INTERNET OF THINGS AND SUPPLY CHAIN PERFORMANCE OF LARGE MANUFACTURING FIRMS IN NAIROBI, KENYA

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ABSTRACT

This research investigates the adoption and impact of Internet of Things (IoT) technology on supply chain performance within Nairobi, Kenya's manufacturing sector. The study explores the integration of real-time data, automation, and connectivity to create a "smart" supply chain enabled by IoT. Two theoretical frameworks, the Technology Acceptance Model (TAM) and Resource-Based View (RBV), were employed to assess the extent of IoT adoption and its potential for enhancing competitive advantage in supply chain management. The primary goal is to offer insights into how IoT can enhance efficiency, agility, and cost-effectiveness, thereby driving overall performance and competitiveness among manufacturing firms in Nairobi. Furthermore, the study seeks to evaluate the degree of IoT implementation, analyze the connection between IoT adoption and supply chain performance, and identify obstacles encountered by manufacturers during IoT technology adoption.

This investigation contributes to the scholarly understanding of IoT's influence on supply chain performance and provides valuable guidance for manufacturers and policymakers aiming to augment operational efficiency and competitiveness. The research design relied on a cross-sectional approach, focusing on prominent manufacturing companies situated in Nairobi, Kenya. The study's target population consisted of 455 significant manufacturers operating within the region. A representative sample was adopted using a stratified random sampling technique. Data was collected through questionnaires, and subsequent descriptive and regression analyses are conducted to examine the association between IoT adoption and supply chain performance. The study's results demonstrate notable correlations between predictor and supply chain performance. Statistical significance was confirmed through an ANOVA table that supports the regression model's validity. The coefficients table reveals the strength and direction of variable relationships, with RFID and wireless sensor networks emerging as particularly significant.

The findings indicate that the implementation of IoT technologies leads to enhanced supply chain reliability, agility, and cost-effectiveness. The study recommends that large manufacturers invest in IoT to bolster supply chain efficiency and fully harness the potential of these technologies. However, challenges surrounding data security, privacy, and behavior must be systematically addressed through appropriate policies and best practices. The study acknowledges certain limitations, including limited data availability and challenges in sourcing experienced respondents. Consequently, the study suggests future research focusing on IoT adoption within small and medium-sized manufacturing enterprises.

DECLARATION

This project is my original work and has not been presented for a degree in any other university.

Raymond Vidonyi Kiliru

D61/18978/2019

Signature… … Date: ……**10/08/2023**………..

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ABBREVIATIONS AND ACRONYMS

APICS	American Production and Inventory Control Society
BSC	Balanced Score Card
CAK	Communication Authority of Kenya
CBK	Central Bank of Kenya
ERP	Enterprise Resource Planning
GDP	Gross Domestic Product
ICT	Information and Communication Technology
IoT	Internet of Things
KNBS	Kenya National Bureau of Statistics
KPI	Key Performance Indicator
LSCM	Logistics and Supply Chain Management
PLC	Public Limited Company
P2P	Person to Person
RBV	Resource Based View
RFID	Radio Frequency Identification
ROI	Return on Investment
SCC	Supply Chain Council
SCI	Supply Chain Integration
SCM	Supply Chain Management
SCP	Supply Chain Performance
SCOR	Supply Chain Operation Reference
WSN	Wireless Sensor Networks
TAM	Technology Acceptance Model
TOE	Technology Organization Environment
TRA	Theory of Reasoned Action

CHAPTER ONE: INTRODUCTION

1.1 Background of the Study

Global integration of the end-to-end supply chain actors & events and the technologies needed to achieve it have become competitive requirements in nearly all industries. Companies are going through a significant transition to a decentralized, automated value generation method, sometimes known as the fourth industrial revolution to meet the demands of contemporary supply chain difficulties (Reaidy et al. 2015). A new industry standard of flexible, agile, and responsive operations is what is driving the expansion of automation and computerized advancements. This is through the utilization real-time data, technology that is enabled to catalyze the connection of people, things, processes and creating a framework that can support automated decision-making. The concept of ordinary items having the ability to recognize, detect, and communicate with one another is identified as the Internet of Things (IoT), and it is quickly overtaking existing technologies in this field.

The basic idea of IoT is a "smart" supply chain, which is made possible by other technologies including radio frequency identification (RFID), Wi-Fi, Bluetooth, sensors, and cloud computing. As a result, the supply system can keep an eye on production, track items, estimate demand, and manage inventories (Mostafa, Hamdy, & Alawady, 2019). This is more so witnessed when it comes to Supply Chain Performance (SCP), where studies like Dweekat et al., (2017) demonstrate how IoT may improve Supply Chain Performance Measurement (SCPM) by enabling real-time data collecting and boosting data productivity. Furthermore, enhancing supply chain performance has also been linked to the enhancement of long-term competitive advantages of respective companies (Vass et al., 2018).

Technology Acceptance Model (TAM) and Resource Based View (RBV) management theories will guide the study. The theories in relation to supply chain performance are discussed by Mangla et al., (2019). The TAM is a theory that provides guidance on how the end consumer adopts & utilizes a given technology. The RBV is a model that is applied in management to establish how the core resources a firm possesses can be utilized to advance and defend their competitive positions. These two theories serve as the theoretical framework for our investigation. The TAM will be used to ascertain the extent to which organizations have embraced IoT, while RBV will be used to demonstrate how IoT capabilities may boost competitive advantage in Supply Chain Management (SCM). The RBV theory describes how organizations may attain performance and competitive advantage via the ownership of scarce and valuable resources that other firms cannot replicate. The IoT is a critical resource for a company that assists it in accomplishing its goals (Sachin, 2019).

Internet of Things is the idea that everyday objects may recognize and detect one another, as well as communicate with one another and various online services in order to accomplish a certain purpose or function (Cortés et al. 2015). When it comes to monitoring supply chain performance, IoT can aid in a better knowledge of the chain, favourably impacting partners and enhancing its general performance, particularly from a cost, dependability, and flexibility or agility standpoint (Cortés et al. 2015). Systems for measuring supply chain performance are vital for management to enhance decision-making and for employees and partners in the supply chain to facilitate efficient communication. Through increased interpersonal communication and a cooperative work environment, performance metrics improve organizational performance (Ashioya, 2013). Agility, cost factor and reliability in regards to supply chain performance measurement, are very integral metrics. Any contributing variables that favour their positive performance like incorporation of external factors IoT should be analysed for the overall potential it can have supply chains efficiency and effectiveness.

Ambe (2014) found that the most significant factors for SCP were cost, quality, and the dependability of final product delivery. In contrast to other factors like adaptability, technology, efficiency, and effectiveness, the Ambe study claims that firms measure quality, cost, and time as their primary performance indicators. In supply chain systems, a company's performance is evaluated in terms of its effectiveness, efficiency, quality, customer satisfaction, cost, and other factors. Whereas cost is a simple measurement to perform and is closely attributed to profit, a study by Chan (2013) exposes the misunderstandings and inconsistencies by evaluating the supply chain only in terms of cost, which should not be the only factor to consider. Cost is only one component of the review of the outcome. Customers are regarded as a company's top priority, according to the survey, although cost is not truly connected to customers. According to the study, customers might not profit from cost-cutting since the supplier frequently refuses to lower prices even when costs are marginally lower. Cost and resource use were determined to be quantitative performance measurement metrics, whereas quality, flexibility, visibility, trust, and innovativeness were determined to be qualitative performance measurement metrics.

Kenya's economy relies heavily on the manufacturing industry. The industry generated an average of under 10 percent of the republic's Gross Domestic Product between the years 2012-2017 (KNBS, 2020). The government of Kenya has implemented policy interventions aimed at boosting the sector's contribution to the GDP, with targets as high as 15%. Some of these initiatives include 'Vision 2030' and 'The Big 4 Agenda' (KNBS, 2020).

A strong and thriving domestic manufacturing base is key to increased economic development as it's a key linkage in vital value chains e.g. the agricultural sector. This enables drive increased efficiency and hence a strong trigger towards productivity gains. Under the Kenya Vision 2030 blueprint document, a key intervention deemed vital by the government in the manufacturing sector was through investment done in research, development & innovation to ensure that efficiencies and competitiveness were enhanced at the firm level leading to increased exports. A company that integrates IoT into its supply chain operations is anticipated to reduce expenses and enhance responsiveness to customers, leading to increased competitiveness compared to its counterparts in the industry.

1.1.1 Internet of Things

The creators of the first MIT Auto-ID Center, , first used the term "Internet of Things(IoT)" about ten years ago (Sundmaeker et al., 2010). "Auto-ID" is a comprehensive term that encompasses a variety of identification technologies utilized in different industries to automate processes, minimize error rates, and improve productivity. These technologies include barcodes, smart cards, sensors, speech recognition, and biometrics. The concept of IoT aims to enhance supply chain integration by connecting objects from an internet perspective (Morssi et al., 2020). The IoT establishes a network that links physical items and devices through the internet. It enables the discovery, identification, and control of devices on a global scale. Consequently, businesses can effectively manage, plan, and monitor their supply chains in real-time and additionally, improve an entity's aptitude to interface through its consumers, suppliers, and core procedures (Morssi et al., 2020). There are numerous IoT definitions accessible in the academic literature. Mehl (2018) describes IoT as a web of interlinked things that can be turned on and off by software and automated processes.

The physical components and resources that make up a company's supply chain are digitally interconnected in order to detect, monitor, communicate, coordinate, and otherwise help the organization run more efficiently (Ben-Daya, (2019). There are currently many components of SCM that depend on IoT to be operationally excellent (Cui et al., 2020). The Internet of Things connects, controls, and optimizes objects and sensors through wired and wireless connections as well as hybrid systems (Guisto et al., 2010; Atzori et al., 2010). An RFID tag connected to a network, for example, might initiate communication to send identifying data (Xu et al., 2014). The RFID (Radio Frequency Identification) is a wireless communication system that utilizes electromagnetic or electrostatic connection within the radio frequency part of the electromagnetic band to distinctively recognize objects, animals, or individuals. The RFID techniques improve waste reduction (42.2%), sales growth (40.1%), and supply chain efficiency (45.4%), among other supply chain metrics (36.3%) (Cui et al., 2020). Adoption of RFID technology may result in long-term competitive advantage, luring more businesses in the near future. The RFID data may be connected to the internet to increase efficiency and production in a firm (Gubbi et al., 2013).

While it is intriguing to use wireless sensor networks (WSNs) to get accurate observations about the real world, techniques for transmitting data that are scalable, dependable, and energy-efficient are required for new WSN applications. Huge amounts of inexpensive but energy-restricted sensor nodes that make up WSNs, would be integral to environment monitoring and surveillance. However, wireless networks' well-known tendency for temporal variation and error-proneness is present (Wang et al., 2015). Benefits associated with the application of WSNs to supply chain integration and performance include reduction of overhead costs, higher reliability, good scalability and flexibility, and increased energy efficiency. In general, other IoT components that include RFID, middleware, cloud computing and application software elements are useful for real-time data collection and exchange among a network of businesses connected to the internet. Consequently, through the synchronization of information and physical flow, the implementation of IoT assists in connecting the tangible and digital domains (Morssi et al., 2020).

Middleware mediates communication between several programs. Additionally, middleware can be viewed as a distribution platform, or as a protocol operating at a layer above that of basic computer communication. Unlike low-level network services, middleware always facilitates the communication of processes rather than just plain computer-to-computer connection. Middleware's objective is to lighten the burden on application programs so that the development process can be optimized through increased productivity (Ajana et al., 2011). The intermediary software layer, referred to as "middleware," plays a pivotal role in connecting the physical layer encompassing RFID tags and readers with the upper layer comprising independent or distributed business applications (Ajana et al., 2011). Its primary function involves facilitating the exchange of information between tag readers and business applications, making it an essential component. In earlier applications of RFID, such as access control, there was no need for networking between RFID readers, thus eliminating the requirement for RFID middleware. However, in specialized domains like Supply Chain Management (SCM), multiple RFID readers are interconnected to capture data that is subsequently distributed to various backend applications.

Despite the fact that cloud computing has almost 20 years of history, supply chain experts are still cautious in migrating their systems to the cloud infrastructure. This is because of lack of enough sensitization on practical implications to cloud computing (Cervi, 2015). By 2021, sales of supply chain management (SCM) software were anticipated to reach $19 billion (Cervi, 2015). Despite the fact that the industry has just beginning its journey to cloud computing, the application cloud technologies by SCM is very rational as it helps locate the product throughout its existence. As a result of the need to track shipments at any point of a supply chain process, cloud-based supply management can also considerably lower the amount of lost goods. Additionally, if a shipment is misplaced, you can quickly decide what to do and communicate efficiently using IoT application software. Practically all industries may examine and utilize the data collected by these devices for a variety of purposes. For instance, IoT in supply chain management improves logistical efficiency and guards against delivery delays. It makes sense that in 2021, real-time supply chain visibility would be a priority for around 40% of supply chain management executives (Statista, 2021). Additionally, it facilitates the technology-encouraged interchange and transparency of supported information.

The major objective of SCM should be to maximize the supply chain surplus or the total value created. The management of all resources and flows (financial, informational, and material/product) throughout the supply chain is described as SCM. Moreover, apart from suppliers, manufacturers, and buyers, the supply chain establishes connections between multiple layers in the upstream segment and end-users who derive value from the product or service on the downstream side. This implies that to attain optimal efficiency, it is essential to economically manage an d interconnect the entire supply chain network (Chopra & Meindl, 2013).The IoT creates a new environment for supply chain practitioners by connecting products, people, equipment, and supply management. The traceability of information with supply chains has been enhanced due to IoT technology, which was not promising with earlier technologies. By enabling process integration and information transmission, it also stimulates more effective supply chain organization.

