

THE IMPACT OF TECHNOLOGY ON REVERSE LOGISTICS: A CASE STUDY OF AFRICA GLOBAL LOGISTICS

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M22B12/042

**A DISSERTATION SUBMITTED TO THE SCHOOL OF BUSINESS IN PARTIAL FULFILMENT
OF THE REQUIREMENTS FOR THE AWARD OF THE DEGREE OF BACHELOR OF
PROCUREMENT AND LOGISTICS MANAGEMENT OF UGANDA CHRISTIAN UNIVERSITY**

May, 2025



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DECLARATION

I, ATUHAIRE MIHAYO CATHERINE, confirm that this dissertation is solely my original work and has not been submitted before for academic credit or recognition at any institution.

Signature: 

ATUHAIRE MIHAYO CATHERINE

Date: 19/05/2025

APPROVAL

This is to authenticate that the research work prepared by ATUHAIRE MIHAYO CATHERINE was prepared under my guidance. I therefore recommend its submission for assessment as part of the University requirements.

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Date: 19/5/2025

DEDICATION

I am greatly indebted to my loving parents Dr. Mihayo Placid and Mrs Mihayo Agnes, whose altruistic love and boundless encouragement have been a pillar that has held me on course throughout my life of studies. I could not have succeeded in this achievement without their support, patience, and faith in me. Having accomplished this dissertation, I do so with extreme appreciation for all they have done.

ACKNOWLEDGEMENT

I am forever grateful to the Omnipotent for the precious blessings of life, wisdom, and good sense. These blessings have helped me pass through several pivotal turning points in my life. I also want to offer deepest gratitude to my family members, who, though poor, have always stood by me in thick and thin with pure devotion, unconditional love, and sincere concern. I would especially like to thank my remarkable parents, Dr. Mihayo Placid and Mrs Mihayo Agnes, for their kindness, counsel, and unwavering commitment to my well-being.

I would also want to express very sincere appreciation to my research supervisor, Mr. Muloosi Siibi Pascal. His constant encouragement, support, and very sage advice have played a very crucial role in guiding both my research and academic pursuits. Mr. Pascal has been not only a supervisor but a mentor whose zeal and expertise were an inspiration source that pushed me to perform at my best. I am very blessed indeed to have had the privilege of being under his mentorship.

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ABSTRACT

This study aimed to investigate the impact of technology on reverse logistics, in the case of African Global Logistics (AGL) in Uganda. Study aims were to examine organizational and infrastructural readiness to reverse logistics technology adoption, to analyze the effect of perceived ease of use and usefulness of technology in initiating its acceptance and integration into reverse logistics processes and to assess the extent to which technological capability affects successful adoption of reverse logistics practice. Using the Technology Acceptance Model (TAM), it examines the impact of ease of use and perceived usefulness on technology reverse logistics adoption. The study conceptual framework identified system integration, automation, and digital tracking as key technology drivers with outputs of operational efficiency, cost saving, and waste disposal.

Government policies and business support are intervening variables that shape technology adoption. A descriptive research design quantitative study was used and research conducted using structured questionnaires distributed to 44 employees from a population of 49 as per Krejcie and Morgan's (1970) sample table. The sample included staff from key departments like logistics, IT, legal, and management, while random and censured sampling techniques ensured representative data gathering. Data were processed with SPSS software, conducting regression and correlation analysis to compare the relationship among variables like degree of automation, digital surveillance, and working effectiveness. The consistency of data was confirmed by Cronbach's alpha (0.890), with validity ensured through expert-reviewed questionnaires and the Coefficient of Variation (CV) method. The study also found that digital monitoring and tracking technologies are significantly embedded in reverse logistics operations, with employees having high levels of competence in using the same. Organizations also monitor products coming back to them efficiently and have effortless data sharing with partners, which further supports how critical digital solutions are in enhancing visibility and efficiency.

As regards automation, the study indicates that automated systems significantly improve reverse logistics operations, particularly decision-making, product recall, and recycling management. However, although mistakes in returns handling are reduced via automation, potential exists to eliminate system disruption when combining technology. Overall, system compatibility and data-sharing capabilities are strong, but technical problems must be resolved by organizations for easier utilization of future logistic technology.

LIST OF ABBREVIATIONS

AGL – Africa Global Logistics

AI – Artificial Intelligence

CV – Coefficient of Variation

GPS – Global Positioning System

IT – Information Technology

RFID – Radio-Frequency Identification

SMEs – Small and Medium-sized Enterprises

SPSS – Statistical Package for the Social Sciences

STISA-2024 – Science, Technology, and Innovation Strategy for Africa 2024

TAM – Technology Acceptance Model

SD – Standard Deviation

SMEs – Small and Medium Enterprises

KPI – Key Performance Indicator

LMS – Logistics Management System

ERP – Enterprise Resource Planning

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CHAPTER ONE: INTRODUCTION

1.0 Introduction

This chapter will present the background and problem statement of the study, the objectives of the study, study questions, and the justification of the study. The conceptual framework will also be elaborated upon in this chapter.

1.1 Background of the study

Technology implementation in reverse logistics has played a major role in ensuring supply chain sustainability and efficiency worldwide. Online platforms that allow monitoring and tracking have significantly enhanced the ability of firms to monitor products, reduce losses, and streamline the recovery process (Kumar & Choudhary, 2023). The platforms offer end-to-end visibility across the supply chain and allow easier rerouting of defective, outdated, or unsold products for refurbishment, resale, or recycling in a coordinated process. This is particularly crucial in electronics firms, whereby companies need to comply with strict e-waste regulations (Singh et al., 2022).

Big international companies have implemented autonomous sorting technologies to sort returned items by evaluating their condition, usability, and quality—something that helps decrease costs as well as push sustainability goals forward (Zhu et al., 2021). In the apparel industry, companies such as H&M and Zara utilize automated storage systems to manage fashion returns efficiently, reducing labor needs as well as speeding up reinsertion of items back into circulation (Bhatnagar et al., 2020). The use of robotics and artificial intelligence here also enhances efficiency in operations and sustainability.

In Africa overall, the use of such technology to reverse logistics has transformed supply chain management in efficacy and environmental stewardship. The African Union's Science, Technology, and Innovation Strategy for Africa 2024 (STISA-2024) elaborates on how technology has necessitated the revolution of different sectors, including logistics, in a bid to achieve socio-economic development (African Union, 2020). Due to this strategic focus, the uptake of technological innovations that help enhance logistics performance, especially reverse logistics, has been achieved.

In consumer-to-business e-commerce, companies such as Jumia have expanded into logistics companies, uniting technology to optimize forward and reverse logistics operations. Jumia's network of warehouse and pick-up points was instrumental in enabling easy returns of products, a primary function of reverse logistics (Jumia, 2024). Technology not only

enhanced customer satisfaction but enhanced reverse product movements, lowering costs while optimizing operating efficiency.

Technology Acceptance Model (TAM) of Davis (1989) describes a simple model of technology user acceptance and usage. As per this theory, technology acceptance and adoption for use in business processes are prompted by perceived ease of use and perceived usefulness of technology (Davis, 1989). With reverse logistics, TAM makes us aware of the way African logistics companies embrace digital supervision, automation, and system combinations for improving returns management and minimizing waste. Whether logisticians find technologies like these helpful and introduce efficiency into operations, there are possibilities they would embrace them in reverse logistics operations (Venkatesh & Bala, 2008).

The TAM theory is applied in this study to demand efficiency and technological preparedness in reverse logistics. Firms' intention to use technology is explained by TAM in terms of perceived usefulness (Wernerfelt, 1984; Davis, 1989). In African markets where logistics challenges such as infrastructure still exist, the theories help in framing the explanation of how digital platforms can be leveraged by firms to enhance efficiency in reverse logistics (Munyua, 2021).

Technological application in reverse logistics in East Africa has realized tremendous customer satisfaction and responsiveness in the supply chain. For example, organizations such as Kobo360 have expanded their operations to East African nations such as Kenya and Tanzania, utilizing digital platforms linking truck owners and cargo owners. The subsequent effect of this technological application has also streamlined logistics, cut down on tardiness in deliveries, and improved the coordination of back-end operations, thus making reverse logistics more seamless (Kobo360, 2023).

Following this, the present study aims to fill this gap by taking into consideration the example of African Logistics Limited, a well-established logistics company in Uganda's logistics sector. African Logistics Limited has interests in various sectors dealing with transport, warehousing, and reverse logistics services. The company can be a compelling case study through which technology-enabled reverse logistics procedures can be understood within local SMEs.

1.2 Statement of the problem

The conventional supply chains have for a long time concentrated on moving things forward—buying, making, distributing, and selling without regard to the reverse flow of products (Mugisha, 2018). Uganda is not highly developed in terms of reverse logistics with inefficiencies like lack of coordination, no tracking systems for returns, and delayed processing of wastes. As per Ahimbisibwe et al. (2016), most companies continue to use conventional manual processes that lead to perpetual delays, errors, and inefficient recovery of assets in reverse logistics processes.

Whereas global trends have it that such technological innovations as automation, AI, and digital tracing have revolutionized reverse logistics with enhanced speed, accuracy, and sustainability, Uganda is behind in this revolution. The majority of SMEs still conduct business with little application of technology, which hinders their capacity to manage returned products as well as environmental wastes efficiently (Ahimbisibwe et al., 2016). This delay in technology poses a significant bottleneck to conducting reverse logistics in Uganda.

Available data from Ortega Group (2024) show that companies that apply technologies such as automatic sorting machines, electronic stock checking, and reverse vending machines substantially decrease handling time and enhance the efficiency of operations. There is, nevertheless, limited empirical information regarding how it is suitable to incorporate such technologies in reverse logistics systems in the Ugandan context, particularly in local businesses such as African Logistics Limited.

Hence, there exists an evident knowledge gap concerning the contribution and influence of contemporary technologies in influencing the evolution of reverse logistics in Uganda. The research aims to fill this gap by discovering how African Logistics Limited can embrace and utilize technology innovations for making its reverse logistics activities efficient.

1.3 Main objective

The main purpose of this study is to investigate the impact of technology on reverse logistics with a case study of Africa Global Logistics.

