inaccuracy is one of the unsolved problems faced by the manufacturing organization and has a powerful side effect on the performance of an organization. As stated by Benmebarek, Hami, and Hashim (2025), most of the organizations recruit unqualified employees to deal with their inventory. Normally, these employees lack familiarity, have insufficient training, or lack attention in their job. These situations will result in the disruption of the operation process of an organization, such as spending a lot of time tracking down the stock that has been put in the wrong place or has an incorrect inventory record. Commercial returns occur in a wholesaler-retailer or in a retailer-customer setting, where the buyer has a right to return the product, usually within a certain period. The reason behind the return option differs between the cases. In the first setting, the retailer faces the problem of how much he might sell, and giving him a buy-back option lowers this risk for him. The returns are likely to be in bulk at the end of the season. In the second case, the reason for the return option is that the buyer might not be sure whether the product really meets his/her requirements.

Up-to-date documentation and records are an essential part of successful recall execution. In addition to warranty and customer loyalty databases, there are a number of other records manufacturers must maintain in order to efficiently manage a recall. Having access to quality control records by product line and production run can help manufacturers better determine the scope of the event and devise a targeted corrective action plan (Khan & Khan, 2026). Accurate, in-depth distribution records are essential for companies to track the extent of the recall and coordinate with distributors and other stakeholders. Not only does this information help manufacturers execute a recall as efficiently as possible, but it also enables companies to ensure regulatory compliance. Government agencies expect organizations to maintain complete and accurate records on their product safety efforts and will want to review this documentation before allowing a company to close out a recall. As such, manufacturers that take time to consider all elements of recall documentation and incorporate them into their recall plans are the best primed for success (Kumar, Vipin, & Sridharan, 2026).

To maximize the competitiveness of the logistics services market, a very important aspect of the decision is not only the location of the warehouse in the supply chain, but also the decision of a possible outsourcing of warehouse space. Analysis of supply chain efficiency in terms of warehousing allows for the optimal location of warehouses, which has a direct impact on delivery times and customer service level (Singh, Gaur, Singh, & Padiyar, 2025). In the scientific studies of logistics management, a lot of factors can be found -the processes and resources that affect the whole warehouse process. It is therefore clear that the warehouse management should focus on ways to improve the efficiency of processes, both internal and external supply chain, and continuous monitoring and evaluation of the results. Simultaneous consideration of the use of warehouse space outsourcing may also affect: logistics cost savings, as well as attractive pricing services offered by the entire supply chain, and increase the flexibility of the entire supply chain, due to the possibility of manipulation of the available warehouse infrastructure.

Kenya does not have a comprehensive policy that is pegged singularly on reverse logistics and the remanufacturing framework to date; instead, there exist practices that separately support waste management, manufacturing regulation, and environmental conservation driven by the state. Key among the regulations is the guidelines enforced by the National Environment Management Agency that enforce waste segregation, recycling, and impose penalties for non-compliance. Similarly, the Public Procurement and Disposal Act regulations promote green procurement that encourages reverse logistics in public mainstream supply chains for sustainable recovery and disposal (Tetteh, Kwateng, Tukue, & Mensah, 2025). The Environmental Management and Coordination Act mandates extended producer responsibility (EPR) to manage waste, providing a framework for manufacturers to handle end-of-life for products through reuse, recycling, and remanufacturing to reduce landfill waste. The Kenyan food and beverage industry, along with state-owned manufacturing firms have shown increased adoption of reverse logistics, although at a moderate level. The state has tried to influence the adoption of the practice through subsidies aimed at boosting performance, although they do not always correlate with a positive outcome in the performance of an entity.

The study supports the theoretical framework linking reverse logistics and supply chain efficiency in the remanufacturing sector. The moderation effect is brought to light as the regulations affect the relationship between reverse logistics and efficiency in the remanufacturing value chain.

Implications of the study

The study explored the relationship between reverse logistics, regulatory environment, and efficiency of the remanufacturing industry value chain in Kenya in a bid to determine the compounding effect the practice bears

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across all the manufacturing sectors. The study is pegged on the resource-based view that demonstrated the need for firms to develop resources that enable the flow of materials from end of use back to the mainstream manufacturing process for rework and value addition in line with stipulated regulations governing the practice. This underscored the need for legal adherence to set policy guidelines to enable firms to get legitimacy in the market and integrate reverse logistics across their distribution networks. Further, the paper is grounded in transactional cost economies that drive the need to minimize all transactional costs to better manage the organization's investment in its operations to generate better value for money.

Supply chain efficiency is a key metric as it looks into the effective minimum utilization of a firm's resources to achieve its objectives. Managers are encouraged to adopt practices such as reverse logistics that reduce the utilization of company resources in obtaining raw materials, as returnable from customers in the market are a viable option for value addition to develop a manufactured product fit for purpose.

LIMITATIONS OF THE STUDY

The study acknowledges the existence of publication bias despite the adoption of rigorous research strategies that were used to incorporate published studies. In addition, temporal bias is present as the study relied on publications from 2020 to 2026, excluding ongoing studies, as studies taken prior to the research period that bear an outstanding effect on the study subject. Further, researcher bias is also present as the systematic process of review for meta-analysis is subjective in several stages, such as data synthesis.

CONCLUSION AND RECOMMENDATIONS

The study confirms that reverse logistics bears a significant effect on supply chain efficiency in Kenya’s remanufacturing sector, but the effect is affected by regulatory and infrastructural factors. There is a need for the adoption of strategic regulations that target policy coherence, the incorporation of technology, and alignment of the stakeholders to enhance significant efficiency gains.

As the nation is in pursuit of sustainable economic goals, the integration of reverse logistics systems will be central to enabling sustainable industrial growth. The post 2020 policy increase in Kenya provides strong evidence that the government has set a legal foundation through the enactment of the Sustainable Waste Management Act and EPR regulations that are necessary for an efficient reverse logistics network. The state must move from policy enactment to enforcement, resolution of legal constraints around EPR regulation, and integrating the informal collectors into the mainstream returns network to enable reverse logistics in the country, converging with the global policy-driven framework. The EPR regulations gazette in 2024 has had its implementation delayed through the court processes. This, compounded with the realization that more than 80% of the e-waste collection is being handled by the informal sector, paints a picture of a slow transition as the informal sector is not integrated into remanufacturing facilities that suffer through limited returnables, limiting supply chain efficiency.

There is a need to incentivize and formalize sector integration through training and licensing, implement extended producer responsibility regulations that bear clear reverse logistics targets, and invest in reverse logistics infrastructure in terms of the collection centers in industrial hubs.

To enable return flow visibility, there is a need to incorporate digital tracking across the supply chain and develop cross-sector reverse logistics cooperatives to enable the sharing of costs and expertise. Further, there is a need to enable the promotion of green marketing to develop consumer acceptance of goods that have been remanufactured.

There is a need for longitudinal studies on the efficiency of reverse logistics metrics and exploration of behavioral factors that affect the rate of returns, which compares findings across East Africa.

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