1.1.2 Supply Chain Performance

The SCM encompasses the management of actions within a network that deals with the shifting of products, services and information from raw materials to finished products ready for consumption by the end user. Consequently, SCM is concerned timely manufacturing and delivery of products to clients (Chang et al., 2013). For the measurement of SCP, Balanced Score Card (BSC) has been successfully employed by Frederico et al., (2021) in supply chain performance evaluation during the 4.0 industrial period and (Balaji et al., 2021) in deducing supply chain performance using the BSC approach. The original concept of the balanced BSC achieves equilibrium by integrating a blend of short-range and enduring performance indicators, encompassing both financial and non-financial aspects. The BSC introduces metrics from three distinct outlooks: customer, internal processes, and learning and growth. These viewpoints are interconnected through cause-and-effect relationships and are considered pivotal in generating long-term shareholder value. These measurements are an addition to traditional financial performance measures (Mio et al., 2021).

The Supply Chain Operations Reference (SCOR) model is a valuable outline used to describe, communicate, evaluate, and identify opportunities for improving workflow efficiency. This model mainly focuses on delineating the principal processes within a SC system (Oswaldo Mañay et al., 2022). The most recent iteration, SCOR 12.0, was jointly developed by the American Production and Inventory Control Society (APICS) and the SCC in 2017. Since its initial launch in 1996, the SCOR model has undergone several revisions to reach its current 12th edition, serving as a practical resource for planning, measuring, and comparing supply chain practices and outcomes (Phadi & Das, 2021). This model incorporates supply chain operations, performance metrics, best practices, and technology into a unified framework, facilitating efficacy in communication and uninterrupted SC enhancement. It's recognized as an integrated strategy based on the concept of a connected SCsystem (Es-Satty et al., 2020). Furthermore, the SCOR model serves as a global benchmark for supply chain comparisons and has gained increased utilization among practitioners and academics in value chain management (Lemghari et al., 2018). The model defines five key activities: planning, sourcing, making, delivering, and the returns process.

The SCOR model is a strategic key performance indicator management tool that enables an organization obtain quantifiable and implementable results, as per Ntabe et al., (2015), hence this very rigorous SC assessment approach. There are about 250 performance measures according to APICS (2020), which are classified as follows into the five supply chain performance elements namely agility, reliability, costs, responsiveness and asset management efficiency. The foundation of each company's market rivalry is its products. Enhancing the efficiency of the SC can significantly lower the operating expenses of goods in terms of production, distribution, and transportation, as well as increase operational effectiveness and market response time. To achieve the harmonious coexistence of upstream and downstream businesses, minimize cross-chain friction, and increase supply chain efficiency, supply chain optimization must begin from a broad perspective (Xia & Liu, 2021).

Satisfaction of client requests, such as timely, damage-free, and complete order delivery, is a key indicator of an organization's level of reliability. The most crucial element involved in the administration growth and success of a supply chain is a solid partnership between the network's stakeholders, one in which they can have reliance in each other's talents and actions. Therefore, increasing partner confidence and trust as well as assuring their dependability are essential for the long-term development of any integrated supply chain (Taghizadeh & Hafezi, 2012). If a firm intends to satisfy the needs of its customers, one of its stakeholders, its supply chain must be flexible. The agility of a supply chain, measured by its ability to respond to market changes and boost competitiveness, is paramount. As stated by Mostafa et al. (2019), IoT-driven supply chain solutions play a vital role in facilitating real-time management of the entire system, thereby elevating the SC adaptability and responsiveness to new scenarios. Haddud et al. (2017) discovered that the implementation of IoT in SC enhances reliability, responsiveness, and agility through swift real-time information exchange and advancements in supporting process activities.

Most supply chain organizations work on managing the overall cost of supply chain procedures. The most significant benefits for businesses come from increased productivity and lower costs, which may be achieved by shortening the length of the supply chain. Less missed sales, less inventory, and cheaper operating costs are indications of this. By increasing productivity, IoT has been proved to have a favourable financial and operational impact on business models (Schmidt et al., 2022). Amazon serves as an excellent example of effectively implementing a multi-layered company model to enhance productivity. They focus on optimizing organizational procedures by leveraging innovation to improve performance, considering factors such as time, cost, and information flow (Schmidt et al., 2022). The integration of IoT in SCM offers a wide array of benefits, as emphasized by Morssi et al. (2020). These advantages encompass the application of predictive analytics for demand forecasting, warehouse automation to minimize related expenses, the incorporation of chatbots in procurement to streamline processes and reduce costs and sales cycle time, the utilization of intelligent transportation systems, and real-time monitoring and management of cargo location.

1.1.3 Large Manufacturing firms in Kenya

The economy of Kenya relies heavily on the manufacturing industry (Rodrik, 2016). Recent performance concerns in the manufacturing sector have included the trade deficit, the decline in GDP, and the shutdown of foreign manufacturing companies in the country. The issue has resulted in decreased government yearly GDP share, unemployment, inflation, and trade imbalances, which have caused the currency to weaken and become unstable as a result of an increase in imports. As compared to its present performance stagnation, Kenya was formerly a top investment location in Africa (Magutu et al., 2015). Due to their innovativeness, manufacturing companies in industrialized nations like Canada perform better than those in underdeveloped nations.

Within the economic component of Kenya Vision 2030, the significant expansion of the manufacturing sector is anticipated to robustly bolster the economy and national advancement, creating employment opportunities, attracting foreign currency, and promoting foreign investments. The creation of jobs, generating income, processing local raw materials to create value, and engaging in international trade are currently the most pressing needs of the large-scale manufacturing subsector. Implementing the necessary production and communication technology to improve the quality, speed, and flexibility is crucial in this regard (Magutu et al., 2015). According to Price Waterhouse

Coopers (PWC), (2010), the Kenyan large-scale manufacturing subsector has a troubled past, an ad hoc approach, and a disjointed industry structure. Multinational manufacturing corporations in particular have moved their activities out of Kenya's large-scale manufacturing subsector. These organizations have moved, closed, or reduced the size of their operations because they view Kenya as one of the least productive nations in the world. Poor infrastructure, high tariffs, and taxes are to blame for this. Despite these obstacles, the sector is anticipated to contribute significantly to Kenya's Vision 2030 goal of industrialization and its ability to compete globally.

The manufacturing sector's employment representation has historically averaged 18.9 percent, ranking second after the agriculture sector. KAM (2018) statistics shows that the manufacturing share of the GDP in Kenya has maintained an average of 10 percent from 1964 to 1973, experienced a slight increase to 13.6 percent from 1990 to 2007, and recently dropped below 10 percent. In contrast, countries with similar economic profiles to Kenya at the time of independence, such as the Democratic Republic of Congo, Vietnam, Cameroon, Malaysia, and Bangladesh, have witnessed their manufacturing sectors contribute significantly more to GDP, with respective percentages of 18.1, 16, 15.3, 22, and 18 (World Bank Group, 2019).These GDP numbers of the manufacturing sectors are double that of Kenya. Research and innovation are essential for long-term industrial development and production, and are typically the outcome of foreign direct investments (FDIs) in the early phases of success. In the long term, research and development allows for increased product diversity and competitiveness. Research and development initiatives are still lacking in Kenya and the rest of the East African Community (EAC) (World Bank Group, 2019). Manufacturing in Kenya is in its early phases, with the focus on integrating foreign technology into current production structures and processes, as well as designing goods for local markets that are adapted to the country's needs.

Kenya's manufacturing industry has several advantages. In the last two decades, its export share has expanded globally, and it holds a dominant position in the exports to the EAC market, particularly in some high-value industries like chemicals and pharmaceuticals. Kenyan manufacturers are frequently youthful and energetic, benefit from highly trained managerial personnel, and have an expanding ability for innovation, particularly in new product development. Despite these successes, formal employment growth is modest, productivity has stagnated, and overall output growth lags behind that of services. The sector's FDI has stalled, and exports are extremely tiny and primarily restricted to low-value markets. Additionally, exporters have significant mortality rates; just 35% of them make it past the first year (Farole & Mukim, 2013).

The issues with manufacturing competitiveness are caused by various interconnected restrictions. Manufacturing companies tend to be small, under-utilize their productive potential, concentrate little on export markets, and invest less in quality. These firm dynamics appear to mirror some of the restrictions. The business environment that enterprises must operate in further shapes these immediate explanations of competitiveness performance. The manufacturing sector in Kenya is constrained by a number of issues that affect investment, growth, productivity, and innovation. Inadequate access to financing, high costs and unreliability of electricity, the burden of corruption and regulatory restrictions, the lack of competitively priced inputs, and technical impediments to trade, particularly with regional markets, are among the most significant of these (Farole & Mukim, 2013).

1.2 Research Problem

There are several advantages to incorporating Internet of Things (IoT) into business and supply chain models. Currently available research shows that IoT may be beneficial in product monitoring to find items, commodities, and assets, as well as to know their present state and environmental conditions (López et al, 2007). Supply chain traceability may be improved by enabling increased visibility and monitoring of goods along with better communication between supply chain actors thanks to RFID technology. In order to satisfy consumer expectations for safe and high-quality food, the food industry must increase its traceability capabilities (Maksimovi et al, 2015). The IoT may reduce operating expenses for clients in numerous ways (Aryal, 2018). For companies, IoT allows them to better understand their customers' demands and interact with them so that they may better regulate demand and provide customer care (De Vass et al, 2018). The IoT makes it possible to gather real-time data across organizational units, processes, and people in a timely manner (Kamble et al, 2019). Due to the new technologies, incoming logistics for export operations may become more affordable and timely (Pishdar et al, 2018).

The IoT's potential to improve SCM is a pertinent issue across the world. Data about supply chain partners' actions, resources, and processes may support supply chain innovation (SCI) by enhancing the general effectiveness of all SC stakeholders. (Dhumale et al., 2017) showed in their study of the effect of IoT implementation across SC, companies may benefit from this technology in terms of growth and the capacity to tackle current and future challenges. The IoT and cyber-physics systems (CPS), big data, smart factories, and interoperability were studied in Pakistan by Imran et al., (2018) using quantitative research methods and a cross-sectional study methodology.

Altogether, the five qualities were shown to have a positive correlation with both manufacturing and service output, demonstrating that they play a vital role in improving productivity. Following an investigation into the commercial and societal repercussions of incorporating IoT and Industry 4.0 technologies into storage facilities, the findings of this study were collected. The study sought to show how doing so can save money for any industrial organization while also improving performance.

Farmers' adoption of IoT sensors and monitoring systems, their effect, and what can be done to extend the technology beyond early adopters and maximize the potential of IoT in an agricultural environment were studied by Odhiambo, (2018). He discovered that technical factors influence farmers' adoption of IoT technology in farming. Higher education institutions in Kenya should lower their latency time in their business architecture in order to better support instructional technology, according to a study by (Letting, 2020). Mugeni et al., (2020) investigated how IoT may be used to better prepare for floods and droughts. In Kenya, variables such as perceived technical expertise, perceived simplicity of use, and apparent value all play a role in flood and drought management adoption. African socioeconomic difficulties were the subject of study by Machii et al., (2020) on the strategic integration and use of IoT and big data. For example, it has been shown that increased IoT acceptance would lead to increased service delivery, productivity and strategic planning as well as improved logistical decision-making and increased profit maximizing.

Oswaldo Rodríguez Mañay et al., (2022) measured the SCP of a floricultural segment by means of the SCOR model. The result was the development of a framework in which measuring the overall supply chain performances of companies was possible. This particular study supports the approach in which the study is aiming to pursue in using the SCOR model to measure the SCPs of large manufacturing companies operating in Kenya in relation to their different capabilities of adopting IoT in their SC processes. Panya et al. (2021) carried out an investigation to assess the efficiency of Kenya's sugar sub-sector concerning sustainable supply chain practices. The research established a robust correlation between the performance of Kenya's sugar sub-sector and the practice of green procurement. To mitigate production costs and align with the technological shifts shaping the manufacturing sector in Kenya and globally, the report recommended that manufacturing companies adopt green manufacturing approaches. Additionally, the report emphasized the necessity of further research to determine the overall positive impact of modern SC techniques on the performance of manufacturing enterprises operating in Kenya. Cement, textiles, chemicals, and related industries are among these other manufacturing sectors.

Kariuki et al. (2021) recently conducted a study in Kenya that examined the implementation of IoT in the manufacturing and construction sector. Their research revealed that larger corporations and high-end businesses are categorized as early adopters due to their ability to handle significant financial risks. Furthermore, the adoption of IoT in these industries is driven by the inherent need to enhance visibility in underlying operations. However, Kariuki et al. did not explore the specific net effect of IoT on the SCP of these major manufacturing companies, which is the focus of the present study. In light of this, the following research questions will be addressed in this study:

1. To what extent have major companies in Kenya embraced the IoT?
2. What is the association between IoT adoption and the SCP of large manufacturing companies in Kenya?
3. What difficulties do Kenya's huge manufacturers encounter when using the internet of things?

1.3 Research Objectives

1.3.1 General Objective

The overall aim of this research was to investigate how the adoption of IoT impacts the SCP of large manufacturing companies.