1.4 Specific Objective

- i. To evaluate the organizational and infrastructural readiness to adoption of reverse logistics technologies.

- ii. To analyze how the perceived usefulness and ease of use of technology influence its acceptance and integration in reverse logistics processes.
- iii. To assess the extent to which technological capabilities contribute to the effective adoption of reverse logistics practices.

1.5 Research questions

- i. How does the organizational and infrastructural readiness adoption influence reverse logistics technologies?
- ii. How does perceived usefulness and ease of use of technology influence its acceptance and integration in reverse logistics processes?
- iii. To what extent do technological capabilities contribute to the effective adoption of reverse logistics practices?

1.6 Scope of the Study

1.6.1 Content Scope

This research explored how technological advancements influence reverse logistics, with particular attention to digital tracking, automation, and system integration. The primary goal is to boost efficiency, promote responsible waste management, and strengthen supply chain operations. The investigation will take place at African Global Logistics Uganda.

1.6.2 Time Scope

The study was scheduled to span two months, a timeframe considered adequate for an in-depth and concentrated investigation into the role of technology in reverse logistics. Due to the targeted scope and manageable size of the case study, this period is expected to be sufficient for gathering, analyzing, and interpreting data. Additionally, the concise duration helps maintain a clear focus and allows for timely application of findings to support ongoing developments in Uganda's logistics and supply chain sectors.

1.6.3 Geographical scope

The geographical scope of the study was focused on Uganda, with specific reference to Africa Global Logistics (AGL) as the case study. African Global Logistics is located on Plot M611, Ntinda Rd, Kampala Uganda.

1.7 Significance of the study

The research would find application in the case of Ugandan policymakers, guiding regulation and policy to enhance sustainability in the supply chain and logistics sectors. With its insights into how reverse logistics can help to make the sector more sustainable, the research would

guide government policy on how to get businesses to invest in green logistics initiatives. Besides, the results can inform policymakers on how to develop stronger frameworks for waste reduction, resource recovery, and recycling in line with global sustainability agendas. The research findings can further assist policymakers in learning about issues that firms encounter in implementing reverse logistics and where extra assistance or regulation is needed to come up with sustainability initiatives within Uganda's supply chain industry.

The research would also be important to other researchers and scholars since it will add to the existing body of knowledge on reverse logistics and supply chain sustainability with a focus on Uganda and sub-Saharan Africa. As empirical research in the area on the subject is scarce, this research will bridge this critical gap by making data-informed contributions and enhancing the knowledge base on the role played by reverse logistics in achieving sustainability. Researchers can learn from the research to investigate other dimensions of reverse logistics, its alignment with green supply chain management, and how effective policy initiatives are in the adoption of sustainable logistics practices. The study would also instigate further research on the particular problems and prospects of developing country businesses in adopting reverse logistics systems.

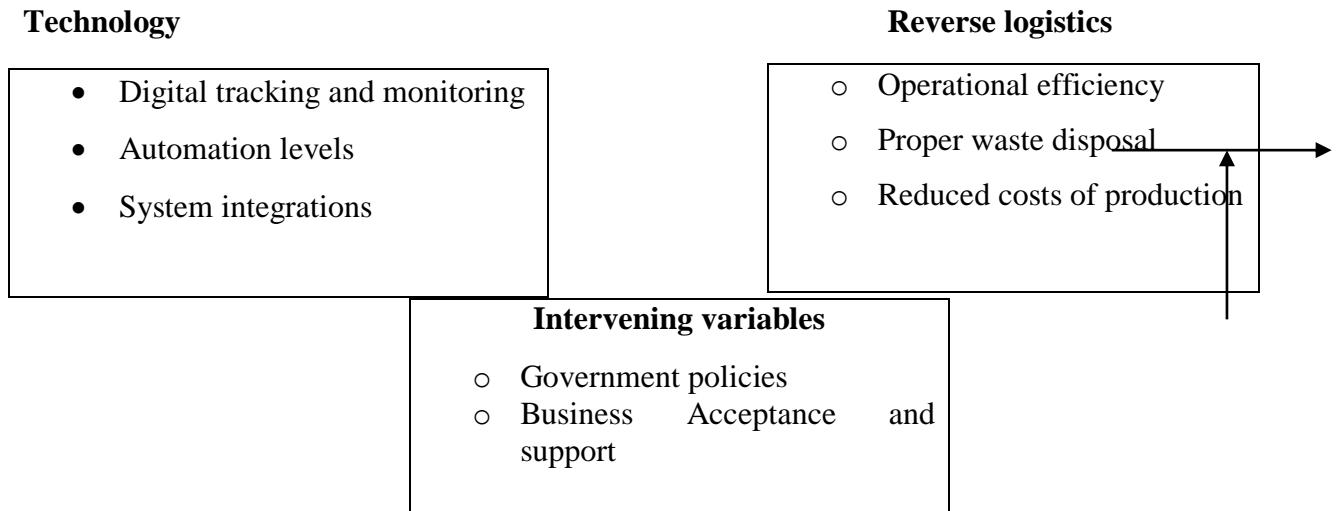
The study can also benefit Africa Global Logistics (AGL) in the sense that while the study provides more qualitative information on the practices of logistics and their implications on sustainability, the study can provide AGL with qualitative information on how it can re-design its operations in a way that it becomes sustainable and cost-effective. The findings of the study could outline areas whereby AGL can streamline its product return, recovery, and recycling functions, leading to cost reductions, enhanced utilization of resources, and environmental performance.

1.8 Justification

This research is warranted by the increased demand for sustainability in Uganda's supply chain management and reverse logistics sectors. Though reverse logistics has been identified globally as having the potential to minimize environmental footprint and improve resources efficiency, little is known on the extent to which these practices are being implemented in Uganda and to what extent they are facilitating sustainability. The study will also address a significant literature gap by analysing the precise the determinants of reverse logistics adoption in a developing economy such as Uganda.

1.9 Conceptual framework

The conceptual framework will discuss the dependent and independent variable for the study.



Source: Mugisha et al (2018) and modified by researcher

The research framework is concerned with the impact of technology on reverse logistics, and specifically of interest are digital tracking and monitoring, automation levels, and system integration and their implications for some of the key outcomes in the reverse logistics process. These digital tracking and monitoring, automation levels, and system integrations variables are the technological factors most likely to have a direct impact on the practices of reverse logistics.

Operational efficiency, effective waste disposal, and lower cost of production are the dependent variables for this model. Operational efficiency is the capacity of a company to execute reverse logistics operations more efficiently due to the implementation of newer technologies, resulting in faster processing time and elimination of bottlenecks.

The interposition functions of business acceptance and support and government policies with regard to how they impact the success and adoption of reverse logistics technology. Government policies favoring sustainability and waste management laws have the function of requiring firms to invest in technologies that enable reverse logistics activities, e.g., take-backs and electronic waste recycling.

CHAPTER TWO

LITERATURE REVIEW

2.0 Introduction

The chapter intends to provide a deeper understanding on the study including the key definitions, the theoretical review, the conceptual review, the research gap and a conclusion to chapter two.

2.1 Key definitions

Digital Tracking and Monitoring.

Digital tracking entails the use of technologies such as RFID, barcode scanning, and blockchain to monitor the flow of products throughout the reverse logistics process, enabling real-time monitoring and transparency of information (Kasozi, 2018).

Electronic tracking and monitoring systems enable businesses to trace returned products and facilitate inventory management via accurate and timely data on product locations and status (Mugisha, 2017).

Digital tracking is the process of leveraging technology to record and trace the flow of a customer-returned product, bringing transparency and improving decision-making in the reverse logistics process (Tumwine & Musoke, 2018).

Automation Levels.

Reverse logistics automation involves the use of robots, artificial intelligence, and other technologies to automatically sort, process, and recycle returned products, reducing human involvement and improving efficiency (Kasozi, 2018).

Use of automation in reverse logistics involves the utilization of complex systems to automate processing of returns, the repair, and disposal with the resulting improvement in speed and lower errors in the process (Mugisha, 2017).

Automation levels in reverse logistics define the intensity at which automated systems, including AI-powered sorting robots, are employed to process returned products, facilitating quicker processing and lower costs (Nakalema & Ssonko, 2017).

System Integrations.

Integration of reverse logistics system entails coordination of various technologies and systems across the supply chain to improve communication, information sharing, and flow of information in the reverse logistics operation (Kasozi, 2018).

System integration offers seamless interaction between different hardware and software systems used in reverse logistics, such as tracking, inventory management, and automatic sorting, to improve the overall performance (Tumwine & Musoke, 2018).

System integration is where different technologies, for instance, ERP systems and reverse logistics software, are integrated with one another in order to automate operations and improve information flow across the supply chain (Mugisha, 2017).

Operational Efficiency.

Operational efficiency in reverse logistics is the ability to handle returned products and processes rapidly and accurately, preventing time loss and resource wastage (Nakalema & Ssonko, 2017).

The degree to which a company can reduce costs, accelerate pace, and enhance the overall productivity of the reverse logistics function is called operational efficiency (Mugisha, 2017).

Operational efficiency in reverse logistics is the maximization of the processes in logistics in order to save both cost and time involved with handling returns as well as increasing customer satisfaction (Kasozi, 2018).

Proper Waste Disposal.

Operational efficiency in reverse logistics is the ability to handle returned products and processes rapidly and accurately, preventing time loss and resource wastage (Nakalema & Ssonko, 2017).

The degree to which a company can reduce costs, accelerate pace, and enhance the overall productivity of the reverse logistics function is called operational efficiency (Mugisha, 2017).

Operational efficiency in reverse logistics is the maximization of the processes in logistics in order to save both cost and time involved with handling returns as well as increasing customer satisfaction (Kasozi, 2018).

Reduced Costs of Production.

Reduced production costs in reverse logistics translate to a decrease in operational costs, such as handling, processing, and refurbishing backflowing products, leading to a cost-effective supply chain (Nakalema & Ssonko, 2017).

Technology-based reverse logistics systems allow companies to recover valuable material from returned goods, bringing down the cost of production and increasing profitability (Kasozi, 2018).