1.3.2 Specific Objectives

The below objectives guided the study:

i. To evaluate the extent of IoT implementation SC of large manufacturing companies located in Nairobi, Kenya.
ii. To examine the relationship between the adoption of IoT and the supply chain performance of large manufacturing firms in Nairobi, Kenya.
iii. To establish and assess the barriers encountered by large manufacturing companies in Nairobi, Kenya, during the adoption of IoT technology in their supply chains.

1.4 Value of the Study

The research holds value for academics as it contributes to the establishment of a knowledge foundation concerning the potential impact of IoT adoption on the SCP of significant manufacturing companies in Kenya. The outcomes of this study can serve as valuable insights for further research in IoT. Consequently, this study has the ability to enrich knowledge within the relevant sector.

For manufacturers, this study provides critical information on how to utilize IoT as a strategy for increased efficiency, which is why this research is so important. As a result, it will be easier for Kenyan manufacturers to connect the value of IoT to the firm's supply chain performance (SCP). With these results in mind, stakeholders may utilize this information to better understand how IoT might impact SCP and how major manufacturers are coping with the difficulties they have in implementing IoT.

Policymakers in Kenya will benefit from this study's results, which may be used to design regulations that encourage the use of innovative IoT and other new technologies. For SCM in Kenya, this will aid in the adoption and proliferation of IoT technology.

CHAPTER TWO: LITERATURE REVIEW

2.1 Introduction

This chapter delves into two relevant theories for the current study: The Technology Acceptance Model (TAM) and the Resource-Based View (RBV). It also covers the concept of IoT and the associated adoption challenges. Furthermore, the chapter investigates the role of IoT in Supply Chain Management (SCM), offering a recap of the conducted literature review and presenting the conceptual framework.

2.2 Theoretical Literature Review

This section establishes the theoretical basis for the study, which revolves around two core theories: TAM and RBV. Each of these theories is described in more depth below.

2.2.1 Technology Acceptance Model Theory

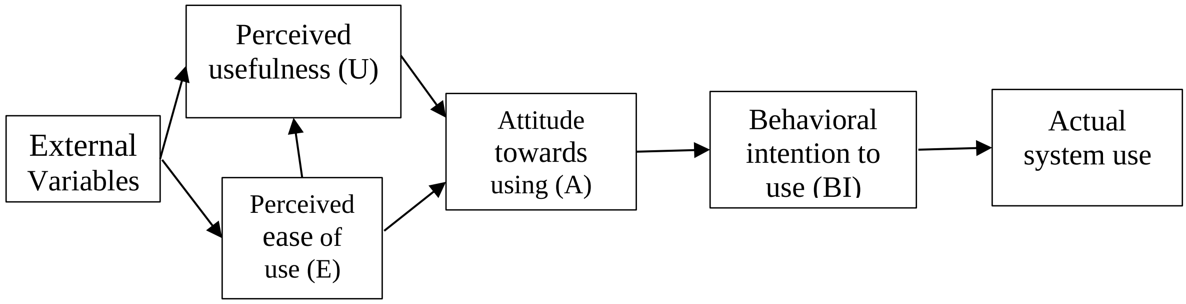
Over the past thirty years, numerous theoretical models have emerged to analyze and clarify attitudes and behaviors associated with the implementation of Information and Communication Technology (ICT). Instruments assessing task-technology fit have been validated and employed to gauge the alignment of a technology with user tasks. One of the extensively recognized models in this domain is the TAM, initially introduced by Davis in 1989. The TAM has since gained widespread adoption as a model for examining the factors influencing users' acceptance of novel technological solutions. According to the TAM, the connection between system qualities (external variables) and system usage is mediated by the perceived usefulness and ease of use of the technology. (Rahimi et al., 2018). The TAM is an extensively employed information systems theory used by researchers across various fields to understand the adoption of IT/IS. It has been referenced in studies by scholars such as Hao (2013), Heili and Assar

(2009), and Ramdani and Kawalek (2008). User adoption and collaboration with technology is rationalized by the theory of rational action (TRA). When it comes to deciding when and how to incorporate and adopt new information, two factors are thought to have the most effect i.e., the perceived ease of use (PEOU) and the perceived utility (PU) of a new technology (Davis, 1989). To better explain and anticipate the embracing of new technologies in society, TAM has undergone many modifications apart from PU and PEOU. The study is based on TAM, with the assumption that the complexity or ease of use of IoT may restrict or accelerate adoption by employees and managers alike. The predicted advantages of IoT are regarded appealing and persuasive to prospective users, which increases their view of the technology's utility, hence increasing IoT adoption in the supply chains of big firms.

Autry et al. (2010) found that in technologically unstable environments, there is a stronger correlation between a firm's assessment of a supply chain technology's utility, usability, and intention to deploy the technology. However, for firms with a greater technological breadth, there is a weaker correlation between a company's intention to employ a supply chain technology and its actual deployment, particularly if the company has already embraced other supply chain technologies.

In view of IoT and its various components such as RFIDs, WSNs, middleware, cloud computing, and IoT application software, it is hypothesized that supply chains are more likely to adopt and utilize these technologies if there is already a significant level of technological disruption or technological environment in place. The figure below explains the concept of TAM.

Figure 1:1: TAM



Source: Davis, F.D. (1986) A Technology Acceptance Model for Empirically Testing New End-User Information Systems: Theory and Results. Doctoral dissertation, MIT Sloan School of Management, Cambridge, MA.

2.2.2 Resource Based View Theory

Edith Penrose's Theory of the Growth of the Firm is a seminal work that presents a process theory of growth cantered on knowledge search and organisation. Penrose's research, conducted between 1956 and 1973, primarily focused on large international corporations that were operating in developing countries. She emphasized the role of government assistance in the growth process. It can be argued that Penrose, influenced by her Austrian mentor Fritz Machlup, employed a revisionist approach and utilized a Marshallian case study method. Her perspective on global growth aligns closely with that of scholars like Roy Harrod, Maurice Byé, and Charles Kindleberger, who advocated for government restrictions on the investment activities of these companies in their economies (Connell, 2009). It should be noted that Penrose (1959) was the first to propose the concept of Resource-based Views (RBV).

Penrose anticipated a distinct departure from the uniformity of the accessible productive resources. The central emphasis of the RBV revolves around the idea of heterogeneity within an organization's resources. According to Penrose, a firm can choose to grow both internally and externally by utilizing its resources through fusion, acquisitions, and diversification. Only when those resources are discovered and used in a way that makes them easily accessible to the business in question can an organization's competitive advantage be extracted from them.

These businesses need to assess their strengths and weaknesses to create strategies for competing with their counterparts using the resources available to them (Wernefelt, 1984). According to the concept of the Resource-Based View (RBV), an organization's valuable resources are the key factors that drive its success and competitiveness. In line with this notion, a company's unique capabilities and resources, which are difficult to replicate and possess value, primarily shape and impact its overall performance and competitive advantage (Barney, 1991). Through RBV, businesses can examine the position of their internal resources and abilities to build and implement their company strategy (Sheehan, 2007). The most major weakness of RBV, on the other hand, is its inability to actualize the alternative resource configurations, which can have the same value for firms and, as a result, gain no competitive advantage.

Resources gain value when they are employed to execute strategies. The true value of these resources is determined by evaluating the value generated by the strategies and connecting this value to the resources and capabilities. For a company to effectively manage its development and growth, it must monitor the factors driving change and growth, as well as those that respond to demands and threats. In this regard, managers are key in optimizing the use of the company's resources to capitalize on opportunities and mitigate threats, while also remaining vigilant about shifts in the business environment. The organization's culture and values should be sufficient to fulfill the primary success criteria, and strategic responses must ensure the realization of these criteria. By viewing of IoT elements (RFID, WSNs, Middleware, Cloud Computing and IoT application software) as potential resources to be utilized by the respective large manufacturing entities in Kenya, they will enable these organizations to develop competitive advantages that can promote growth and diversification driving their supply chain performance to increase. By viewing IoT elements as different resources available to manufacturing companies by the RBV approach, the heterogeneity of these resources can be adopted as internal resources of the organizations and hence can be deployed to implement different strategic approaches taken by these organizations.

2.3 Internet of Things

The term "IoT" was first introduced by Kevin Ashton in 1999 within the context of supply chain management. The IoT refers to intelligent, individually addressable "things" or devices and sensors that are characterized by adaptability, autonomy, and intrinsic security, which stem from their communication protocols (Shafique et al., 2020). The hardware aspect of the IoT architecture encompasses sensor nodes, embedded communication modules, and interface circuits. Middleware encompasses resources for data management, analysis, and storage. The presentation layer involves the use of effective visualization tools compatible with multiple platforms, enabling diverse applications and providing user-friendly data in a comprehensible format (Shafique et al., 2020). The IoT elements comprise of: Connected Devices, Central Control Hardware, Data Clouds, User Interfaces, Network Interconnections, Systems Security and Data Analytics.

Devices comprise the predominant physical elements integrated into the system. Within the device connectivity layer of the Asset Control Systems, the key components are sensors. These advanced sensors constantly gather environmental data and convey it to the underlying layer. Contemporary semiconductor fabrication methods enable the creation of compact, intelligent sensors suited for diverse applications (Roselli et al., 2014). Acting as a centralized hub, a control panel facilitates bi-directional data traffic management across multiple networks and protocols. It interprets various network protocols and ensures seamless compatibility among the interconnected devices and sensors (Roselli et al., 2014).

The IoT generates an extensive volume of data originating from users, applications, and devices, making effective data management essential. The IoT cloud provides functionalities for streamlined data collection, management, processing, and storage. This data can be remotely accessed, empowering businesses and services to make well-timed and informed decisions. The IoT cloud encompasses an advanced, high-performance network of servers, purpose-built for traffic management, high-speed data processing, and precise data analysis. Distributed database systems are pivotal components in the architecture of the IoT cloud (Alessandra & Masotti, 2071).

User interfaces serve as the visible and accessible part of the IoT system, enabling users to interact with the connected devices and access relevant information. Designers must ensure that user interfaces are well thought out to encourage user interaction. In today's competitive market, user interface design plays a crucial role in influencing user decisions to choose a particular product or appliance. User-friendly products that are compatible with widely used connectivity protocols tend to attract more users (Alessandra & Masotti, 2071). The exponential growth of internet-connected devices is a significant trend in IoT in recent years. While each device's specifications may vary, most devices share fundamental characteristics. The IoT relies on various technologies, and the network used for device interaction plays a vital role, with multiple wireless or wired technologies available (Niyato et al., 2017).

The Internet of Things has been evolving since its inception, with the IoT ecosystem expanding through the introduction of new technologies and protocols. The focus has been on improving accessibility, affordability, energy efficiency, and, most importantly, security. Analytical processing involves converting analogue data from networked smart devices and sensors into actionable insights for in-depth study, evaluation, and system administration. Intelligent analytics are essential for effective IoT systems, including real-time analytics that enable engineers to detect anomalies in the data and take prompt action to prevent unfavourable scenarios. Accurate data collection at the right time allows service providers to plan subsequent measures (Niyato et al., 2017).

All that is necessary for RFID to operate is a tag, a reader, and radio waves. The tag may hold more information than a standard barcode. The Auto-ID Centre created an RFID-based Electronic Product Code (EPC) that is incorporated into the tag. Three main kinds of tags are now used. Passive RFID tags are powered by the reader's radio frequency energy, which does not need a battery (Gubbi, Buyya, Marusic, & Palaniswami, 2013). The RFID technology may be used in a number of different contexts, including tracking inventory, passports, tolls, and other fees at the item level. Incorporated in the system is a battery supply and capability to communicate with readers. External sensors may be added to active tags to detect temperature, pressure, chemicals, and other variables. Manufacturing, medical labs, and remote-sensing IT asset management are all examples of industries where active RFID tags are used. Rather than relying on a reader to power their microchips, semi-passive RFID tags use their own batteries. RFID tags that are active or semi-active cost more than passive tags (Reaidy, 2015)

Items may be tracked more effectively using RFID systems and wireless sensor networks (WSN) that distribute autonomous sensor-equipped devices throughout the environment (Atzori, Iera, & Morabito, 2010). In WSN networks, any topology and any number of hops are possible. Compact WSN devices have become more efficient, inexpensive, and power-efficient in recent years because to low-power integrated circuits and wireless communications (Gubbi et al., 2013). Warm-chain logistics, in which temperature-sensitive goods are carried in heated and refrigerated packaging, is the principal use of WSN technology (White & Cheong, 2012; Hsueh & Chang, 2010). Additionally, WSN may be used for routine maintenance and monitoring. When it comes to wind turbines, General Electrics (GE) employs sensors to monitor their performance. With real-time data analysis, General Electric reduces the amount of time and money it spends on maintenance up front. To provide services like preventive maintenance and other services, American Airlines uses sensors that can collect 30 terabytes of data every flight (Gubbi et al., 2013).

The purpose of middleware is to simplify communication and input/output for software developers by placing a layer of software between them. Because it has the ability to obscure the characteristics of different technologies, software services that aren't directly tied to a certain IoT application should be removed from the hands of IoT developers. As it gained popularity in the 1980s, the software layer played an important role in facilitating the transition from older to newer technologies. To establish new services in a distributed computing environment, it became simpler than before. Middleware is well-suited for IoT application development due to its ability to streamline the creation of new applications and services in a distributed infrastructure encompassing a wide range of diverse devices. Using GSN, an open-source sensor middleware platform, sensors may be developed and deployed with almost little programming effort. With an ever-changing and unpredictable network topology, most middleware systems for the Internet of Things are service-oriented (Kamble et al, 2019).