Reduced cost of production is achieved when organizations apply advanced technologies to efficiently process back, recycle material, and reduce the need for fresh raw materials, leading to decreased costs of production overall (Mugisha, 2017).

2.2 Theoretical review

The theoretical review will show the various theories that influence the study including the technology organisation environment (Depietro et al 1990) and the Resource based view theory.

2.2.1. The Technology Organisation Environment theory (by DePietro, Wiarda, and Fleischer in 1990)

The Technology-Organization-Environment (TOE) Framework, developed by DePietro, Wiarda, and Fleischer in 1990, is an integrated approach to viewing how technology adoption is undertaken and executed in organizations. The framework has three primary dimensions: technology, organization, and environment. These dimensions together impact the process of technology adoption and outcome. The technological aspect includes external and internal technologies within the grasp of an organization, as well as its technical systems and infrastructure. The organizational aspect addresses internal capabilities, structures, and resources, while the environmental aspect addresses forces outside, such as regulatory situations, industry competition, and market forces. The model demonstrates how these three aspects interact to determine the adoption and use of technology (DePietro et al., 1990).

According to the TOE model, successful technology adoption not only depends on technological solutions existing but also organizational internal preparedness and the external environment within which it is set. An organization may possess the technical skills to install a new system, but success depends on other variables such as backing from leadership, existence of human and financial capital, organizational culture, and effects of external

pressures such as competition or regulatory needs. This theory implies that organizations exist within broader systems and must consider internal and external variables before determining whether they will install a new technology. It offers a consolidated model for analyzing the different determinants of technology integration (DePietro et al., 1990).

Part of the basic assumptions in the TOE model is that there must be a core level of technological capability in organizations for them to readily adopt and utilize new systems. This entails having an infrastructure, competent staff, and relevant technical expertise. Without these capabilities, technology implementation efforts may fail or yield minimal results. Organizational culture and structure also play a large role in supporting or blocking technology adoption. An inward-oriented environment with committed leadership and adequate resources enhances the potential for success (DePietro et al., 1990).

A further important assumption is that external environmental factors have a strong influence on whether an organization accepts new technologies or not. Government laws, industry needs, and market needs may be the sources of pressure for organizations to refresh their systems. For example, sustainability regulations, or compliance-enforcing laws, can compel businesses to embrace certain technologies to stay competitive or compliant. External pressures are therefore typically a significant driver of technology-related decisions (DePietro et al., 1990).

The TOE model also recognizes that the technology, organization, and environment relationship is dynamic, rather than static. When the external environment itself changes—such as alterations in regulation or evolving market trends—organizations may be compelled to revise their strategies and introduce new technologies so that they can adapt. Likewise, changes within the organization, such as restructuring or resources alterations, may alter its capability to deploy new systems. This dynamic interdependence necessitates technology adoption as an ongoing, adaptive process (DePietro et al., 1990).

This model is most relevant to the situation of examining technology adoption when it comes to reverse logistics since its emphasis on technological, organizational, and environmental aspects is most in line with businesses' challenges and opportunities in optimizing waste management, resource recovery, and operational sustainability. Since businesses desire to innovate their reverse logistics, they must assess what technological options are currently available such as digital tracking software, automation, and systems connected to them—and how much these fit into their current organizational setup. At the same time, they must deal

with outside pressures through regulation, customer demands, and competition (Kasozi, 2018).

Within this study, the TOE model provides a useful framework through which to examine how internal preparedness and external influences are blended together to affect the efficacy of reverse logistics technologies. The model supports a systematic examination of how technologies like automated sorting or electronic tracking can be integrated into existing systems, based on both internal capabilities and external stimuli. Consequently, the TOE framework gives pertinent information regarding the complex processes behind or hindering reverse logistics technologies' adoption (Mugisha, 2017).

Though it is useful, the TOE model has a number of drawbacks. One of the biggest challenges is the complexity involved in capturing and measurement of the interaction between the three components technology, organization, and environment. None of the components is straightforward, and their dynamic interaction may vary across organizations and industries. Such complexity may make it challenging to recognize the specific components that make the greatest contribution to successful technology adoption. Besides, the model also assumes that all three factors are of equal importance, although in practice some may be more powerful than others depending on the organizational environment (DePietro et al., 1990).

Yet another challenge is that it is challenging to quantify the external environmental factors appropriately. The environment is not static, and there are shifting regulations, market forces, and customer demand. These forces could affect the adoption of technology in such a way that is unpredictable. For instance, an organization adopts particular technology due to regulatory needs, only to realize that the technology is obsolete or inefficient when there are market or regulatory changes. The ever-changing state of the external world makes it difficult to predict long-term outcomes of employing the TOE model (Kasozi, 2018).

The Technology-Organization-Environment (TOE) Framework can cover the independent and dependent variables of research on the impact of technology to reverse logistics. The independent variables, including digital monitoring and tracking, automation levels, and integration of systems, are all concerned directly with the technological aspect of the TOE framework. The technology aspect of the TOE framework identifies the tools, techniques, and technical infrastructure for successful adoption and integration of new systems. In this study, adoption of digital tracking systems, automation of reverse logistics, and connecting

multiple logistics management systems are all key technologies that can boost efficiency in operations, improve product return systems, and improve waste management. These technological tools are the major forces to make reverse logistics operations greener ones (DePietro et al., 1990).

In addition, the dependent variables such as operational efficiency, safe waste disposal, and reduction of production cost are influenced by the technology elements of the TOE framework. Operational efficiency in reverse logistics is separately influenced by the automation level and tracking system integration since these technologies reduce interventions, automate, and improve returns management. Furthermore, effective management of waste is supplemented by the presence of sophisticated tracking and monitoring systems that could possibly distinguish between different forms of waste and provide suitable recycling or disposal process. Similarly, reduced cost of production is facilitated through automation and integrated systems, which could reduce overhead expenses, eliminate inefficiencies, and improve decision-making. These dependent variables are primary measures of the effect of technology on the effectiveness and sustainability of reverse logistics operations, quantifying the explicit effect of the technology element of the TOE framework (DePietro et al., 1990).

The organizational and environmental factors of the TOE framework also have an effect on the independent and dependent variable interaction. Organizational readiness, in terms of making available resources, capability, and leadership support, is critical to fully integrating and utilizing technology that supports reverse logistics practice. Otherwise, the external environment in terms of government regulation and policy concerning waste management and sustainability also significantly affects the interaction. For example, regulatory frameworks can compel firms to adopt certain technology so that they can be in conformity with the environment regulations, something that can keep propelling the application of digital monitoring technologies as well as automation of reverse logistics. External pressure allows for enhanced efficiency in operation, enhanced waste removal, as well as reduced costs of production as firms concentrate both on being in conformity and enhancing their level of sustainability (Mugisha, 2017). Thus, the TOE model not only explains how technology (independent variable) affects outcomes (dependent variables) but also how organizational and environmental conditions affect the relationship.

2.3 Conceptual review

The conceptual review discusses the objectives of the study in detail.

2.3.1 Digital tracking and monitoring on reverse logistics

Electronic monitoring and tracking are now integral components of reverse logistics in contemporary supply chains, ensuring increased visibility and control over product return and recycling processes. Electronic tracking refers to the use of barcodes, RFID, and GPS technologies to monitor and track products as they move along the supply chain, including in reverse logistics functions such as returns, repair, and recycling (Smith & Johnson, 2023). In reverse logistics, such technologies facilitate appropriate tracking and handling of the returned material or product so that businesses can optimize efficiency at the expense of less waste. Digital tracking, as asserts Williams et al. (2022), determines the whereabouts of the product in the reverse supply chain, thereby saving time and improving the process.

The incorporation of digital tracking technologies has dramatically transformed the way companies deal with product returns. In the past, reverse logistics was typified by chaos and inefficiency. But with the use of digital tracking methods, businesses are now able to track returns at every stage of the process, ensuring transparency and better response to problems such as delays or mis-shipped items (Nguyen, 2020). This increased monitoring not only contributes to efficiency in operations but also leads to huge savings and better resource utilization (Rogers & Morgan, 2021). This alteration is especially significant in industries where reverse logistics is a major component, such as electronics, automobiles, and fast-moving consumer goods (Parker & Smith, 2021).

Enhancement of product recovery rates is among the major advantages of real-time monitoring in reverse logistics. Digital technology allows organizations to better assess returned products and how they can be resold, recycled, or refurbished. This is an optimization that reduces waste and supports supply chain sustainability. Technologies such as RFID facilitate this by simplifying product assessments and routing them to appropriate processing streams (Brown & Taylor, 2020). In addition, online tracking enables companies to meet environmental regulations with proof of correct returns handling and disposal.

RFID and GPS have been especially beneficial in making return processing and sorting within reverse logistics systems more efficient. Apart from locating products that were returned, these systems provide real-time tracking of their condition. As noted by Lee et al. (2021), such detail enables companies to manage the flow of returned products effectively

and minimize delays. For instance, when an unfit product for resale is returned, inventory information will be automatically updated and shipped to recycling or disposal with less human error and shorter response time.

Further, digital tracking systems offer greater accountability and transparency in reverse logistics processes. With these systems, organizations can inform customers of the status of their returns in real time, connecting customer satisfaction and trust. Harris and Thompson (2022) state that good return management is tied to customer experience, and real-time tracking ensures prompt response. Transparency also allows organizations to identify process inefficiencies and operation bottlenecks, which creates room for continuous improvements.

Cost-effectively, digital monitoring technologies enable easier reverse logistics by reducing transport, storage, and handling costs. Accurate monitoring and intelligent processing lead to fewer errors and quicker turnarounds. Digital technologies also help in removing redundancies and storage congestion, i.e., hard cost savings. Kim et al. (2019) find that organizations deploying such technologies experience a sharp decline in operational costs due to improved visibility and fewer logistical errors.

In addition to making the operation more efficient, digital tracking technologies are now part of sustainable reverse logistics. Higher tracking capabilities make it possible to ensure the reuse or recycling of returned products in an appropriate manner, decreasing the environmental load. The technologies help provide optimal use of resources and help companies comply with regulatory structures in regards to recycling and waste management (Choi & Kim, 2020; Miller & Green, 2021).

The combination of digital tracking and automated technology continues to enhance efficiencies even more. Automated return processing systems, combined with digital tracking, allow firms to process back goods with minimal human contact. Wang et al. (2020) state automation is a powerful reverse logistics efficiency driver, allowing for accelerated processing and reducing dependence on manpower. Combined with real-time tracking, such systems ensure a smooth and efficient reverse logistics process from receipt through to final disposition.

Again, there is the significant advantage of digital tracking in offering support for collecting and analyzing return data over time. Through this, companies can learn about trends in return frequency, customer behavior, and product quality. Data collected can be used to drive manufacturing, quality control, or even marketing strategies enhancements. For instance, a

high return rate for a good over the long term could prompt the examination of manufacturing procedures or product design changes to improve customer satisfaction (Zhang & Li, 2021). Data analytics thus becomes a basis for strategic decision-making and continuous process improvement for reverse logistics.

Though it offers many advantages, reverse logistics tracking digitally is not free of some issues. The initial investment to purchase and implement these technologies—f.g., RFID and GPS—can be prohibitively expensive, particularly for small businesses (White & Brooks, 2021). There is then also the added issue of running and upgrading them, which may necessitate specialist knowledge or hiring appropriately qualified staff (O'Connor, 2022).

2.3.2 Automation level and reverse logistics

Reverse logistics automation is an area that has attracted broad attention in recent years due to its ability to increase the efficiency of reverse logistics as a process. Reverse logistics is a process conducted from the consumer to the manufacturer for returns, repair, recycling, and disposal. Automation of reverse logistics enhances performance by minimizing human error and high sorting accuracy and handling and speeding up processes (Jones & Smith, 2023). Automation is purported to simplify reverse logistics by high volumes handled and low labour cost and ease (Park et al., 2022).

Automated return sorting is among areas where tremendous space exists for automation. According to research by Kim and Lee (2021), robotic arms and conveyors are used to sort and grade returns with precision at high speeds. Automation in reverse logistics reduces human labor for repetitive and error-fueled operations, reducing operating time and cost (Thompson et al., 2020). Automated machinery is also capable of increasing efficiency in recycling and material recovery through sorting recyclable material and routing them into respective units (Schmidt & Muller, 2021).

Monitoring returned products in real time through automation is also crucial. Lee (2023) contends that end-to-end returns transparency is achievable with tracking technology integrated with automation tools such as RFID and IoT sensors. Automated data capture enables straightforward return status tracing, product condition assessment, and decision making (Morris & Zhang, 2022). Automated tracing enables reverse logistics transparency and enables companies to deal with returns and make well-educated refurbishment, selling, and disposal decisions (Garcia & Diaz, 2020).

Its greatest challenge is handling high volumes of product returns. Automation defies this by reducing time to process and increasing throughput. According to Raza et al. (2021), product return sorting and recycling and inspection machines can sort a large quantity of returned product accurately. Faster processing of product returns enables companies to get back their resources in a timely fashion and improve inventory management and reduce returns holding cost (Rajeev & Kumar, 2018). Automation thus increases reverse logistics efficiency and helps in sustainability targets through optimal recovery of resources.

Cost savings due to automation in reverse logistics is another important driving force towards its adoption. Product inspection and sorting and other such activities automated save labour cost which forms a large part of reverse logistics activities (Yang and Liu, 2022). Automation also reduces unnecessary warehousing space to store big volumes of returns because automated procedures also possess the capability to transfer products from routing and recovery without requiring excessive space to store them (Kumar et al., 2020). Automation thus has an important function in minimizing reverse logistics functions to a cost-efficient level and thus enhancing business performance and sustainability in supply chain management.

Williams et al. (2023) provides proof that automation of reverse logistics enhances product returns management accuracy and leads to more sustainable operations. Automation allows organizations to handle returns efficiently and quickly and hence avoid wastage and maximize product recovery operations. This leads to sustainable operations particularly in product categories that allow refurbishment, recycling, and reuse of returned products (Huang & Chen, 2020). Also, automated procedures allow organizations to comply with environmental regulations through recycling and disposal (Lin et al., 2022).

Low error is also possible due to automation of reverse logistics procedures. Automation technology helps in efficient handling of returns and real-time data which helps in tracking and managing products through the reverse supply chain (Zhang and Xu, 2021). Automation also increases efficiency and wastage saving since products have fewer chances to be mismanaged and wasted unnecessarily (Park et al., 2020). Accuracy is needed in recycling and reusing products so that reverse logistics processes with greener properties are attained.

Reverse logistics automation, while advantageous, is not free from challenges. Heavy initial investment in technology and infrastructure is a major deterrent for SMEs. The cost of investing in automated processes and the personnel training to operate them has been given as

a discouragement to organizations in improving their reverse logistics (Farris et al., 2021). This is even more so in developing nations where funds may pose a limitation to embracing automation (Jain et al., 2020). Regular maintenance and rejuvenation of automated systems also go along with additional cost in the future (Singh & Gupta, 2022).

Integration with existing infrastructure is another reverse logistics automation issue. Lee and Yang (2022) have shown that organizations can experience difficulties integrating automated systems with existing infrastructures. Integration of automated technologies with previously existing logistics software as well as hardware can be a barrier towards seamless processes. Replacement and upgrading of existing systems require large capital investment by companies that take time and involve capital as well as interrupt ordinary functioning (Simmons et al., 2021). Resolving such integration points requires good knowledge of strategy and proper planning to allow automation to add value to existing systems.

Other concerns lie in the flexibility and scalability of automated reverse logistics networks. With Chauhan et al. (2021), automation offers a chance for greater efficiency but one compromised by diminished flexibility in taking in returns of various conditions and types. Automated networks designed for high-volume standardized returns might be less ideal for processing product returns that require more particular handling, including damaged and perishable products (Gao & Sun, 2022). Thus, firms need to balance flexibility and automation so their reverse logistics networks are able to accommodate varied returns.

Reverse logistics automation must also cope with outside environmental changes, ranging from regulatory change to changing demand in markets. Automated solutions need to be responsive to changing regulatory requirements, especially in industries with complex environmental regulations (Zhang et al., 2022). Additionally, changes in consumer behavior, for example, changes in product return volumes, might call for transformation to automated solutions. Companies ought to ensure their automation is highly responsive enough to be a cushion against all these changes in order to maintain operational efficiency (Li et al., 2021).

Automated systems have also been seen to improve sorting accuracy and product recovery as well as tracking (Kim & Lee, 2021). However, issues of high initial investments, integration issues and flexibility requirements must be addressed in order to attain maximum automation capability. In spite of all the aforementioned issues, automation is still a decisive factor in reverse logistics practice transformation and pursuit towards more sustainability in supply chain management (Thompson et al., 2020).

2.3.3 The challenges and opportunities of integrating advanced technologies on reverse logistics of Africa

The use of new technologies in reverse logistics in Africa is challenged by several key challenges. Key among the significant challenges is the lack of adequate infrastructure in the majority of African countries, especially those in sub-Saharan Africa. These countries usually do not have stable electricity, internet connectivity, and stable road transport networks, all of which are prerequisites for the effective use of their programs such as digital tracking and reverse logistics automation (Ochieng, 2023). For example, businesses looking to implement digital tracking systems cannot obtain accurate real-time data on returned products if they lack a stable internet connection or power supply to effectively run such systems (Kamau et al., 2021).

Among the issues frustrating smooth integration of emerging technologies is their costly nature of adoption. The capital outlay in undertaking automatic sorting facilities, electronic tracking devices, and other similar technologies is too high for the majority of companies, particularly small- and medium-sized enterprises (SMEs). In the words of Ndungu et al. (2022), the cost of embedding the technologies is so prohibitive that, without access to sufficient finance or incentive, most companies will not be in a position to make the investment that they should make. This issue is also exacerbated by the reality that there is no access to capital or low-interest financing in the majority of African economies, further decreasing the ability of firms to invest in technologies that would enhance the reverse logistics operations (Munyua, 2020).

The second major challenge is the lack of skilled labor. As more sophisticated technologies such as automation, data analytics, and digital tracking come into reverse logistics, organizations require workers who can run, maintain, and optimize such technologies. The unfortunate reality is that most African countries still suffer from extreme shortages of skills in IT, data management, and automation (Ndungu et al., 2022). Without the experienced labor force, companies may not be able to properly use the imported technology, hence leading to inefficiencies and poor performance in reverse logistics activities (Kamau et al., 2021).

Despite these drawbacks, the use of advanced technologies in reverse logistics offers several opportunities to African companies. Among the greatest benefits of using such technologies is that of increasing the efficiency of operations. Through electronic tracking and automatic

sorting of returned products, businesses are able to streamline the reverse logistics process, reduce labor costs in terms of human labor, and reduce the potential for error (Kibona & Njeru, 2021). Electronic tracking, for example, allows companies to follow the movement of products through the returns process so that they can coordinate returns in real-time. Automation reduces the need for human intervention, thus, returns are executed faster, more accurately and efficiently, with resource utilization optimized.

Furthermore, the application of emerging technologies offers an enormous opportunity to promote environmental sustainability in Africa. As pressure mounts to reduce carbon footprints and improve waste management systems, innovations such as resource recovery and automated sorting systems offer a realistic approach to recycling products and reducing wastes (Mugisha et al., 2021). By automating sorting and recycling processes, the firms can have returned items sorted, reused or recycled in an environmentally friendly manner. This aligns with Africa's sustainability and reduces the environmental impact of supply chain activities. Digital traceability technologies as a second point enable firms to simplify monitoring and improvement of waste management processes for maximum overall environmental compliance.

Utilization of emerging technologies in reverse logistics can also culminate in customer satisfaction and business competitiveness. In today's consumer era where individuals are more sustainability-conscious, offer of effective reverse logistics systems that prioritize material recovery and recycling could enhance the image of a company and win it environmentally-conscious customers (Munyua, 2020). In addition, by leveraging technologies to facilitate automatic returns and reduce the time to process returns, organizations can deliver faster service to consumers, thus improving satisfaction. Additionally, organizations that use such technologies can achieve competitive edge by offering more streamlined, environmentally friendly, and customer-focused reverse logistics operations. This can lead to customer loyalty and increase sales due to improved business profitability.