An on-demand pool of programmable resources (computers, networks, servers and storage) that may be deployed as Infrastructure as a Service (IaaS) or a Software as a Service model can be found in the cloud computing paradigm (SaaS). The IoT has resulted in a massive volume of data being created by gadgets that are linked to the Internet (Gubbi et al., 2013). Fast-speed broadband networks, large amounts of data storage, and high processing speeds are all necessities for many Internet-of-things (IoT) applications. Big data and real-time processing for IoT devices and people may be handled by cloud computing, which is a perfect back-end solution. An excellent illustration of how cloud computing may be used in supply chains is Amazon. Amazon is a worldwide internet retailer with headquarters in Seattle. Amazon has established a robust technical infrastructure and developed application software to cater to the needs of businesses and individuals. Its website offers a diverse range of products and services, reflecting the company's strategy to diversify its market offerings. Notably, Amazon has made significant investments in warehouse technology, which plays a crucial role in its operations. The company's business model heavily relies on cutting-edge technology, particularly cloud computing. In the field of cloud computing, Microsoft and IBM are recognized as major market leaders alongside Amazon (Schmidt et al., 2022).

Numerous industry- and user-specific IoT software applications may now be created with the help of the IoT. In contrast to devices and networks, the IoT apps allow devices to communicate with one other and with humans in a secure and dependable way. Data/messages must be received and acted upon in a timely way by IoT apps on the devices they are installed on. Transportation and logistics applications, for example, monitor things like fruits, fresh-cut vegetables, meat, and dairy products as they travel through the supply chain. For preservation, the conservation state is regularly monitored (temperature, humidity, shock) with vital steps performed when the connection is out of range (to prevent rotting). FedEx, for instance, makes use of Sense - Aware to keep track of a package's temperature, location, and other vital indicators (Kamble et al, 2019; Rejeb et al, 2019). Many IoT applications aimed at humans include data visualization to make information more understandable and interactive for end users. This isn't necessary for device-to-device applications, but it is becoming more common in IoT applications aimed at humans in general. An intelligent IoT application is essential for the devices to monitor the environment, recognize faults and interact with one another without the need for human involvement.

2.4 Challenges of Internet of Things Adoption

Smart IoT solutions must be used by companies in order to support more efficient supply chains. Poor supply chain technology integration is a major reason for business failure for the majority of organizations (Majeed and Rupasinghe, 2017). Incorporating the IoT is fraught with challenges. As a consequence, the IoT has been largely ignored by businesses (Ryan and Watson, 2017; Vass et al., 2018; and Da Xu et al., 2014). As a result of a lack of skilled and knowledgeable employees, IoT adoption has been hindered (Ryan & Watson, 2017; and Hung, 2018). Existing organizational settings, structures, and models have historically had difficulty adopting new technologies. After the IoT is implemented, this drawback holds true (Pfisterer et al., 2016; Hognelid & Kalling, 2015; Dijkman et al., 2015).

In addition, there may be obstacles related to the integration of internal and external technology systems (Bröring et al., 2017; Valmohammadi, 2016; Da Xu et al. (2014); Buntz, 2015; Hussain, 2016; Gnimpieba et al., 2015). Risks and variabilities associated with the usage of ecosystems in IoT deployments are further roadblocks to widespread adoption (Lee and Lee, 2015; Riggins and Wamba, 2015; Reaidy et al., 2015). Last but not least, many businesses are just unprepared for such a significant change to occur in their industry. As a result of these issues, there is a lack of infrastructure (objects and network connection, data services, etc.), security and privacy concerns, and organizational reluctance to participate in IoT (Anirudh et al, 2017). (Birkel, 2019), Bardaki (2010).

2.5 Internet of Things and Supply Chain Management

Supply chain performance might be considerably improved by Radio Frequency Identification (RFID) technology, which can provide detailed information in real time, increasing both visibility and control for everyone involved. Many firms are reluctant to use this technology because they are unsure of how to explain the Return on Investment (ROI). To achieve long-term and substantial ROI, RFID deployment must concentrate on multiyear payback periods rather than short-term return, according to a wide range of sources (Brandel, 2003). Reducing inventory and improving asset utilization resulted in an overall 55% reduction in inventory costs and a 30% reduction in asset utilization costs, including capital and system development costs of RFID, according to a case study on RFID-linked supply chain costs compared to barcode-driven supply chains (Jones, Shears, et al. 2004).

Supply chain performance will benefit greatly from wireless sensor networks. A more efficient and effective method may be used in processes that have been affected by this technology. Crates, rolls, pallets, and shipping containers may be fitted with WSN nodes that function as active transport tracking devices for the supply chain. These devices are capable of actively monitoring the transportation operations and verifying the right handling conditions of commodities, such as temperature for fresh and perishable items (Jones, 2004). Supply chain performance in the mobile environment has been greatly enhanced by multi-agent technology, which is being developed by middleware (Erdogmus, 2009). The use of multi-agent middleware dramatically improves supply chain performance. Mobile terminals and external applications benefit from the flexible and useful communication channels that may be provided by the middleware for multi-agent integration, which governs many different function agents or resource agents in a consistent manner.

In an effort to better service consumers and suppliers, cloud computing was investigated. Cloud computing is used to handle real-time demand data and supply chain visibility. By using the cloud, real-time data can be sent back in time, and inventories may move quickly ahead (Christopher, 2000). When it comes to technology, cloud computing is one of the most spoken about. On keeping with the term, cloud computing, it is developed in the cloud without any physical borders or infrastructure. To reap the long-term advantages of cloud computing, it's not only about how easy it is for the user to switch between languages. Data from 227 (Ataseven et al., 2017), who carried out the cross-sectional survey, used structural equation modeling (SEM) to assess Australian retail enterprises. The IoT capabilities are incorporated into internal, client, and supplier operations to enhance organizational and supply chain performance. According to a concept paper on the Internet of Things (IoT), supply chain integration may be enhanced by (Ping et al., 2011). Recognizing the need for a more connected SC in the new environment, (Reaidy et al., 2015) presented a similar IoT architecture for collaborative warehouses.

2.6 Empirical Literature Review

The IoT adoption in corporate supply chains was examined by researchers Haddud, DeSouza, Lee and Khare (2017) to corroborate the major advantages and limitations previously outlined in the literature concerning IoT adoption. The study investigated the impact of IoT on a company and its supply chain. Data was collected through an online survey with the participation of 87 individuals. The survey participants, mainly academics, were from various countries worldwide, including six different countries. Some of the participants have previously published articles in conference proceedings such as the Decision Science Institute, Supply Chain Innovation, and SCM, as well as the 21st International Symposium on Sustainable Transport and Supply Chain Innovation. Some of the evaluated possible advantages were found to be of significant importance to specific firms and their supply networks. However, the research found that there may be additional advantages to IoT adoption that weren't immediately apparent.

Supply Chain Management implementations have been shown to benefit from most of the possible advantages that have been investigated since they help with a number of important success variables. Some of these possible issues are still believed to be major roadblocks to IoT adoption, while the analyzed obstacles are not considered to be barriers to IoT implementation. A comprehensive literature review on IoT, logistics and SCM was undertaken by Da Rocha, Mendes, De Santa-Eulalia, and Da Silva Moris (2017). The IoT and Logistics and Supply Chain Management were detected in 39 articles from the ISI Web of Science database after sifting through more than 72 thousand IoT-related items. According to their findings, there were an overwhelming number of papers (85 percent) using the single case-study technique, indicating that this area of study is still developing. These case studies mostly dealt with IoT platforms and RFID (Radio Frequency Identification) as a means of improving system operations (46 percent). We also found that the complexity of systems was an important issue raised in the literature, including concerns about the absence of standard protocols for exchanging data and challenges connected to data security and privacy.

Research done by De Vass, Shee and Miah (2018), based on the organizational capability theory looked at how IoT may help retailers better integrate their supply chains by connecting them with suppliers, consumers, and internal activities. Nvivo was used to analyze the interviews of retail sector managers in Australia. The theme analysis revealed that the IoT contributes to enhanced supply chain integration through improved visibility, automated data captue, and information exchange. The integration capabilities facilitated by IoT positively influenced various aspects of the SC, including cost, quality, delivery, and flexibility. Consequently, the retail organization experienced improved financial, social, and environmental outcomes. The significance of IoT's impact on supply chain performance has grown in recent years. However, it is crucial to examine empirical evidence to better understand the role of IoT and its influence on SCP. The literature identified a research gap in exploring the effect of IoT on SCP indicators, particularly in developing nations (Morssi et al., 2020).

An investigation by Odhiambo (2018) examined the variables that drive farmers' adoption of IoT sensing and monitoring systems, how they affect it, and what can be done to expand use beyond early adopters while also maximizing IoT's potential for agricultural applications. Ten individuals were selected for the study, which used a quantitative research methodology and a purposive sampling method. There was a correlation between IoT adoption in farming and technological aspects, according to the conclusions of the study. The technology had a substantial and good impact. The adoption of IoT in farming was not influenced by individual, social, or product-related factors. Additionally, age and gender were shown to substantially influence the links between individual factors and IoT adoption, as were the correlations between social factors and IoT adoption in agriculture, according to the study's results. Individual and societal variables were shown to influence the adoption of IoT technology in farming by small-scale farmers, while technical elements were also found to have an impact.

The IoT and the quality of higher education in Kenya were examined in Kenya by Letting and Mwikya (2020). New prospects and possibilities for teaching/learning processes and educational institutions' infrastructure have been brought about by the usage of IoT in academics, according to the research. In addition to smart classrooms and real-time feedback on lecture quality, additional potential areas of effect include smart class attendance. In light of the increasing demand for educational information, the research established that the business architecture of colleges and universities should be overhauled to minimize latency. It was necessary to devise new approaches that respect the privacy, preferences, and aspirations of individuals while still encouraging the development of cutting-edge new technology and services. Furthermore, new approaches to funding information technology infrastructure and services must be developed in higher education.

The IoT adoption was examined in the context of flood and drought disaster management by Mugeni et al. (2020). Among Kenyan experts, opinion leaders, politicians, and members of the general public, the research found that IoT technology is rapidly being utilized to manage flood and drought disasters in Kenya. When it comes to IoT disaster management in Kenya, factors like relative advantage (RA), perceived knowledge (PK), and ease of use are more important than self-efficacy (SE), referent's influence (RI), and others' influence. Research by Machii et al (2020) looked at how IoT and big data are being integrated and used strategically in Kenya. Study aims were to assess IoT and big data technologies, to determine the adoption and implementation levels, as well as to examine the challenges and financial benefits. The research was done on a computer using information gathered from different sources, including academic journals, conference proceedings, and scientific publications. Using the study's findings, the company was able to better understand its customers' needs, improve service delivery, increase efficiency, prepare for the future, and maximize profits. The report also discussed the difficulties in implementing IoT.

2.7 Summary of Literature Review

Table 2.1 summarizes the study's findings. It is included in the scope of study, together with the scholar(s) involved and the study technique, to address any research gaps

Table 2.1: Summary of Literature Review

Scholar(s)	Focus of Study	Methodology	Major findings	Research gaps	Address of Gaps
Haddud, DeSouza, Khare and Lee (2017)	Understanding the possible advantages and disadvantages of integrating the IoT into supply chains.	Online survey and 87 participants completed the survey	The SCM implementation success may be attributed in large part to several of the possible advantages that have been evaluated.	The study examined benefits and challenges of IoT integration in Supply Chains but did not explore the how IoT affects SCP. It also did not establish the extent of adoption of IoT in SC	Current study will investigate the how IoT affects SCP and establish to what extent IoT has been adopted in Manufacturing firms
Da Rocha, Mendes, De Santa-Eulalia and Da Silva Moris (2017)	Adoption of IoT in Logistics & SCM	A systematic literature review of articles in the Web of Science	Out of 72,000 documents, 39 articles explicitly combine IoT with LSCM implying that this knowledge area is still at an infancy stage	The goal of this study was to ascertain the range and depth of available research on the subject, rather than to find the relationship between the studied variables.	Study will examine the relationship between IoT and SCP
De Vass, Shee and Miah (2018)	Internet of Things for improving Supply Chain Performance	Exploratory quantitative survey of Australian retail industry	Cost, quality, delivery, and flexibility all benefit from IoT integration in Supply Chains as does a retailer's long-term financial health as well as the firm's social and environmental impact.	Context is retail sector in Australia.	Context will be manufacturing firms in Kenya
Odhiambo (2018)	Kenyan farmers' decisions to deploy IoT sensing and monitoring technologies for greenhouse farming are influenced by many factors.	The study used a quantitative research methodology and a purposive sampling method to choose 10 participants.	The use of IoT technology in farming was influenced by technical issues. It had a substantial and good impact.	Did not address the relationship between IoT and SCP. Context is farming.	Current study will investigate the relationship between IoT and SCP. The context is manufacturing firms.