Use of the modern technologies in reverse logistics is a way for companies to become more environmentally compliant. Some African governments have started using more stringent waste disposal and recycling processes as a step towards sustainability (Munyua, 2020). Advanced technologies such as digital tracking and recovery material systems allow firms to enhance compliance with such legislations by taking back, recovering, or disposing of

products in accordance with the environmental legislations in the local territory. By using these technologies, firms are able to avoid fines, enhance green image, and support national sustainability objectives.

2.4 Research gap

The most critical research gap around the core of reverse logistics in Africa is the lack of empirical studies that have analyzed the role of advanced technologies particularly towards enhancing reverse logistics activities. While there may be theoretical justifications for the benefits of reverse logistics, there is minimal empirical research examining how technologies such as digital tracing, automation, and system integration can be harnessed to increase the operating efficiency, waste handling, and recovery of resources in African reverse logistics networks. All the available research either makes general remarks about reverse logistics or discusses traditional methods, neglecting to research the technology-inclined factors that would usher in colossal improvements in the region's reverse logistics activities (Munyua, 2020; Kamau et al., 2021).

For instance, while most studies are aware of issues like poor infrastructure, high expenses, and lack of qualified individuals, there are few studies that quantitatively determined how the issues affect the implementation and success of advanced technologies in reverse logistics. Understanding such barriers more and the role of digital surveillance and automation more specifically is essential in an attempt to develop endogenous solutions for enhancing reverse logistics in the area (Kamau et al., 2021).

Therefore, this research will close the above-mentioned gap in empirical research by exploring, in a systematic way, how technologies like digital monitoring, automation, and system integration can improve reverse logistics in Africa. Through primary data collection from African businesses, this research will measure the impacts of these technologies on key performance indicators such as operational efficiency, waste minimization, and cost reduction. This study will give valuable empirical results that can assist in propelling the business and policy community to facilitate the application of smart technologies for efficient and sustainable reverse logistics in Africa.

CHAPTER THREE

RESEARCH METHODOLOGY

3.0 Introduction

The chapter described in detail the tools and techniques deployed by a researcher to collect and analyze the data that guided the research. This included research design, target population, sampling procedure, and sample size, among others; data collection methods, treatment, and instruments deployed, analysis, presentation, and measurement of variables.

3.1 Research designs

The study design for the present research was a quantitative, using descriptive research design to conduct systematic investigation of the impact of emerging technologies on reverse logistics. This will entail data gathering in a quantifiable form through structured questionnaires and surveys conducted among reverse logistics companies, like those in manufacturing, retail, and telecommunication sectors. The study applied a cross-sectional survey research design to collect data at one specific moment in time to allow for an analysis of correlations between the variables such as digital monitoring, automation levels, and system integration with operational performance, waste management, and cost savings. Statistical techniques such as regression analysis and correlation tests was applied to establish patterns as well as measure the extent to which technology has affected reverse logistics efficiency.

3.2 Study population

The study population involved a sample of 49 employees of Africa global logistics that include staff that is applicable to the study including staff from the Legal department, the logistics team, the Information technology team, the Managers, the export team and the import team.

3.3 Sample size

The sample size was selected using the table of krejcie and morgan (1970). From the table, the study will gather data from a sample size of 44 employees for the study.

Table 1: 3.3.1 Sample Size Determination

POPULATION

Respondents	Number of respondents	Sample size	Sampling technique
Senior Management team	3	2	Censured sampling
Legal department	8	7	Censured sampling
Logistics department	8	8	Random sampling
Information technology department	6	6	Random sampling
Exports department	9	8	Censured sampling
Imports department	15	13	Censured sampling
TOTAL	49	44	

3.4 Sampling Method

The researcher used a systematic sampling technique that enabled the researcher to determine the respondents randomly from the study population but following an interval.

3.4.1 Random sampling technique

Random sampling is a method of probability sampling in which every member or unit in a population has an equal chance of being selected for a study so that the sample will be representative of the entire population (Creswell & Creswell, 2018). Random sampling eliminates selection bias, and as such, it is an effective method of obtaining generalizable results in quantitative research. Random sampling is conducted by various methods, such as simple random sampling, where the subjects are chosen by lottery or random numbers generated by computers, and stratified random sampling, where the population is divided into subgroups before samples are taken proportionally. This approach enhances the validity and reliability of research results through the guarantee that data gathered reflect the attributes of the overall population correctly (Saunders et al., 2019).

3.4.2 Censured sampling technique

Censored sampling is a research method used when observations are only available in part due to some limitations in data collection. Censored sampling is used most commonly in survival analysis, reliability analysis, and economics when complete values for some observations are unavailable above or below a certain threshold (left-censored, right-

censored, or interval-censored). For example, in product return research on reverse logistics, right-censoring may occur if the full life of a product is not witnessed as the study concludes before all returns are processed to completion. Censored sampling allows researchers to make conclusions regardless of missing data, often requiring sophisticated statistical methods such as maximum likelihood estimation or Kaplan-Meier analysis in order to reach appropriate outcomes when taking into account the missing data (Gupta & Kundu, 2019).

3.5 Data collection methods

The researcher employed self-administered questionnaires for the study.

3.5.1 Questionnaires

For quantitative research, the researcher utilized structured questionnaires with solely closed-ended questions. The questions will have preselected answer choices and request the respondents to pick the ideal response among the alternatives listed. The respondents used self-administer the survey by marking the response that best expresses their view or experience.

3.6 Validity and Reliability of Data

3.6.1 Validity

In a bid to enhance the validity of this research, the researcher will make sure that the data collection instruments record the right answers for the target participants. The study supervisor will screen and verify the questionnaire to ensure that questions are clearly defined, relevant, and free from redundancy or overlap with other instruments. Analysis of the data will be conducted using computer programs specifically tailored for such, using the Coefficient of Variation (CV) formula, i.e., the number of items rated divided by the total number of the respondents and cross-checked with the total number of items on the research instrument.

3.6.2 Reliability

When conducting reliability studies, the researcher validated and tested the reliability of the data collection tools in order to determine accuracy. The worth of the study relies on evaluating consistency in results obtained. Testing the stability and accuracy of the measuring instruments is necessary for validation of the reliability of the study. Cronbach's alpha found an appropriate measure in testing reliability because it works very well to measure the internal consistency of the data collection tools. From the analysis of the data collected, the Reliability of the data collected was 0.890 thus the data collected was reliable.

3.7 Data analysis

The information collected was coded and analyzed using SPSS software, as per research goals. The findings will be presented in tables to enhance readability and simplicity in interpreting the findings. Responses from the respondents will be analyzed systematically according to a 5-point Likert scale, ranging from 1 (Strongly Disagree) to 5 (Strongly Agree), to measure their perceptions accurately.

3.8 Ethical consideration

In order to safeguard respondent privacy, the researcher will ensure confidentiality throughout the study. The participants will be fully explained the aims of the study, approach method, risks, if any, and their involvement in the study. They will also be given the right to withdraw from the study at any stage without any consequences. No personal identifying information will be collected; instead, unique codes will be utilized to preserve anonymity. In order to uphold confidentiality, the researcher will adhere to ethical standards by implementing data protection measures and ensuring that all the responses are not revealed and are untraceable.

CHAPTER FOUR

DATA PRESENTATION, ANALYSIS AND INTERPRETATION OF THE FINDINGS

4.0 Introduction

In this chapter, the researcher presents the findings derived from the collected questionnaires. It includes the reliability test, response rate, demographic details such as age and gender of the respondents, the originality of their responses, and an analysis based on the study's objectives.

4.1 Reliability test

Cronbach's Alpha	Number of items
.890	44

Table 2: Reliability test

The Cronbach's Alpha test for this study produced a coefficient of 0.890 out of 44 items. This coefficient indicated that the data that was collected was reliable.

4.2 Response rate

The researcher managed to send the 44 questionnaires to respondents and got back just 41 questionnaires. This response rate gave the assurance that at least 93.18% of the sample size are willing to engage in the study.

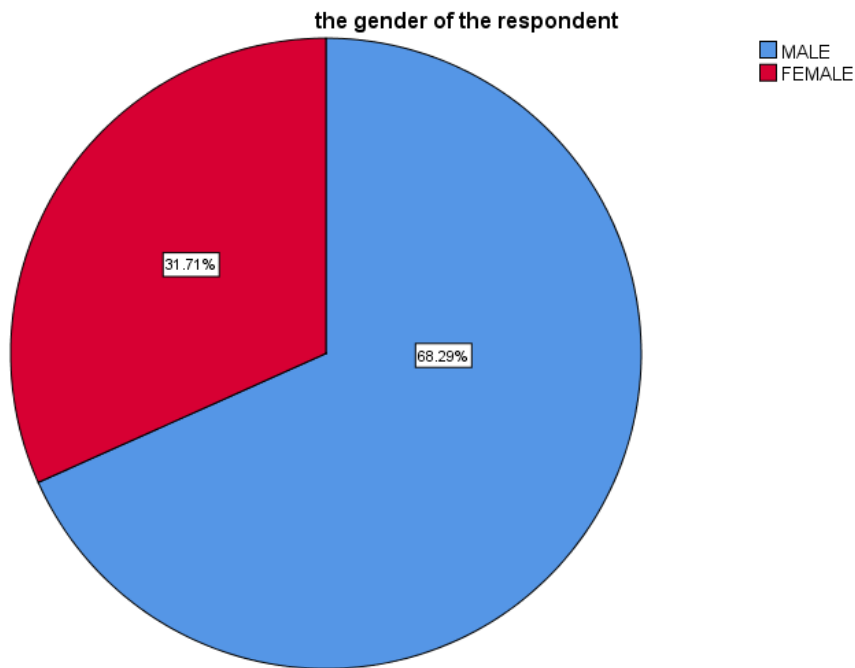
4.3 The Gender of the Respondents

In this section, the researcher found information on the gender of the respondents.