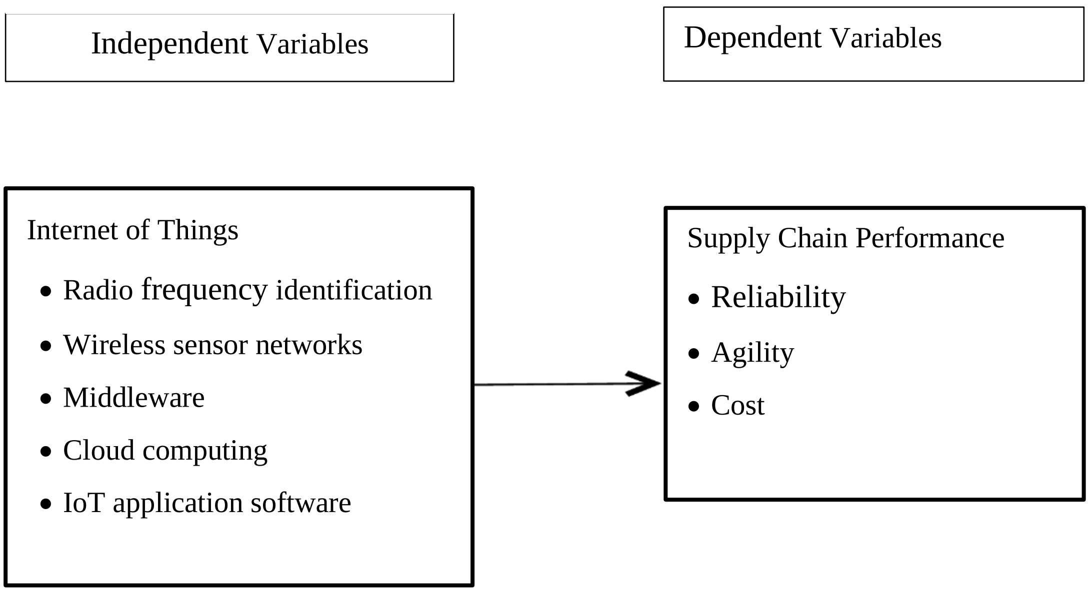
Letting and Mwikya (2020)	IoT and quality of higher education in Kenya	A literature review	The IoT presents massive opportunity for higher learning institutions in areas such as smart class room management, smart class attendance, real time lecture feedback.	The study did not examine the extent of IoT adoption, neither did it investigate the relationship between IoT adoption and effect on performance	Study will investigate extent of IoT adoption as well as the how it affects SCP
Mugeni, Omieno, Wabwoba, Karume, Mabele and Otanga (2020)	Determinants for adoption of IoT for flood and drought disaster management in Kenya	Experts, opinion leaders, policymakers, and members of the general public were interviewed by researchers in Kenya.	Perceived ease of use (PE), perceived knowledge (PK), and relative benefit are all elements that must be taken into account while using IoT technology (RA).	The study did not explore the extent of IoT adoption, the relationship between its adoption and performance	Research seeks to establish the relationship between IoT and SCP as well as the extent to which IoT has been adopted

Source: Author (2022)

2.8 Conceptual Framework

The Internet of Things (IoT) was the independent variable in this study and supply chain performance is the dependent variable. Figure 2.1 below depicts a schematic representation of the hypothesized connection.

Figure 2.2: Conceptual Model



Source: Author (2023)

CHAPTER THREE: RESEARCH METHODOLOGY

3.1 Introduction

This section provides a summary of the research methods utilized in this study. The topics addressed include the Research Design, Target Population, Sampling Method, Data Collection, and Data Analysis.

3.2 Research Design

The research design is the systematic and organized plan that outlines how different components of the study will be integrated in order to address the research topic in a logical and coherent manner. It provides a framework for conducting the research and guides the overall approach and methodology used in the study. It provides guidance on how to collect, measure, and analyse data, ensuring the successful accomplishment of research objectives (Saunders et al., 2009).

This study, which took part in Nairobi Kenya employed a cross-sectional research design. This is because the research aimed to capture data at a particular time interval and not over time as the case of longitudinal. According to this research design, researchers may observe and characterize the variables of interest in their studies using a cross-sectional survey, which does not use any modification techniques at all (Kothari, 2004). This research is relevant due to the design's facilitation of the acquisition of substantial data on industrial IoT. An analysis of elements that impact the adoption of IoT in Kenya's flood and drought disaster management by Mugeni et al (2020) employed this technique, according to the research.

3.3 Target Population

The target population is the specific subgroup that is the subject of investigation or the group that the study aims to examine. In this particular research, the main focus was on large manufacturing companies situated in Nairobi, Kenya. According to the Kenya Association of Manufacturers (2021), Nairobi is host to 455 businesses classified as major manufacturers based on their employment of a significant number of workers (over 100). The specialization of production techniques or skills, mechanization, technical innovation, stratification and organizational structure, and unequal geographic distribution are all traits of contemporary large manufacturing firms (KAM, 2021).

3.4 Sampling Method

According to Barlett, Kotrlik, and Higgins (2001), research surveys are designed to collect data from a representative sample of the population. To generalize the population based on a sample, researchers used information gained from a survey. The data collection process in this study involved initial contact with the target organizations through phone calls or emails. The reasons for conducting the study was explained, and permission was requested for data collection. The organizations were also asked about their adoption of IoT in their supply chain operations and their willingness to play a part in the study. Once the contributors agreed to take part, the questionnaire was distributed either through a Google Form, a Word document, or a physical copy provided to them. For those organizations which have not adopted IoT in their supply chains, the researcher did not proceed with data collection. The sample population for this descriptive research was determined to be at least 15% of the entire population (Mugenda, 2003), hence 455 manufacturing companies in Nairobi, Kenya were selected using a stratified random technique, as indicated in Table 3.1 below.

Table 3.1: Determination of sample size

Category	Population	Percent Of industry	15 percent
Building	16	3.5	2
Food and Beverage	108	23.7	16
Rubber and Plastics	48	10.5	7
Energy	34	7.5	5
Metal and Allied	55	12.1	8
Textile and Apparels	36	7.9	5
Leather Products and	6	1.3	1
Furniture, Wood products and Timber	17	3.7	3
Pharmaceuticals	18	4.0	3
Paper and Paperboard	44	9.7	7
Chemical and Allied	59	13.0	9
Motor vehicle	14	3.1	2
Total	455	100	68

Source: Author (2023)

3.5 Data Collection

In this research, the researchers depended on information gathered via the distribution of questionnaires to the respective firms located in the Nairobi Metropolitan Area to gather primary data. Questionnaires are the most popular method for collecting data since they enable researchers to contact a wide range of people and are also cost-effective. Because of the great dependability of a questionnaire, if a study is conducted numerous times, respondents offered almost identical results (Saunders & Buckingham 2017; Bryman & Bell, 2018)

The questionnaire was divided into four sections: I, II, III, and IV, with each portion matched with a specific research purpose. Part I gathered demographic data about the person and the organization. Part II queried the degree to which large manufacturers in Kenya are using IoT. The third and fourth parts of the research process gathered data on the SCP of the large manufacturing firms in Nairobi, Kenya as well as data on the challenges that were encountered in implementing the Internet of things. Participants' preferences and levels of agreement with a statement or set of statements were assessed using Likert scale questions with a five-point response range as shown below

Table 3.2: Linkert Scale

Response Range	Description
1	Not at All
2	Little Extent
3	Moderate Extent
4	Great extent
5	Very great extent

Source: Author (2023)

Operations managers, supply chain managers, or their counterparts were surveyed. This is because the selected respondents are the knowledge managers and decision-makers related to manufacturing companies. The respective respondents were presented with web-based surveys. In view of the current COVID-19 epidemic, which encourages virtual engagement and social separation, this strategy is suggested. Respondents were contacted through phone and email as part of the study's follow-up procedures.

3.6 Data Analysis

Descriptive data were utilized to analyse the dependent variable and independent variables. To ascertain whether or if there is a correlation between IoT and SCP for large companies, a regression study was performed. The regression model shown below;

$$\mathbf{Y = \alpha + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5}$$

Where:

Y = The effect of IoT on SCP of large manufacturers (Dependent variable)

α = the Y intercept when x is zero or the constant

β = Regression Coefficients

X_1 to X_5 are independent variables where;

$\mathbf{X_1}$ = RFID

$\mathbf{X_2}$ = WSN

$\mathbf{X_3}$= Middleware

$\mathbf{X_4}$= Cloud computing

$\mathbf{X_5}$= IoT application software

CHAPTER FOUR: DATA ANALYSIS RESULTS AND DISCUSSIONS

4.1 Introduction

The main goal of this study was to explore the impact of IoT adoption on the SCP of major manufacturing companies situated in Nairobi, Kenya. The study precisely intended to evaluate the degree of IoT implementation in the supply chains of these companies, investigate the correlation between IoT adoption and SCP, and identify the challenges and obstacles faced by large manufacturing firms during the adoption of IoT. The subsequent chapter presents the research findings, aligning with the previously stated objectives.

4.2 Response Rate

This research used cross-sectional research design to determine the sample size of participants. Generally, the research targeted 68 participants which was a 15 percent representation of the total population. Out of the organisations which were contacted, 90 of them responded to be using IoT in their supply chain. However, the researcher was successful to acquire 69 respondents who returned the questionnaire. The researcher proceeded to analyze the collected responses, which accounted for a 76.7 percent response rate. As highlighted by Mugenda and Mugenda (2003), a response rate surpassing 70 percent is considered satisfactory for statistical testing and reporting.

4.3 General Information

The research aimed to gather general information from the study participants, specifically focusing on their educational background, experience in SCM and the size of the companies they were associated with.

4.3.1 Number of employees

This research aspect was employed to assess the employee capacity of the company where the participating individuals are employed. This data was necessary to verify that the involved companies were of a significant size (with a capacity of more than 100 employees). The resulting data output is presented in the table below:

Table 4.1: Number of Employees

No of Employees	Frequency	Percent	Cumulative Percent
>100	69	100	100
<100	0	0.0	100
Total	69	100.0	

Source: Author, 2023

The research results indicate that all the companies included in the research had a workforce comprising a minimum of 100 employees, thereby categorizing them as large manufacturing firms. Moreover, the results validate the achievement of the study's objective, which was to explore the effect of IoT adoption on the SCP of these specific large manufacturing firms.

4.3.2 Level of education

To analyze the educational background of the participants, an attribute analysis was conducted as part of this research. The purpose was to understand participants' educational qualifications and evaluate their level of knowledge regarding the use of IoT in SCM. The outcomes of this analysis are summarized in Table 4.2:

Table 2.2 : Level of Education

Educational Level	Frequency	Percent	Cumulative Percent
O-Level	0	0	0
A-Level	3	4.35	4.35
College Level	3	4.35	8.7
Graduate Level	39	56.52	65.22
Postgraduate Level	24	34.78	100

Source: Author, 2023

According to the study output above, most participants (56.52 %) were graduates while 34.78% were postgraduates. Very few participants had O-level education (0%) and A-level education (4. 35%). This proves that most employees dealing with IoT in supply chain management are well-educated. This statistic can also be interpreted in the sense that the most respondents were obtained from management and senior management levels who have high levels of education and understands the SCM processes better.

4.3.3 Experience in SCM

The primary aim of this statistical study was to explore the composition of participants based on their experience in supply chain management. Experience is a crucial factor to consider when examining the implementation and utilization of IoT in SCM, as individuals may have varying perceptions and interpretations of the technology's impact on their SCM operations. To achieve this, participants were requested to provide their job experience based on predefined categories. Below is the summary of the results.

Table 4.3: Experience in supply chain management

Experience(Years)	Frequency	Percent	Cumulative Percent
<1	3	4.35	4.35
1-5	22	31.88	36.23
6-10	29	42.03	78.26
>10	15	21.74	100

Source: Author, 2023

The output above proves that the majority of the employees (42.03%) had an experience of between 6-10 years while few were below 1 year (4.35%). This shows that the participants had a wide experience concerning the application of IoT in their SCM and therefore the data collected is valid.

4.4 Internet of Things Technologies

4.4.1 Radio Frequency Identification (RFID)

This study explored how participants use Radio Frequency Identification (RFID) capabilities. The RFID is a key IoT capability used by supply chain companies. The variable is divided into three major groups; My organization uses RFID tagging and tracking, RFID in our supply chain provides individual item-level identification and RFID technology is implemented in our supply chain operations to enable precise identification at the unit level, encompassing product groups or pallets.

4.4.1.1 My organization uses Radio Frequency Identification (RFID) tagging and tracking

This study explored how the participants use RFID tagging and tracking mechanisms. The table below displays study results.

Table 4.4: Use of RFID for tagging and tracking

	i. My organization uses Radio Frequency Identification (RFID) tagging and tracking			
		Frequency	Percent	Cumulative Percent
Valid	1	5	7.2	7.2
	2	4	5.8	13.0
	3	15	21.7	34.8
	4	27	39.1	73.9
	5	18	26.1	100.0
	Total	69	100.0	

Source: Author, 2023

The outcome above indicates that most participants (39.1%) work in organizations that greatly use RFID tagging and tracking and to a very great extent (26.1%). This shows that most of the large manufacturers in Nairobi have adopted RFID for use in tagging and tracking their products in transit.

4.4.1.2 RFID in our supply chain provides individual item-level identification

This study's aim was to determine the level at which RFID is employed for item identification among the firms under study as shown below.

Table 4.5: RFID in our supply chain provides individual item-level identification

	ii. RFID in our supply chain provides individual item level identification			
		Frequency	Percent	Cumulative Percent
Valid	1	8	11.6	11.6
	2	14	20.3	31.9
	3	19	27.5	59.4
	4	18	26.1	85.5
	5	10	14.5	100.0
	Total	69	100.0	

Source: Author, 2023

The above output proves that most firms (27.5%) only use RFID to enhance individual item identification to a moderate extent while a considerable number (20.3%) use it on a little extent. This shows that while RFID is an important technology among manufacturing companies, it is not widely used to identify individual items due to cost implications (RFID would rather be placed on a group of items like a pallet of pens with the same batch number than on an individual item).