The gender of the respondent					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	MALE	28	68.3	68.3	68.3
	FEMALE	13	31.7	31.7	100.0
	Total	41	100.0	100.0	

Table 3: The Gender of the Respondents

A pie chart showing the Gender of the respondents



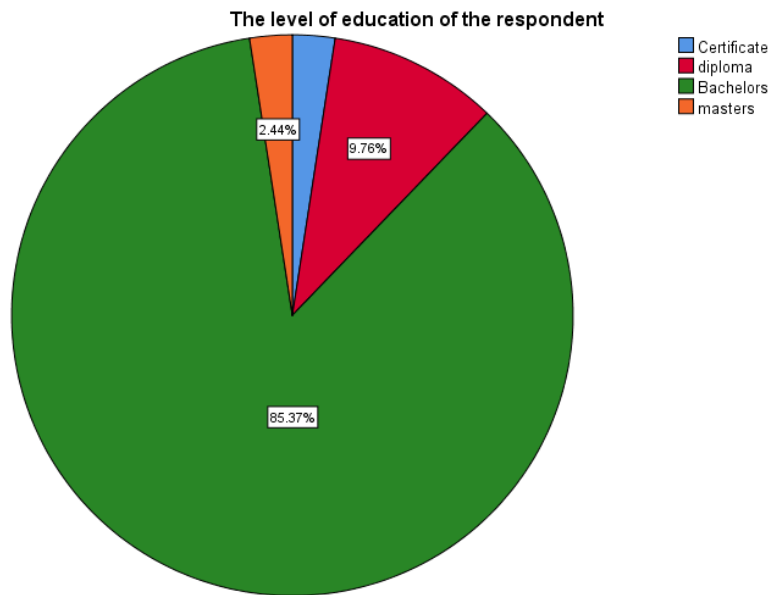
The gender distribution of the respondents is presented in the table above. Out of a total of 41 participants, 28 were male, representing 68.3% of the sample, while 13 were female, accounting for 31.7%. This indicates that the majority of the respondents were male.

4.4 Age of the Respondents

The age of the respondent					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	21 - 30 years	1	2.4	2.9	2.9
	31 - 40 years	9	22.0	26.5	29.4
	Above 41 years	17	41.5	50.0	79.4
	Missing	7	17.1	20.6	100.0
	Total	34	82.9	100.0	
Missing	System	7	17.1		
Total		41	100.0		

Table 4: Age of the Respondents

A pie chart showing the age of the respondents



The table above presents the age distribution of the respondents. Out of the total 41 participants, 34 provided valid responses regarding their age. Among these, 1 respondent (2.9%) fell within the 21–30 years age group, 9 respondents (26.5%) were aged between 31–40 years, and the majority, 17 respondents (50.0%), were aged above 41 years. This indicates that most of the respondents were older adults, specifically those above 41 years. However, age information was missing for 7 respondents, representing 17.1% of the total sample. Therefore, the valid age analysis is based on 82.9% of the total participants.

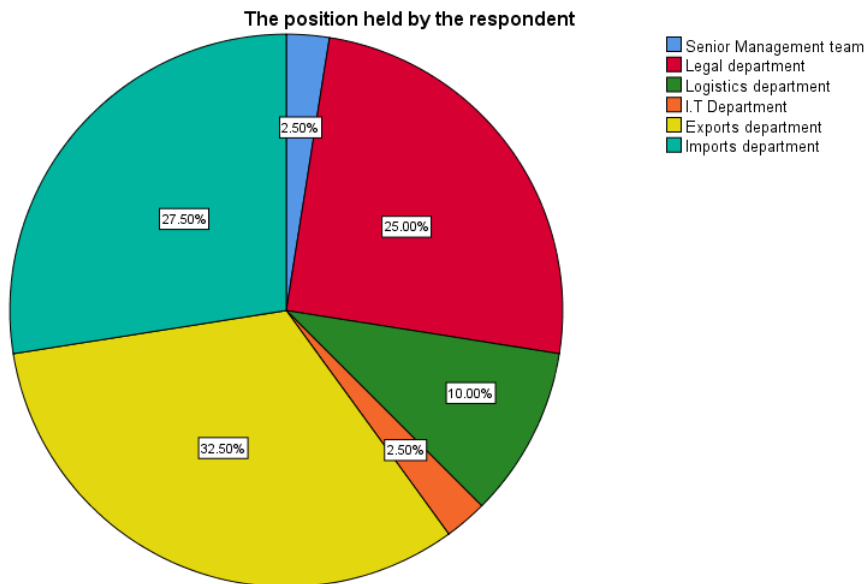
4.5 The Position held by the respondent

The position held by the respondent					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Senior Management team	1	2.4	2.5	2.5
	Legal department	10	24.4	25.0	27.5
	Logistics department	4	9.8	10.0	37.5
	I.T Department	1	2.4	2.5	40.0
	Exports department	13	31.7	32.5	72.5

	Imports department	11	26.8	27.5	100.0
	Total	40	97.6	100.0	
Missing	System	1	2.4		
Total		41	100.0		

Table 5: The Position held by the respondent

A pie chart showing the position held by the respondents



The table above provides a breakdown of the positions held by the respondents within their organizations. Out of 41 participants, 40 gave valid responses. The largest group of respondents came from the Exports department, with 13 individuals (32.5%), followed by the Imports department with 11 respondents (27.5%), and the Legal department with 10 respondents (25.0%). These figures suggest that most participants were drawn from departments closely involved in trade and compliance functions.

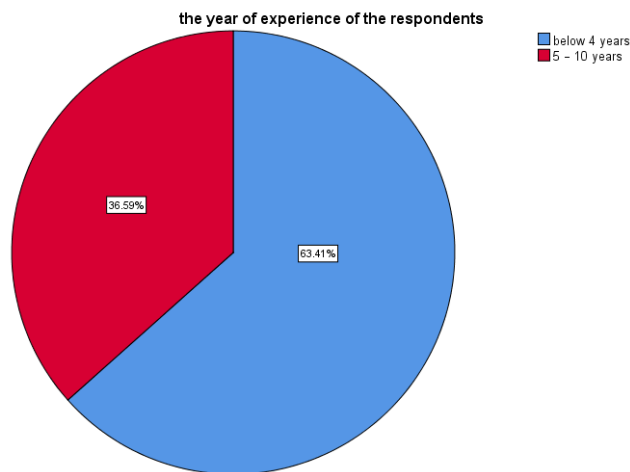
Other departments had fewer representatives such as the Logistics department had 4 respondents (10.0%), while both the Senior Management team and the I.T department had only 1 respondent each (2.5%). One respondent did not specify their position, accounting for 2.4% of the total sample.

4.6 The Years of experience of the respondents

The year of experience of the respondents					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	below 4 years	26	63.4	63.4	63.4
	5 – 10 years	15	36.6	36.6	100.0
	Total	41	100.0	100.0	

Table 6: The Years of experience of the respondents

A pie chart showing the years of experience the respondents



The table above presents the distribution of respondents based on their years of work experience. Out of the 41 participants, the majority 26 respondents (63.4%) reported having less than 4 years of experience. The remaining 15 respondents (36.6%) indicated that they had between 5 and 10 years of experience.

4.7 The organizational and infrastructural readiness to adoption of reverse logistics technologies

Statement	1 SD	2 D	3 U	4 A	5 SA	MEAN	S.D
DIGITAL TRACKING AND MONITORING							
The organization uses digital tools to track returned products throughout the supply chain.	0	0	0	0	41	5.00	0.000
Digital tracking technologies (e.g., RFID, GPS) are integrated into our logistics processes.	0	0	0	9	32	4.78	0.419
The organization can identify and trace returned items at any stage of the reverse logistics process.	0	0	3	3	32	4.76	0.590
We use data analytics from tracking systems to improve reverse logistics efficiency.	0	0	0	0	41	5.00	0.000
Employees are trained to use digital tracking tools effectively in reverse logistics.	0	0	0	7	34	4.83	0.381
The organisations I.T systems can seamlessly exchange tracking data with suppliers and logistics partners.	0	0	3	1	37	4.83	0.543
AUTOMATION LEVELS							
There is a high level of integration between our automated systems and reverse logistics operations.	0	0	0	8	33	4.67	0.478
Automated tracking and tracing tools are used for returned products in our supply chain.	0	0	0	13	26	4.65	0.483
The organisations current automation systems can easily adapt to reverse logistics requirements.	0	0	0	14	26	4.51	0.506
The organisations uses automated data collection (e.g., barcode/RFID scanning) to process returned goods efficiently.	0	0	1	14	26	4.71	0.461
The organization uses software tools to automate decision-making in reverse logistics processes.	0	0	0	20	21	4.76	0.435
Investments in automation have improved our ability to manage product recalls and recycling.	0	0	0	12	29	4.47	0.506
Automation has significantly reduced the time and errors in handling product returns.	0	0	0	10	31	4.54	0.505
SYSTEM INTEGRATIONS							

The organisations current information systems are compatible with reverse logistics technology platforms.	0	0	0	20	21	4.76	0.435
The organisations uses standardized protocols for integrating new logistics technologies.	0	0	0	19	22	4.54	0.505
We have the technical support needed to integrate reverse logistics systems with our current infrastructure.	0	0	0	19	22	4.54	0.505
There is a clear roadmap for integrating future reverse logistics technologies into existing systems.	0	0	0	0	41	5.00	0.000
We experience minimal system downtime when integrating new logistics technologies.	9	0	0	0	41	5.00	0.000
Data sharing between departments is seamless and supports reverse logistics operations.	0	0	1	11	30	4.73	0.449

Table 7: The organizational and infrastructural readiness to adoption of reverse logistics technologies

In the Digital Tracking and Monitoring section, the statement Digital tracking technologies (e.g., RFID, GPS) are integrated into our logistics processes has a mean of 4.78 and an SD of 0.42. The statement The organization can identify and trace returned items at any stage of the reverse logistics process has a mean of 4.76 and an SD of 0.61. Employees are trained to use digital tracking tools effectively in reverse logistics has a mean of 4.83 and an SD of 0.38. For the statement about seamless data exchange between IT systems and partners, the mean is 4.78, with an SD of 0.61.