4.4.1.3: RFID in our supply chain operations provides unit-level (product group/pallet) identification

This study intended at exploring the scope to which the participants use RFID in supply chain operations to provide for unit-level identification. The output is shown below;

Table 4.6: RFID in our supply chain operations provides unit-level (product group/pallet) identification

iii. RFID in our supply chain operations provide unit level (product group/pallet) identification				
		Frequency	Percent	Cumulative Percent
Valid	1	1	1.4	1.4
	2	1	1.4	2.9
	3	8	11.6	14.5
	4	17	24.6	39.1
	5	42	60.9	100.0
	Total	69	100.0	

Source: Author, 2023

The results above affirm that most participants (60.9%) said that they use RFID for group/pallet identification to a very great extent while a considerable number (24.6%)uses it to a great extent. This statistic proves that most large manufacturers that have IoT embedded into their SCM highly utilize the capability to identify products through their units/groups.

4.4.2 Wireless Sensors Network

This study explored how the participants have incorporated wireless sensors and wireless networks in their IoT supply chain. Wireless sensor networks help in actively monitoring transportation operations and verifying the right handling conditions of commodities, such as temperature for fresh and perishable items. The variable is divided into three major groups; Our supply chain incorporates a network of sensors that monitor various supply chain entities through automated data capture, the sensors deployed in our network measure a wide range of supply chain activities, processes, and environmental conditions, and sensors within our network contribute to the remote control of supply chain processes.

4.4.2.1 Our supply chain has a network of sensors to monitor supply chain entities through auto-captured data

This refers to the level at which an organization uses sensors to observe supply chain processes such as the use of machine sensors, GPS, and smartphones among other mechanisms. This study explored how such capabilities are utilized among large the companies under investigation as shown:

Table 4.7: Our supply chain has a network of sensors to monitor supply chain entities through auto-captured data

i. Our supply chain has a network of sensors to monitor supply chain entities through auto-captured data (e.g., Machine sensors, barcode, QR code, GPS, smartphones)				
		Frequency	Percent	Cumulative Percent
Valid	1	3	4.3	4.3
	2	8	11.6	15.9
	3	7	10.1	26.1
	4	26	37.7	63.8
	5	25	36.2	100.0
	Total	69	100.0	

Source: Author, 2023

The outcome above proves that most participants (36.2%) use a network of sensors to monitor supply chain entities through auto-captured data to a very great extent. This shows that monitoring supply chain entities through auto-captured data is an important capability provided by IoT for SCM in large manufacturing companies.

4.4.2.2 The sensors in our network measures supply chain activities, processes, and environmental conditions

Supply chain management is influenced by a variety of activities, processes, and environmental conditions, including factors such as temperature, speed, and customer shopping behaviour, among others. These elements have a direct influence on the overall efficacy and efficiency of the supply chain. This study evaluated how sensors are used to measure these conditions and ensure an optimal working environment as shown below;

Table 4.8: The sensors in our network measures supply chain activities, processes, and environmental conditions

ii. The sensors in our network measures supply chain activities, processes and environmental conditions (e.g., temperature, speed, customer shopping behaviour)				
		Frequency	Percent	Cumulative Percent
Valid	1	5	7.2	7.2
	2	5	7.2	14.5
	3	19	27.5	42.0
	4	21	30.4	72.5
	5	19	27.5	100.0
	Total	69	100.0	

Source: Author, 2023

The above study output show that 30.4 percent of the participants indicated a significant utilization of sensors within their network. This observation underscores the essential role that wireless sensor networks play in improving the efficiency of supply chain processes, activities, and monitoring of environmental conditions.

4.4.2.3 The sensors in our network help control supply chain processes remotely

This factor measured the extent to which the sensors remotely control supply chain activities such as alerts, auto reporting, and safety shutdowns among others as summarized below:

Table 4.9: The sensors in our network help control supply chain processes remotely

iii. The sensors in our network help control supply chain processes remotely (e.g., alerts, auto reporting, safety shutdowns)				
		Frequency	Percent	Cumulative Percent
Valid	1	3	4.3	4.3
	2	12	17.4	21.7
	3	19	27.5	49.3
	4	19	27.5	76.8
	5	16	23.2	100.0
	Total	69	100.0	

Source: Author, 2023

The outcome above indicates that most participants (27.5%) stated that the sensors in their network help control supply chain processes remotely to a moderate and great extent while a considerable number (23.2%) uses them to a very great extent. This shows that sensors are critical in remotely managing the SCM activities hence reducing the on-the-job activities.

4.4.3 Middleware

The use of middleware, which is an IoT multi-agent technology, has dramatically improved supply chain performance (Erdogmus, 2009). Mobile terminals and external applications can greatly benefit from the flexible and efficient communication channels facilitated by middleware, which enables the integration of multiple agents. Middleware ensures consistent management of various functional agents and resource agents, allowing for seamless coordination and interaction. This study intended to explore the scope to which large manufacturers have integrated the concept of middleware into their supply chain and how such incorporation enhances SCM efficiency. This concept is measured by three variables and the results are presented in the preceding tables.

4.4.3.1 The company has software that connects and integrates all devices used in supply chain operations

This factor measured the extent to which the companies have incorporated software that integrates all devices used in supply chain operations as summarized below:

Table 4.10: The Company has software that connects and integrates all devices used in supply chain operations

i. The company has a software that connects and integrates all devices used in supply chain operations				
		Frequency	Percent	Cumulative Percent
Valid	1	0	0	0

	2	12	17.4	17.4
	3	17	24.6	42.0
	4	19	27.5	69.6
	5	21	30.5	100.0
	Total	69	100.0	

Source: Author, 2023

The results above prove that most participants have incorporated the software that integrates all devices used in supply chain operations to a great (27.5%) and very great (30.5%) extent showing hence proving that device integration is a growing capability in SCM among large manufacturers.

4.4.3.2 Our supply chain has a huge number of diverse things and sensors connected and communicating with one another over the internet

This factor measured the extent to which the companies have incorporated diverse things and sensors which are connected and communicate with one another over the internet. The outcome is shown below:

Table 4.11: Our supply chain has a huge number of diverse things and sensors connected and communicating with one another over the internet

ii. Our supply chain has a huge number of diverse Things and sensors connected and communicating with one another over the internet				
		Frequency	Percent	Cumulative Percent
Valid	1	2	2.9	2.9
	2	13	18.8	21.7
	3	18	26.1	47.8
	4	28	40.6	88.4
	5	8	11.6	100.0
	Total	69	100.0	

Source: Author, 2023

The study output above affirms that most companies investigated have, to a moderate and great extent, a huge number of diverse things and sensors connected and communicating with one another over the internet. This shows that IoT has helped companies integrate different devices and tools for effective and central communication and coordination.

4.4.3.2 Middleware software is a key enabler in the integration of different components in the supply chain

This factor measured the extent to which the participants felt that middleware software is a key enabler in integrating different components in the supply chain as shown below:

Table 4.12: Middleware software is a key enabler in the integration of different components in the supply chain

iii. Middleware software is a key enabler in the integration of different components in the supply chain				
		Frequency	Percent	Cumulative Percent
Valid	1	3	4.3	4.3
	2	6	8.7	13.0
	3	16	23.2	36.2
	4	16	23.2	59.4
	5	28	40.6	100.0
	Total	69	100.0	

Source: Author, 2023

The study output above affirms that most participants expressed their opinions that middleware is a key enabler in the incorporation of diverse components in the SC to a great and very great extent.

4.4.4 Cloud Computing

Cloud computing is often applied in SCM to handle real-time demand data and supply chain visibility. By using the cloud, real-time data can be sent back in time, and inventories may move quickly ahead (Christopher, 2000). This variable was used to measure the extent to which participants utilize cloud computing capabilities to drive SCM activities. Participants were asked to state, on a scale of 1-5,how they utilize cloud computing services. The results are summarized below;

4.4.4.1 Data collected by gadgets in our supply chain operations is stored in the cloud

This factor investigated whether the participants utilize cloud storage for storing the data collected during supply chain operations. The outcomes are given in the table below:

Table 4.13: Data collected by gadgets in our supply chain operations is stored in the cloud

i. Data collected by gadgets in our supply chain operations is stored in the cloud				
		Frequency	Percent	Cumulative Percent
Valid	1	3	4.3	4.3
	2	7	10.1	14.5
	3	20	29.0	43.5
	4	22	31.9	75.4
	5	17	24.6	100.0
	Total	69	100.0	

Source: Author, 2023

Based on the output above, a moderate to a great extent of participants stores their data in the cloud. The findings indicate that cloud computing plays a crucial role in effectively managing SCM activities.

4.4.4.2 Users in our supply chain can access cloud resources in real-time through computers and other devices

This factor measured the way through which users in the organizations under investigation access cloud resources. The outcomes are summarized in the table below;

Table 4.14: Users in our supply chain can access cloud resources in real-time not only through computers but also through all types of devices and computer networks

ii. Users in our supply chain can access cloud resources in real time not only through computers but also through all types of devices and computer networks				
		Frequency	Percent	Cumulative Percent
Valid	1	1	1.4	1.4
	2	5	7.2	8.7
	3	15	21.7	30.4
	4	22	31.9	62.3
	5	26	37.7	100.0
	Total	69	100.0	

Source: Author, 2013

As illustrated in the output above, most participants can access cloud resources in real-time through computers and other devices and computer networks. This is an important aspect as it helps quick processing of information and utilization of other resources instead of depending on manual processes that takes longer periods and consumes more resources.

4.4.4.3 Supply chain information resources stored is shared between multiple cloud users.

This study evaluated if the supply chain information resources stored in the cloud are shared between multiple cloud users. The study outcomes are presented in the table below:

Table 4.15: Supply chain information resources stored is shared between multiple cloud users

iii. Supply chain information resources stored is shared between multiple cloud users.				
		Frequency	Percent	Cumulative Percent
Valid	1	2	2.9	2.9
	2	12	17.4	20.3
	3	12	17.4	37.7
	4	22	31.9	69.6
	5	21	30.4	100.0
	Total	69	100.0	

Source: Author, 2023

As illustrated in the output above, most participants expressed their opinion that supply chain information resources stored are shared between multiple cloud users. This might be due to other factors such as scalability and ease of access offered by cloud services.

4.4.5 IoT Application Software

This variable specifically examines the practicality and effectiveness of IoT software in SCM processes. The IoT application soft-wares are key in enabling the utilization of IoT in supply chain management. Most organizations that have IoT capabilities have software installed in gadgets such as phones, tabs, and computers to enable communication between devices. The software's are also able to enhance real-time monitoring of activities within the network and also visualize the conditions of products from the factory to supply chain actors downstream. This statistic investigated, on a scale of 1 – 5 how participants felt that IoT application software's are used among large manufacturing companies to enhance the supply chain management processes & provide them with the desired experience. The output is displayed in the tables below;

4.4.5.1 Supply chain gadgets are installed with software that enables the communication between devices

The participants were requested to share their perspectives on how communication is improved through the use of supply chain devices. The study's findings are outlined in Table 4.16 below:

Table 4.16: Supply chain gadgets are installed with software that enables the communication between devices

i. Supply chain gadgets such as phones, tabs and computers are installed with softwares that enable communication between devices				
		Frequency	Percent	Cumulative Percent
Valid	1	3	4.3	4.3
	2	9	13.0	17.4
	3	22	31.9	49.3
	4	17	24.6	73.9
	5	18	26.1	100.0
	Total	69	100.0	

Source: Author, 2023

As shown above, most respondents expressed their opinion that their supply chain gadgets such as phones, tabs, and computers are installed with software that enables communication between devices to a moderate extent. This shows that most companies have not highly adopted centralized communication mechanisms enabled with IoT software based on a variety of reasons that might include the sensitivity of the information shared and the users of such information.

4.4.5.2 Software installed in our supply chain devices enables real-time monitoring of activities within the network

The researcher explored the extent to which software installed in participants supply chain devices enables real-time monitoring of activities within the network. The summarized results are presented in the table below:

Table 4.17: The software installed in our supply chain devices enables real-time monitoring of activities within the network

ii. Softwares installed in our supply chain devices enable real-time monitoring of activities within the network				
		Frequency	Percent	Cumulative Percent
Valid	1	2	2.9	2.9
	2	15	21.7	24.6
	3	18	26.1	50.7
	4	17	24.6	75.4
	5	17	24.6	100.0
	Total	69	100.0	

Source: Author, 2023

As shown above, it is notable that software installed in the supply chain devices is considered very important in enabling real-time monitoring of activities within the network and the entire SCM environment. However, not all companies have maximized this capability with 21.7% stating that such software is used to a little extent. This can be accredited to other aspects such as cost, skills and capacity, and availability among others.

4.4.5.3 The software we use in our supply chain helps us to visualize the conditions of products from the factory to supply chain actors downstream

Supply chain visibility is key in ensuring that the products are monitored from the time of despatch to the destination. This factor explored how the software used by companies helps visualize the conditions of products from the factory to supply chain actors downstream. The blow table summarizes the study output.

Table 4.18: The software used in our supply chain helps us to visualize the conditions of the products from the factory to supply chain actors downstream

iii. The softwares we use in our supply chain helps us to visualize the conditions of products from the factory to supply chain actors downstream				
		Frequency	Percent	Cumulative Percent
Valid	1	7	10.1	10.1
	2	5	7.2	17.4
	3	15	21.7	39.1
	4	24	34.8	73.9
	5	18	26.1	100.0
	Total	69	100.0	

Source: Author, 2023

The results above shows that the most contributors felt, to a great extent (34.8%) that IoT application software are key in enabling the utilization of IoT in supply chain management. While most organizations have embraced IoT in their supply chain processes, the majority have not fully utilized its capabilities in instances such as communication, real-time monitoring and product visualization. These capabilities have been used but not to a high extent as restricted by other factors such as cost, skills, and data security among others.

4.5 Supply Chain Performance Indicators

4.5.1 Reliability

Reliability is the consistent capacity of an organization to meet customer requirements regarding product volumes, timing, location, and expected quality. It ensures that customers' needs are consistently fulfilled with the desired level of product performance and satisfaction. The IoT is thought to enhance reliability by making it easier to locate goods, track their movement, and establish any issues that might hinder effective delivery such as monitoring the best routes, ensuring the right temperatures are maintained, and estimating the approximate time at which the products will arrive. This variable measured the extent to which IoT is used to enhance reliability within the SCM of organizations under study. The results are presented using a Likert scale of 1 – 5 in the table below;

Table 4.19: Reliability

Reliability				
		Frequency	Percent	Cumulative Percent
Valid	1	0	0	0
	2	5	7.2	7.3
	3	12	17.4	24.7
	4	19	27.5	52.2
	5	33	47.8	100
	Total	69	100.0	

Source: Author, 2023

Generally, most participants had a view that IoT enhances reliability in SCM process. 47.8% indicated that they agreed to a very great extent, 27.5% to a great extent and none of the participants (0%) has a contrary view. This firmly shows that IoT enhances reliability in SCM.

4.5.2 Agility

Agility refers to an organization's capacity to respond and acclimatize to market changes effectively, thereby preserving or enhancing its competitive advantage within the supply chain. The IoT enhances agility in the SCM cycle by reducing supply chain blind spots through real-time monitoring, and information sharing and enhancing better flexibility. This study was aimed at evaluating how IoT is used to enhance the agility of large manufacturers within the area under study. The results are presented using a Likert scale of 1 – 5 below.

Table 4.20: Agility

Agility				
		Frequency	Percent	Cumulative Percent
Valid	1	1	1.5	1.5
	2	3	4.3	5.8
	3	15	21.7	27.5
	4	23	33.3	60.8
	5	27	39.2	100
	Total	69	100.0	

Source: Author, 2023

A high percentage of respondents (39.2%) affirmed that IoT enhances agility in SCM to a very great extent while the other 33.33% affirmed it to a great extent. This shows that large manufacturers have benefited a lot from the use of IoT by making their supply chains more agile and resilient hence increasing their performance.

4.5.3 Cost

Cost is the ability to maintain minimum supply chain management costs. By enhancing smart inventory management through the incorporation of IoT systems, organizations are able to ensure visibility across inventory, warehouse, and distribution centers which reduces inventory costs. This variable explored the extent to which participants felt that IoT in SCM reduces the costs to the firm. The output is elaborated in the table below and is presented using a Likert scale of 1 – 5 below

Table 4.21: Cost

Cost				
		Frequency	Percent	Cumulative Percent
Valid	1	0	0	0
	2	6	8.7	8.7
	3	17	24.6	33.3
	4	26	37.7	71
	5	20	29	100
	Total	69	100.0	

Source: Author, 2023

Based on the findings presented in Table 5.9, the integration of IoT in SCM processes significantly reduces operational costs. Most of the participants agreed that cost is among the factors that motivate organizations to invest in IoT for SCM as manual laborers are replaced with automation hence lowering the operation cost.

4.5.4 Ranking of SC Performance Indicators

This study explored, among the three factors, the one with the highest performance resulting from the adoption of the IoT. The results are shown in the table below:

Table 4.22: Ranking of SC Performance Indicators

SC Performance Indicators	Average	Rank
Reliability	4.15942029	1
Agility	4.043478261	2
Cost	3.869565217	3

Source: Author, 2023

The results above shows that IoT enhances performance of large manufacturing firms in Nairobi, Kenya by highly influencing the reliability of the supply chain, followed by enhancing agility and lastly reducing cost. This shows that most organizations have adopted IoT for them to have a competitive advantage through highly reliability of their products and services.

4.6 Challenges of Internet of Things Adoption

Smart IoT solutions have widely been encorporated by companies to support more efficient supply chains. However, not all companies have implemented these solutions. Even those which have adopted IoT, some have not fully maximized the capabilities provided by these technologies. This study aimed at exploring some of the challenges that have largely affected the adoption of solutions in supply chains among large manufacturers as shown below:

Table 4.23: Challenges of internet of things adoption

S/N	Problem	Rating (Percent)				
		Not at all	Little extent	Moderate Extent	Great extent	Very Great Extent
1	Unclear benefits and ambiguity on return on investment	31.9	29	21.7	11.6	5.8
2	Data scalability (inadequate storage capacity)	27.5	34.8	20.3	7.2	10.1
3	Data security and privacy	17.4	20.3	39.1	18.9	4.3
4	Lack of data handling procedures	18.9	31.9	20.3	18.9	7.2
5	Behavioral issues	17.4	24.6	29	23.2	5.8
6	Time-consuming	28.8	30.8	26.4	10.5	3.5
7	Limited resources	8.7	37.7	21.7	20.3	8.7
8	Lack of expertise among staff	13	36.2	26.1	21.7	3
9	Lack of top management support	56.5	26.1	7.2	8.7	8.7
10	Poor quality of data	42.0	42.0	11.6	4.4	0

Source: Author, 2023

The adoption of IoT in supply chains is coupled with various challenges. As shown in table 6.0 above, data security and privacy, behavioral issues, limited resources, and lack of data handling procedures were among the challenges that were felt on a moderate to a great extent level. More than 39 % of the participants agreed to a moderate extent that data privacy was an issue in the adoption of IoT in their SCM, while 23.2% and 20.3 agreed that behavioral issues and limited resources were problems faced to a great extent. Lack of management support, time consumption, poor quality data, inadequate storage, and lack of expertise from the staff were felt to a little to no extent. Generally, all the problems explored were not highly faced to a very great extent meaning that IoT adoption in SCM is not faced with many challenges.

4.7 Regression Analysis

To ascertain whether or if there is a correlation between IoT and SCP for large companies, a regression study was performed. Below is a summary model:

$Y = \alpha + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5$

4.7.1 The Model Summary

This statistic provides an overview of the study's model by computing the values of R and R2, offering details about the model's characteristics. Table 25 below summarizes the regression model used in this research.

Table 4.24: Model Summary

Model Summary				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.910a	.828	.815	.320543885123211

a. Predictors: (Constant), IOT Application Software, RFID, Cloud Computing, WSN, Middleware

Source: Author, 2023

The R-value in the provided table represents the correlation between the predicted variable and the predictor variables. According to Mukaka (2012), a value that is larger than 0.4 is good enough to be used for further analysis. This research output displays an R-value of 0.910, indicating a significant correlation that surpasses the minimum threshold of 0.4. The R-squared value indicates the proportion of the total variation in the dependent variable that can be accounted for by the independent variables. In this study, the R-squared value is 0.828, surpassing 0.5, which suggests that the model effectively explains the relationship (Mukaka, 2012). Additionally, the adjusted R-squared value measures the generalization of the outcomes. The adjusted R-squared for this study is 0.815, indicating that the response variable can be effectively explained by the predictor variables. The model summary, as indicated by these study results, is deemed satisfactory, permitting further analysis.

4.7.2 The Analysis of Variance (ANOVA)

The analysis of variance (ANOVA) is a statistical tool utilized to evaluate the extent of variability within the regression model and ascertain its significance in explaining the outcomes. The subsequent table displays the ANOVA output, offering valuable insights into the predictive efficacy of the regression equation for the dependent variable.

Table 4.25: ANOVA

ANOVAa

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	31.211	5	6.242	60.753	<.001[b]
	Residual	6.473	63	.103		
	Total	37.684	68			

a. Dependent Variable: Averall effect of IoT on SCP of large manufacturers
b. Predictors: (Constant), IOT Application Software, RFID, Cloud Computing, WSN, Middleware

Source: Author, 2023

Based on the results presented above, the significance value (sig) is 0.001, indicating statistical significance at a 95 percent confidence level. This suggests that the regression model effectively forecasts the outcome variable and is considered a good fit for the data. The df depicts the degrees of freedom that is linked with the sources of variance. The aggregate variance is typically denoted by N-1 df. In this study, there are 69 respondents and therefore the total df is 69-1=68.The regression df denotes the aggregate number of predictors including the intercept -1. The number of predictors in this study are 5 including the intercept makes 6.Hence, the regression df is 6-1=5.The residual df in this study has been calculated by subtracting the regression df from the total df (68-5=3). Finally, the F value is computed by dividing the mean square regression by the mean square residual, resulting in a value of 60.753.

4.7.3 Coefficients

The coefficients table provides essential information regarding the strength and direction of the relationship between variables within the model. It indicates the magnitude of the impact each independent variable has on the dependent variable. The sign of the coefficient in linear regression reveals the type of relationship. A positive sign signifies that an increase in the independent variable leads to an increase in the mean of the dependent variable. Conversely, a negative coefficient implies that an increase in the independent variable corresponds to a decrease in the dependent variable's mean. The coefficient value represents the change in the mean of the dependent variable resulting from a unit change in the independent variable, assuming all other variables remain constant. Additionally, the standardized beta statistic measures the strength of the relationship between dependent and independent variables. A higher absolute value indicates a stronger relationship. The following table displays the coefficients obtained in this study:

Table 4.26: Coefficients

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	t	Sig.
1	(Constant)	.113	.244		.461	.646
	RFID	.288	.069	.353	4.192	<.001
	WSN	.251	.075	.288	3.322	.001
	Middleware	.190	.097	.182	1.953	.055
	Cloud Computing	.147	.070	.137	2.093	.040
	Iot Application Software	.130	.056	.147	2.342	.022

a. Dependent Variable: Overall effect of IoT on SCP of large manufacturers

Source: Author 2023

The information provided indicates that all the coefficients bear a positive sign, demonstrating that they increase with a unit rise in the dependent variable. The variables related to Radio Frequency Identification exhibit high significance, with the highest absolute value of standardized beta. This suggests that RFID has a substantial impact on the success of IoT in SCM among large manufacturers. Other influential factors include wireless sensor networks, cloud computing, and IoT application software. On the contrary, the Middleware variable was found to be insignificant and had low absolute values for standardized beta, indicating a minimal effect on the SCP of large manufacturers. This output also highlights that the independent variables are correlated with the dependent variable, thereby supporting the central research question.

4.7.4 Ranking of Independent Variables

Based on the information provided in Table 27, here is the ranking of the independent variables based on their average standardized coefficients. The variables are ranked according to their standardized coefficients, which represent the strength of the relationship with the dependent variable while accounting for the scales and variances of the independent variables.

Table 4.27: Ranking of Independent Variables

Variables	Average	Rank
RFID	0.353	1
WSN	0.288	2
Middleware	0.182	3
Cloud Computing	0.137	5
IoT Application Software	0.147	4

Source: Author, 2023

As seen above, RFID is ranked first followed by WSN and the least ranked variable is cloud computing. This shows that most large manufacturing firms in Nairobi, Kenya use IoT for Radio Frequency Identification and wireless sensor networks than they use it for cloud computing services.

4.7.5 Finding the Value of Y

The regression equation for this study was;

$$Y=\alpha + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5$$

Where:

Y = The effect of IoT on SCP of large manufacturers (Dependent variable)

α = The Y intercept when x is zero or the constant

β = Regression Coefficients

X_1 to X_5 are independent variables where;

X_1 = RFID Variable

X_2= WSN Variable

X_3= Middleware Variable

X_4= Cloud computing Variable

X_5= IoT application software Variable

Substituting the significant values to get the value of Y

$Y=0.113+ (0.288*X_1) + (0.251*X_2) + (0.190*X_3)+(0.147*X_4)+(0.130*X_5)$

Y=0.113+ (0.288*3.75) +(0.251*3.67)+(0.190*3.66)+(0.147*3.76)+(0.130*3.54)

=3.82

This shows that the use of IoT in SCM specifically RFID, WSN, Middleware, Cloud Computing, and IoT application software enhances an organizational performance by 3.82 units.

CHAPTER FIVE: SUMMARY OF FINDINGS, CONCLUSIONS, AND RECOMMENDATIONS

5. 1 Introduction

This section offers a succinct overview of the research outcomes, presents conclusions derived from the analysis, and provides recommendations rooted in the identified focal points. These areas directly correspond with the research objectives, which involve evaluating the extent of IoT implementation in the supply chains of significant manufacturing firms, investigating the relationship between IoT adoption and supply chain performance in these firms, and assessing the challenges faced by large manufacturing companies in Nairobi, Kenya, during the adoption of IoT technology.

5.2 Summary of the Key Findings

The primary goal of this research was to examine the effect of IoT adoption on SCP within major manufacturing companies located in Nairobi, Kenya. The research aimed to evaluate the degree of IoT application in their supply chains, explore the relationship between IoT adoption and SCP, and identify the challenges faced by these large manufacturing firms during the adoption of IoT technology.