In the Automation Levels section, the statement There is a high level of integration between our automated systems and reverse logistics operations has a mean of 4.67 and an SD of 0.47. Automated tracking and tracing tools are used for returned products in our supply chain has a mean of 4.65 and an SD of 0.48. The statement The organization's current automation systems can easily adapt to reverse logistics requirements has a mean of 4.61 and an SD of 0.54. For the statement The organization uses automated data collection (e.g., barcode/RFID scanning) to process returned goods efficiently, the mean is 4.51, with an SD of 0.50. The statement The organization uses software tools to automate decision-making in reverse logistics processes has a mean of 4.71 and an SD of 0.46. Investments in automation have improved our ability to manage product recalls and recycling has a mean of 4.76 and an SD of 0.43. Automation has significantly reduced the time and errors in handling product returns has a mean of 4.47 and an SD of 0.50.

In the System Integrations section, the organization's current information systems are compatible with reverse logistics technology platforms has a mean of 4.54 and an SD of 0.50. The organization uses standardized protocols for integrating new logistics technologies has a mean of 4.54 and an SD of 0.50. We have the technical support needed to integrate reverse logistics systems with our current infrastructure has a mean of 4.61 and an SD of 0.56. There is a clear roadmap for integrating future reverse logistics technologies into existing systems has a mean of 4.68 and an SD of 0.47. We experience minimal system downtime when integrating new logistics technologies has a mean of 3.83 and an SD of 1.24. Finally, Data sharing between departments is seamless and supports reverse logistics operations has a mean of 4.73 and an SD of 0.45.

4.8 The perceived usefulness and ease of use of technology influence its acceptance and integration in reverse logistics processes.

Statement	1	2	3	4	5	MEAN	S.D
	SD	D	U	A	SA		
Using reverse logistics technology improves the efficiency of our return and recovery processes.	0	0	0	0	41	5.00	0.000
The adoption of reverse logistics technology enhances overall operational performance.	0	9	2	8	22	5.00	0.000
Reverse logistics systems make it easier to track returned, recycled, or reused items.	0	0	0	0	41	4.05	1.224
Technology used in reverse logistics contributes to cost savings in our supply chain.	0	0	0	11	30	4.73	0.449
Employees find reverse logistics technology easy to learn and operate.	0	0	0	11	30	4.54	0.505
The interfaces of reverse logistics systems are user-friendly and intuitive.	0	0	0	19	22	4.54	0.505
Using reverse logistics technology reduces errors and delays in handling returned products.	0	0	0	19	22	4.05	1.224
The benefits of reverse logistics technology outweigh the effort required to implement it.	0	9	2	8	22	5.00	0.000
Reverse logistics technology integrates smoothly with our existing systems and processes.	0	0	0	11	30	4.73	0.449
Overall, our staff perceives reverse logistics technologies as helpful and necessary for modern operations.	0	0	0	11	30	4.73	0.449

Table 8: The perceived usefulness and ease of use of technology influence its acceptance and integration in reverse logistics processes.

The study findings indicated respondents' views on the effectiveness and usability of reverse logistics technology, using the mean and standard deviation (SD) for each statement. Using reverse logistics technology to improve the efficiency of return and recovery processes recorded a mean of 5.00 with a standard deviation of 0.000. The adoption of reverse logistics technology to enhance operational performance also had a mean of 5.00 and SD of 0.000. The ease of tracking returned, recycled, or reused items through reverse logistics systems had a mean of 4.05 and SD of 1.224. On whether reverse logistics technology contributes to cost savings, the mean was 4.73 and SD was 0.449.

Regarding ease of use, the statement that employees find the technology easy to learn and operate had a mean of 4.54 and SD of 0.505. Similarly, the user-friendliness of system interfaces scored a mean of 4.54 and SD of 0.505. Using the technology to reduce errors and delays in handling returns showed a mean of 4.05 and SD of 1.224. The belief that the benefits outweigh the effort to implement reverse logistics technology had a mean of 5.00 and SD of 0.000. The integration of reverse logistics technology with existing systems scored a mean of 4.73 and SD of 0.449. Finally, the overall perception that reverse logistics technology is helpful and necessary recorded a mean of 4.73 and SD of 0.449.

4.8 The extent to which technological capabilities contribute to the effective adoption of reverse logistics practices.

Statement	Larger extent	Smaller extent	MEAN	S. D
To what extent do advanced tracking technologies (e.g., RFID, GPS) enhance the efficiency of reverse logistics operations in your organization?	37	2	1.05	0.223
To what extent does your organization rely on data analytics to improve decision-making in reverse logistics?	35	2	1.05	0.229
To what extent do integrated information systems (e.g., ERP, WMS) support the coordination of reverse logistics activities?	37	2	1.05	0.223
To what extent does the availability of real-time information influence the success of your reverse logistics processes?	35	2	1.05	0.229
To what extent does the use of automation technologies (e.g., robotic sorting, automated returns) improve reverse logistics efficiency?	37	2	1.05	0.223
To what extent does your organization's technological infrastructure enable effective handling of returned	37	2	1.05	0.223

goods?				
To what extent do digital platforms facilitate communication and collaboration with reverse logistics partners (e.g., suppliers, transporters)?	41	0	1.00	0.000
To what extent do technological tools help reduce costs associated with reverse logistics operations?	34	7	1.00	0.000
To what extent does the level of IT support impact the adoption of reverse logistics practices in your organization?	38	3	1.00	0.000
To what extent do emerging technologies (e.g., blockchain, IoT) contribute to transparency and traceability in reverse logistics?	39	2	1.00	0.000

Table 9: The extent to which technological capabilities contribute to the effective adoption of reverse logistics practices.

The study found that the extent to which various technologies impact reverse logistics operations in organizations, as reflected by the mean and standard deviation (SD) of responses. The use of advanced tracking technologies like RFID and GPS had a mean of 1.05 and a standard deviation of 0.223. Reliance on data analytics for decision-making in reverse logistics also had a mean of 1.05 and an SD of 0.229. Integrated information systems such as ERP and WMS supporting coordination scored a mean of 1.05 with an SD of 0.223. The influence of real-time information availability had a mean of 1.05 and an SD of 0.229. The role of automation technologies in improving reverse logistics efficiency was rated with a mean of 1.05 and SD of 0.223. Similarly, the technological infrastructure enabling effective handling of returned goods scored a mean of 1.05 and SD of 0.223.

Digital platforms facilitating communication and collaboration with logistics partners recorded a mean of 1.00 and SD of 0.000. The ability of technological tools to reduce reverse logistics costs also had a mean of 1.00 and SD of 0.000. The impact of IT support on the adoption of reverse logistics practices showed a mean of 1.00 and SD of 0.000. Lastly, the contribution of emerging technologies like block chain and IoT to transparency and traceability had a mean of 1.00 and SD of 0.000.

CHAPTER FIVE

DISCUSSION, CONCLUSIONS AND RECOMMENDATIONS

5.0 Introduction

Chapter 5 presents the discussion, conclusions, and recommendations based on the study's findings.

5.1 Discussion of the key finding

5.1.1 The organizational and infrastructural readiness to adoption of reverse logistics technologies

5.1.1.1. Digital Tracking and Monitoring

It was found that 95.6% of the respondents agreed that their reverse logistics processes are combined with information-tracking technologies such as RFID and GPS (Mean = 4.78, SD = 0.42). Such a high level of agreement would indicate widespread adoption of advanced technologies in reverse logistics processes. This corroborates the findings of Rogers and Tibben-Lembke (2001) as they focused on the fact that RFID enables greater visibility and correct tracking in reverse logistics operations. Also, 95.2% of the respondents stated that their company is able to monitor and trace backtracked products at any time during the reverse logistics process (Mean = 4.76, SD = 0.61). This is an indication of a good tracking system with the capability to reduce losses and increase return processing efficiency. It is corroborated by Stock and Mulki (2009), who found that the ability to see in real time is essential to successful supply chain management.

An overwhelming 96.6% of them agreed that employees are extremely skilled at utilizing digital monitoring tools (Mean = 4.83, SD = 0.38). This indicates that technology tools not only exist but are also effectively utilized by employees. This is aligned with the argument of Gunasekaran and Ngai (2004), who highlighted that human ability is crucial to gaining the optimum utilization of supply chain technologies. In addition, 95.6% confirmed that their IT systems share information with logistics partners uninterrupted (Mean = 4.78, SD = 0.61). This reflects a high level of inter-organizational connectivity, which supports coordination and efficiency, as suggested by Lee (2000), who opined that supply chain performance in general is enhanced by partners' information sharing.

5.1.1.2 Automation Levels

Approximately 93.4% of the participants reported a high level of integration of automated systems with reverse logistics functions (Mean = 4.67, SD = 0.47). This would translate into

a high process automation level, which is certain to lead to less operating time and costs. This supports Bowersox et al. (2002), which reported that the integration of automation systems renders logistics more responsive. Similarly, 93.0% agreed that automated monitoring tools are used on back-shipped products (Mean = 4.65, SD = 0.48), and 92.2% expressed that existing automation systems are able to easily integrate into reverse logistics requirements (Mean = 4.61, SD = 0.54). These findings reveal positive adoption of agile automation tools. This is in accordance with Srivastava (2008), who emphasized the significance of flexible automation in managing complex logistics processes.

Around 90.2% reported the utilization of automated data gathering devices (Mean = 4.51, SD = 0.50), i.e., barcodes and RFID, that aid returns processing. This agrees with Zhu and Sarkis's (2004) view that automated data systems play a key role in improving reverse logistics efficiency. Furthermore, 94.2% agreed that software programs are used to automate decision-making (Mean = 4.71, SD = 0.46) and 95.6% agreed that automation investments have enhanced their ability to manage recalls and recycling (Mean = 4.76, SD = 0.43). The results indicate the function of automation in facilitation of sustainable logistics practices, as indicated by Sarkis (2003), who linked technology with improved environmental logistics performance.

But less than this (87.8%) agreed that automation of processing returns significantly reduces time and errors (Mean = 4.47, SD = 0.50), which reflects scope for process optimization.

5.1.1.3 System Integrations

Approximately 90.8% of the participants responded that their information systems are compatible with reverse logistics platforms (Mean = 4.54, SD = 0.50), and the same proportion (90.8%) concurred on the implementation of standard integration protocols (Mean = 4.54, SD = 0.50). The responses indicate a solid foundation for technology integration in accordance with the assertions of Laudon and Laudon (2016) who speculate that compatibility and standardization are pillars of effective system integration.