To accomplish these objectives, a cross-sectional research design was utilized. Semi-structured questionnaires were employed to gather primary data, involving 90 participants, of which 69 respondents completed the questionnaires. Regression analysis was conducted to analyze the collected data, while descriptive statistics such as percentages and frequencies were employed to provide a comprehensive explanation of the data.

The primary discovery of this research is that the integration of IoT technologies, including Radio Frequency Identification (RFID), wireless sensor networks, IoT application software, middleware, and cloud computing, improves various aspects of organizational supply chain performance, such as reliability, agility, and cost-effectiveness. Specifically, IoT use in the supply chain increases reliability through better monitoring and identification of products in the stores and on transit, enhances the agility of the organizations through real time information sharing and reduces the cost of operations majorly through automation of manual processes.

Various IoT technologies used in the supply chain among large manufacturers in Nairobi, Kenya were explored. The research affirmed that majority of organizations that have adopted IoT in the supply chains use RFID to track and manage their products within the supply chain. As illustrated by Shafique et al., 2020, one of the bottlenecks in SCM is facilitating the tracking, storage, and distribution of goods. Hence, the majority of manufacturers have implemented RFID to provide these services. The major role of RFID was found to provide product group/pallet identification. While these capabilities of RFID were explored, it was noted that not all organizations investigated have implemented them to a very great extent, meaning that they supplement them with other methods. This study, therefore, affirms the research by Li and Visich, 2016 that alluded that most RFID adoption in the manufacturing industries is restricted by factors such as cost, security and privacy, and integration challenges among others. These challenges make it difficult for firms to implement RFID in the entire supply chain and therefore only adopts them in strategic places such as the main distribution store or the company headquarters.

This study also examined the utilization of Wireless Sensor Network (WSN) technologies, and the findings affirmed that a significant number of participants' employ sensor networks to monitor supply chain elements by automatically collecting data. These sensors included machine sensors, barcodes, QR codes, GPS, and smartphones some are installed within the company stores while others are embedded in the goods. The sensors were extensively utilized to measure various aspects of supply chain activities, processes, and environmental conditions such as temperature and humidity. Additionally, they were employed for remote control of supply chain processes. However, not all companies use these technologies to provide the aforementioned services meaning that there exist some alternatives to the application of sensors in SCM.

Apart from the sensor network, this study explored the applicability of middleware technologies in SCM among the study population. While the participants acknowledged the significance of middleware as a crucial facilitator for integrating different components within the supply chain, the majority expressed their opinion that the utilization of such technology is limited to a moderate extent. They believed that middleware should be more extensively employed to enable effective communication and integration of all supply chain operations involving diverse devices and sensors. This research, therefore, affirms the study by Mehdia, Harroud, Boulmalf, & El Koutbi, 2011 which stated that effective implementation of middleware depends on the type of organization. For example, organizations with a supply chain focused on a single process or internal activity, such as distribution center processes, Just-In-Time manufacturing processes, or asset tracking, can derive significant benefits from centralizing information and assets. However, from this study, different organizations with different supply chain processes were explored meaning that the utilization of middleware technologies would differ.

Cloud Computing technology was also explored in this study. It was found that a moderate to a great extent of participants store their data in the cloud which is accessed in real-time through various devices and also shared among multiple devices and cloud users. In addition to cloud computing, the research revealed that participants reported moderate to significant utilization of IoT software installed in their devices. This software facilitated device-to-device communication, real-time monitoring of network activities, and visualization of product conditions throughout the supply chain, from the factory to end users and other supply chain actors. Overall, the adoption and utilization of cloud computing and IoT software were not as extensive as other technologies such as RFID and wireless sensor networks. This shows that while most organizations have embraced IoT in their supply chain processes, a significant number have not fully utilized its capabilities in instances such as communication, real-time monitoring, and product visualization.

To explore the supply chain performance, reliability, agility, and cost-effectiveness of the IoT adoption in SCM were explored. Generally, IoT adoption provides for all these attributes but on different scales. According to the findings of this study, the adoption of IoT in supply chain management significantly enhances reliability by providing reliable visibility into products from the production stage to the point of delivery. Reliability is also realized through the optimization of the production process and also efficient goods transmission. The IoT adoption in the SCM has also been boosted by cost-effectiveness. Most participants felt that IoT enhances automation which then reduces the cost related to manual processes. Additionally, IoT adoption was found to enhance the agility of organizations through real-time data sharing, speed, and scalability of business processes. Of the three factors investigated, IoT was found to enhance reliability more than saving cost and providing for agile organizations. Most organizations are aiming to today are aiming at meeting customer requirements, especially in terms of quality, time, and place. As described by De Vass, Shee, and Miah (2018), IoT is highly adopted to enhance connection with suppliers, consumers, and internal activities and therefore the reliability of these technologies makes them highly adopted by large manufacturers with a diverse customer base and supply networks.

The IoT has often been viewed as the best way of managing complex and diverse supply chains. However, the technology has not been adopted completely among manufacturing companies due to various challenges that hinder such adoption. As indicated in this study, the main challenges identified for the adoption of IoT in manufacturing companies are data security and privacy concerns, behavioral issues, and limited resources. This shows that IoT is affected by normal technological challenges such as cybersecurity issues that can negatively affect an organization. As illustrated by Da Rocha, Mendes, De Santa-Eulalia, and Da Silva Moris (2017), the lack of clear protocols and guidelines makes it difficult for IoT users to have guidelines that make them to safely navigate through the technological world. Other challenges like data scalability, time consumption, expertise, management support, and poor quality data were felt on a very limited scale. However, it should be noted that the issue of a lack of top management support may have some bias in this study, as a significant proportion of the respondents consisted of top managers.

5.3 Ranking by sector

The table below shows the ranking in the use of IoT and its convenience level among large manufacturing sectors in Nairobi, Kenya

Table 5.1: Ranking by Sector

Category	Average	Rank
Metal and Allied	3.841667	1
Food and Beverage	3.816667	2
Energy	3.84	3
Rubber and Plastics	3.625	4
Textile and apparels	3.6	5
Pharmaceuticals	3.177778	6
Motor vehicle	3.1	7
Furniture, Wood products, and Timber	3.044444	8
Paper and Paperboard	2.761905	9
Leather Products and Footwear	2.633333	10
Chemical and Allied	2.62963	11

Source: Author

According to the table above, IoT in SCP is highly used among metal and allied, and food and beverage sectors. However, the technology is less used within leather and footwear and chemical and allied industries.

5.3 Conclusion

By utilizing technology adoption theory as a framework and conducting thorough data exploration and analysis, this research investigated the influence of IoT adoption on the supply chain performance of large manufacturing firms in Nairobi, Kenya. It is evident that IoT implementation in the supply chains enhances the performance of the organizations. Some large manufacturers in Kenya have implemented different IoT technologies on their supply chains including Radio Frequency Identification for tagging and tracking, wireless sensors networks for monitoring transportation operations and verifying the right handling conditions of commodities, middleware for device and user integration, cloud computing for data storage and exchange as well as IoT application software for real-time monitoring and visualization. Out of the various technologies examined, RFID stands out as one of the most widely adopted. This is due to its crucial role in ensuring product identification throughout the entire supply chain, from dispatch to the final destination. To enhance the efficiency of the supply chain process and provide additional capabilities such as storage and data management, several other technologies have been implemented. These technologies work in conjunction with RFID to optimize the overall performance of the supply chain.

The findings of this study highlight the significant capability of IoT in addressing a wide range of supply chain challenges. For instance, IoT adoption has been found to enhance reliability, and agility and also reduce costs within manufacturing firms. Before, business expressed their reluctance to adopt IoT in the supply chain due to its costly nature and disruption of existing processes. This research provides critical information on how to utilize IoT as a strategy for increased efficiency and reliability in supply chains. Actually, IoT reduces the cost instead of increasing it as perceived by some organizations. While some challenges exist to the implementation of IoT such as data security and privacy and behavioural issues, such challenges are minimal and can be addressed through proper policies and best practices in managing IoT capabilities.

5.4 Recommendations

This study investigates the influence of IoT adoption on supply chain performance within large manufacturing companies. In Kenya, several major firms have yet to implement IoT due to factors such as cost, reliability concerns, and capacity limitations. To gain deeper insights into the impact of IoT on supply chains, this study concludes that significant manufacturing firms should consider investing in IoT as a means to improve supply chain efficiency. It is evident that IoT improves the reliability, agility, and cost-effectiveness of large manufacturing firms. However, to fully benefit from IoT, these firms must effectively utilize essential capabilities such as radio frequency identification, wireless sensor networks, middleware, cloud computing, and IoT application software. This study further reveals that although these capabilities have been adopted, their maximum potential remains untapped.

The findings from this study can contribute to the manufacturing industry's comprehension of the significance of IoT adoption in influencing the SC performance of large manufacturing companies. Generally, the adoption of IoT by major manufacturers faces relatively few challenges, with the majority stemming from operational capabilities. Nevertheless, some issues remained unexplored due to the study's specific nature and scope. For instance, the research explored only large manufacturers who have the financial power to purchase the technologies, employ experienced staff and even reduce the risks related to its adoption. Therefore, there is a need to conduct similar studies among small and medium-sized manufacturing entities to establish other factors that affect IoT adoption.

5.5 Limitations of the study

The constraints encountered throughout the research process includes information scantiness and finding respondents with enough experience. Some organizations had not implemented IoT in their supply chain and some had only implemented certain capabilities investigated but not others. Additionally, while some organizations are based in Nairobi, Kenya, their major operations are conducted outside the city which made it difficult for the respondents to clearly respond to the questions.

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APPENDIX: RESEARCH QUESTIONNAIRE

PART 1: GENERAL INFORMATION

1. Kindly indicate if you have more than 100 employees in your organization
   Yes ☐ No ☐

2. Kindly Indicate your highest level of education
   O-Level ☐ A-Level ☐
   College Level ☐ Graduate Level ☐
   Post graduate Level ☐ Any Other (Specify)…………

3. Kindly indicate your experience in supply chain management/operations
   Less than 1 year ☐ 1-5 year ☐
   6-10 year ☐ above 10 years ☐

PART II: INTERNET OF THINGS ADOPTION

To what extent has your firm implemented the following Internet of Things technologies in your supply chain operations? Kindly tick as appropriate using the following Likert scale of 1 – 5 where 1=No at all; 2=Little extent; 3=Moderate Extent; 4=Great extent; 5=Very Great extent

	INTERNET OF THINGS TECHNOLOGIE S	**Respondents Rating**				
		1	**2**	**3**	**4**	**5**
4.	**RFID**					
i.	My organization uses Radio Frequency Identification (RFID) tagging and tracking					
ii.	RFID in our supply chain provides individual item level identification					
iii.	RFID in our supply chain operations provide unit level (product group/pallet) identification					
5.	**Wireless Sensors Network**					
i.	Our supply chain has a network of sensors to monitor supply chain entities through auto-captured data (e.g., Machine sensors, barcode, QR code, GPS, smartphones)					
ii.	The sensors in our network measures supply chain activities, processes and environmental conditions (e.g., temperature, speed, customer shopping behaviour)					
iii.	The sensors in our network help control supply chain processes remotely (e.g., alerts, auto reporting, safety shutdowns)					
6.	**Middleware**					
i.	The company has a software that connects and integrates all devices used in supply chain operations					
ii.	Our supply chain has a huge number of diverse *Things and sensors* connected and communicating with one another over the internet					

iii.	Middleware software is a key enabler in the integration of different components in the supply chain					
7.	**Cloud Computing**					
i.	Data collected by gadgets in our supply chain operations is stored in the cloud					
ii.	Users in our supply chain can access cloud resources in real time not only through computers but also through all types of devices and computer networks					
iii.	Supply chain information resources stored is shared between multiple cloud users.					
8.	**IoT Application Softwares**					
i.	Supply chain gadgets such as phones, tabs and computers are installed with softwares that enable communication between devices					
ii.	Softwares installed in our supply chain devices enable real-time monitoring of activities within the network					
iii.	The softwares we use in our supply chain helps us to visualize the conditions of products from the factory to supply chain actors downstream					

PART III: SUPPLY CHAIN PERFORMANCE

To what extent has Internet of Things adoption affected the following measures of supply chain performance? Kindly indicate on a scale of 1 to 5 where, 1 it totally deteriorated and 5 totally improved it

9.	SUPPLY CHAIN PERFORMANCE INDICATOR	RATING
i.	Reliability-Ability to consistently met the customer requirements in product volumes, at the right time, right place with the expected quality	
ii.	Agility-The ability to adapt to changes in the marketplace in order to preserve or improve a company's competitive edge in the supply chain.	
iii.	Cost-The ability to maintain supply chain management costs to a minimal.	

PART IV: CHALLENGES OF INTERNET OF THINGS ADOPTION

To what extent does your organization face the following challenges when implementing Internet of Things* ? Tick as appropriate using the following Likert scale of 1-5 where: 1= Not at all; 2= Little Extent; 3= Moderate Extent; 4= Large Extent; 5=Very Large Extent

	CHALLENGES OF INTERNET OF THINGS ADOPTION	Respondents Rating				
		1	2	3	4	5
10.	Unclear benefits and ambiguity on return on investment					
11.	Data scalability (inadequate storage capacity)					
12.	Data security and privacy					
13.	Lack of data handling procedures					
14.	Behavioural issues					
15.	Time consuming					
16.	Limited resources					
17.	Lack of expertise among staff					
18.	Lack of top management support					
19.	Poor quality of data					

THANK YOU FOR PARTICIPATING IN THIS STUDY!