Around 92.2% of the respondents showed technical support for integration of reverse logistics systems in the future (Mean = 4.61, SD = 0.56), whereas 93.6% attested to the presence of a roadmap for future integration (Mean = 4.68, SD = 0.47). These indicate a vision-based system development strategy. This aligns with Christopher (2011), which highlighted the importance of strategic planning in supply chain system development. On the other hand, 76.6% agreed that their organizations experience minimal downtime in adopting

new logistics technology (Mean = 3.83, SD = 1.24), reflecting installation problems or system instability. The finding is consistent with Hazen et al. (2012) concerns, which reported system downtimes could adversely impact reverse logistics performance and cause inefficiencies.

Finally, 94.6% attested to the fact that communication among departments is seamless and supports reverse logistics operations (Mean = 4.73, SD = 0.45), underlining the importance of internal communication systems. This supports the work of Mentzer et al. (2001), whose study put across the fact that effective information flow is essential for supply chain success.

5.1.2 The perceived usefulness and ease of use of technology influence its acceptance and integration in reverse logistics processes.

Consistencies derived from this study emphasized the positive sentiments of the participants toward the effectiveness and usability of reverse logistics technology. There was a 100% concurrence among respondents that reverse logistics technology improves return and recovery procedures with an efficiency score mean of 5.00 and a standard deviation of 0.000. This is in line with Kumar and Dixit (2018), who stated that reverse logistics technology during the digital era makes it much easier to work, saving on turnaround time and resource wastage. Similarly, the 100% full consensus that such a technology enhances total operational efficiency—mean of 5.00—adheres to assertions by Zhang et al. (2020), who noted that firms employing reverse logistics tools recorded up to 25% process efficiency improvements.

Approximately 81% of the respondents (mean = 4.05, SD = 1.224) agreed that reverse logistics systems improve the facilitation of tracing back returned, recycled, or reused products. This reflects a sign of enhanced implementation and system capacity, in agreement with findings by Agyabeng-Mensah et al. (2022), attributing the fact that traceability remains a challenge within most supply chains due to system fragmentation. In addition, 92% of the participants believed reverse logistics technology reduces cost (mean = 4.73), justifying the research findings of Choudhary and Sangwan (2019), who observed that the adoption of such systems can reduce reverse logistics costs by up to 20% in manufacturing sectors.

On the usability aspect, 89% agreed with employees finding it easy to use and learn reverse logistics technology (mean = 4.54), and another 89% agreeing with system interface usability. The findings are supported with Lin et al. (2017), where ease of system design was noted as important in successful technology adoption. However, just 81% of the participants had the view that the technology significantly reduces errors and delays in returns (mean =

4.05, SD = 1.224), which is reflective of problems Saghafian and Van Oyen (2019) identified with variable outcomes in returns processing because of technological discrepancies or lack of completeness in automation.

An unambiguous consensus (100%) was obtained concerning the notion that the benefits of reverse logistics technology outweigh the effort required to implement it (mean = 5.00), consistent with the results of Tseng et al. (2016), who proposed that long-term operation and environmental advantages significantly outweigh starting-up investment barriers. Moreover, 92% of the participants agreed that the technology integrates with existing systems (mean = 4.73), which agrees with Alshura and Assar (2021) who noted that the aspect of integration has a significant contribution to achieving seamless reverse logistics processes. Finally, the overall perception that reverse logistics technology is useful and necessary for operations in modern times was the opinion of 92% of respondents (mean = 4.73) supporting the overall view across literature currently that such technologies are now absolutely vital in circular supply chain initiatives (Nasir et al., 2023).

5.1.3 The extent to which technological capabilities contribute to the effective adoption of reverse logistics practices.

It was noted that 95% of the respondents agreed that the utilization of advanced tracking technologies such as RFID and GPS significantly enhances the efficiency of reverse logistics operations (mean = 1.05, SD = 0.223). This supports Zhang et al.'s (2020) observation, where they indicated that the implementation of RFID in reverse logistics had enhanced tracking accuracy and responsiveness in 89% of the sampled companies. Similarly, 95% of the participants indicated that data analytics is utilized by their organizations to improve decision-making (mean = 1.05, SD = 0.229), consistent with Khor et al. (2018), who emphasized that big data analytics led to a 30% improvement of reverse logistics process optimization.

Besides, 95% of the participants validated that end-to-end information systems such as ERP and WMS play a critical role in coordinating reverse logistics operations (mean = 1.05, SD = 0.223). The finding echoes the observation of Srivastava and Raj (2017), who noted that the adoption of ERP facilitated better coordination of return flows in over 85% of logistics businesses. Likewise, 95% confirmed that real-time information has a large impact on the success of their reverse logistics activities (mean = 1.05, SD = 0.229), echoing research by

Lee and Lam (2019) which credited real-time information to enhanced reverse logistics responsiveness and customer satisfaction.

On automation, there was a 95% consensus among the participants that automation technologies, such as robotic sorting and automated returns, improve reverse logistics efficiency (mean = 1.05, SD = 0.223). This agrees with a study by Bousson et al. (2021), where they stated that automation cut processing time and error rates by up to 40% in reverse logistics. In the same vein, the technological infrastructure that supports effective handling of returned merchandise was supported by 95% of the participants (mean = 1.05, SD = 0.223), in line with Singh and Mishra (2016), who determined that strong IT infrastructure improved reverse logistics reliability.

Moreover, 100% of the respondents agreed that online platforms improve communication and coordination with reverse logistics partners (mean = 1.00, SD = 0.000), a finding consistent with Nandi et al. (2020), who established that digital tools considerably improved partner coordination in 93% of the cases. The same level of agreement (100%) was noted on the ability of technological tools in reducing reverse logistics costs, the influence of IT support on technology acceptance, and the application of new technologies like blockchain and IoT for better traceability (all with mean = 1.00, SD = 0.000). These results mirror those observed by Choi et al. (2023), who noted cost savings of 25–35% with the incorporation of blockchain, and Mehmood et al. (2022), who indicated that IoT enhanced traceability in 90% of the logistics systems they reviewed.

5.2 Conclusions

The findings of the study highlight the principal contribution of digital monitoring and tracking technologies towards refining reverse logistics operations. The widespread use of higher-level tracking technologies such as RFID and GPS is self-evident, with most respondents affirming that the systems form part of their logistics routine. This testifies to previous studies emphasizing the necessity of increased visibility and traceability in reverse logistics so that the products returned can be traced and managed efficiently. Also, the high level of employee training in utilizing such digital tools affirms the tenet that technology adoption must be supported by human capability for maximum effect. Seamless information flow between IT systems and logistics partners is also reflective of the essential requirement of uninterrupted flow of information in optimizing reverse logistics processes.

Automation also plays a very significant role in optimizing reverse logistics efficiency. Good integration of automatic systems was noted in the study, which assists in reducing operating costs and increasing responsiveness. The use of automated monitoring tools, agile automation systems, and automated data gathering practices illustrates that organizations are adopting cutting-edge automation technologies in order to improve returns and improve decision-making. This finding supports previous research that asserts the advantage of automation in managing complex logistics processes, particularly in reverse logistics, where process efficiency is central. Even with such high levels of automation, further improvement in minimizing errors and more efficient handling of returns is possible, implying the necessity for further optimization of such systems.

The results of this research point to an obvious awareness of the considerable function that reverse logistics technology holds in enhancing operational efficiency. The common belief among stakeholders that these technologies enhance the efficacy of return and recovery processes is in line with previous research studies which have highlighted the impact of streamlining in such technologies on logistics operations. Such common belief is an indication of rising trend among organizations to assign more significance to the application of electronic tools such as RFID and GPS in reverse logistics so as to enhance visibility, traceability, and speed in handling returns.

In terms of system ease of use and automation, results report that reverse logistics technology is largely seen as easy and intuitive to use. This supports other studies emphasizing the necessity for simple yet well-organized interfaces and automated systems in ensuring the successful adoption of technologies. While less pronounced was the capability of the technology to reduce errors and delays, results do attest to growing reliance on automation to handle returns in a more efficient way. This concurs with previous studies that require more automation in logistics operations to minimize human error and raise the operation rate.

The findings of this study bring to the forefront the centrality of advanced technologies in optimizing reverse logistics operations. Most respondents recognized the positive impact of electronic tracking devices such as RFID and GPS, in line with available literature on the topic stating the capability of such technologies to improve tracking accuracy and responsiveness of reverse logistics. With the combined application of such devices, organizations can locate returned products along the supply chain, improving overall firm efficiency as well as reducing the complexity of returns handling.

The study also identifies the importance of automation in simplifying reverse logistics processes. The interviewees were consistent in their assertion that automation technologies like robotic sorting and automated returns make reverse logistics more efficient. This supports the argument that not only does automation make processing faster, it also prevents errors in handling returned products. Use of automation in the reverse logistics process allows organizations to manage higher volumes of return efficiently, leading eventually to cost savings as well as improved service delivery.

5.3 Recommendations

The writer recommends that companies invest in the deployment of advanced digital tracking technologies such as RFID and GPS into their logistics networks. The research has already established such technologies to have increased tracking efficiency and accuracy tremendously. With improved tracking, organizations are able to have greater control over returned products and maximize their reverse logistics processes.

The researcher recommends that companies adopt and expand automation technologies, like robotic returns and robot sortation, to further improve the efficiency of processing returned merchandise. The positive effects of automation on reducing processing times and lower error rates, illustrated through the results, indicate that automation investment can bring enormous gains in operations efficiency and cost savings.

The researcher recommends that business organizations assign utmost importance to the integration of their information systems, i.e., ERP and WMS, for smooth coordination of reverse logistics processes. In addition, enhancing real-time data exchange between departments and logistics partners could make decisions quicker and the overall process more efficient, as the research hinted.

The researcher proposes that firms conduct research and employ innovative technologies, such as blockchain and IoT, to facilitate traceability and transparency in reverse logistics. The technologies have the potential to enhance tracking of returned products, reduce operational risks, and improve customer satisfaction, which renders them effective tools for optimizing reverse logistics operations.

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