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Leveraging blockchain technology benefits to enhance maize value chain performance in Kenya.

Nzau, Kelvin
Strathmore Business School
Strathmore University

LEVERAGING BLOCKCHAIN TECHNOLOGY BENEFITS TO ENHANCE MAIZE VALUE CHAIN PERFORMANCE IN KENYA

Kelvin Nzau

136610

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Strathmore University,

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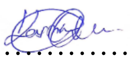
DECLARATION

I declare that this work has not been previously submitted and approved for the award of a degree by this or any other university. To the best of my knowledge and belief, this dissertation contains no material previously published or written by another person except where due reference is made in the thesis itself.

KELVIN NZAU

136610

Signature: ………………. Date: …June, 8, 2023………

APPROVAL

The dissertation of Kelvin Nzau was reviewed and approved for examination by:

Dr. James Ndegwa

Lecturer,

Strathmore Business School

Signature: ……… Date……9/8/23……..............

Dr. Ceaser Mwangi

Dean Strathmore Business School

Signature: ………………….. Date……………......................

Dr. Bernard Shibwabo

Dean Graduate School

Signature: ………………….. Date……………......................

DEDICATION

I dedicate this dissertation to my immediate family who has supported me in the course of my studies.

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ABSTRACT

The maize value chain as other agricultural value chain experiences problems of mistrust among its multiple actors, limited access to information to actors, manipulation of data, and lack of traceability of products. The advance of blockchain technology in other industries has already shown its significance in alleviating these issues thereby enhancing its performance; yet, its application in the agricultural sector lags behind other sectors. The maize value chain has been marred by fraud, corruption, health and safety concerns which can be addressed by adoption of blockchain technology. Using the Diffusion of Innovation theory, this research explored how blockchain technology components: traceability, transparency, transaction costs, and immutability while maize value chain performance is the dependent. A positivist research philosophy was adopted under which 14 state and non-state agencies were included into the sample size using purposive sampling method. In each organisation, snowball sampling was used to select 3 staff engaged in market research and development in maize production. A structured questionnaire based on 5-Likert scale item was developed and found valid and reliable for administration. Descriptive analysis was done followed by diagnostic tests performed before undertaking correlation and multiple regression analysis. The 4 BCT dimensions explained 88.6 % of change in performance of the maize value chain and this was significant at the 95 % confidence interval. Out of the 4 determinants, transparency had a positive and significant effect on maize value chain performance while the other determinants had an insignificant effect. Study concludes that adoption of BCT would enhance the transparency in the maize value chain while it would not have any effects on maize value chain by immutability, transaction costs, and traceability.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

DEFINITION OF TERMS

Blockchain technology – This is technology that enables all actors involved to secure the settlement of transactions, attain transactions, and transfer assets at a low-cost (Tschorsch & Scheuermann, 2016).

Immutability – This refers to transaction information residing in blockchain that are tamper proof; that is, they cannot be changed or removed (Politou, Casino, Alepis, & Patsakis, 2019).

Smallholder farmers – These are farmers that own farms that are less than five acres in size; producing 80% of the world's food supply (Muyanga, 2013).

Traceability – This is the capability to follow specific locations, events, and various entity functions (Astill et al., 2019).

Transaction cost – This refers to the reduction of costs in blockchain technology by eliminating the intermediaries and automating transactions (Berg & Myllymaa, 2021).

Transparency – This is where certain information is apparent and accessible to certain external observers and stakeholders in a value chain (Astill et al., 2019).

Value chain – This is the group of functional actions that an enterprise engages in to add value to its products for its consumers (Dubey et al., 2020).

LIST OF ACRONYMS AND ABBREVIATIONS

ASC	Agriculture Supply Chains
BCT	Blockchain Technology
FRAs	Food Reserve Agency
ICTs	Information and Communication Technologies
IoT	Internet of Things
LMICs	Low-And Middle Income Countries
NACOSTI	National Commission for Science, Technology and Innovation
OLS	Ordinary Least Squares
RSPO	Roundtable on Sustainable Palm Oil
SCF	Supply Chain Finance
SCM	Supply Chain Management
SDGs	Sustainable Development Goals
SPSS	Statistical Package for the Social Sciences
SSA	Sub-Saharan region
SSCM	Sustainable Supply Chain Management
SSFs	Small Scale Farmers
SU-ERB	Strathmore University Ethical Review Board
SWOT	Strength, Weakness, Opportunity, and Threat
UN	United Nations
UNCTAD	United Nations Conference on Trade and Development
VIF	Variance Inflation Factors

CHAPTER ONE

INTRODUCTION

1.1 Background to the study

The increasing volatility of weather situations and globalization are influencing the demands for value-added agricultural production (Tran & Trinh, 2021). The United Nations (UN) sustainable development goals (SDGs), especially goal number 2 on zero hunger and goal number 12 on liable consumption and production has emphasized transparency and traceability in worldwide food supply chains (Lindén & Persson, 2021). The importance of the maize value chain to Kenya in achieving the Sustainable Development Goals (SDGs) is espoused in SDG 1 and 8 which focus on reducing poverty and providing economic growth and decent work for society. Maize is the second agricultural product in Kenya; according to Rwanyiziri et al. (2019), improving the maize value chain will ensure increased maize yields and sustainable food security.

A value chain is the connection of brokers, raw material, service providers, sales markets, processing firms, and various stakeholders where these actions promote competition among each other in a market and maintain the introduction of process innovations in the value chain (Keshelashvili, 2018). A value chain is the total activities that aim to create value to its consumers (Dubey et al., 2020). The agricultural sector is known to be the least digitized industry that missed out to take advantages of the internet, due to lack of connectivity.

In other industries, Information Communication Technologies (ICTs) has successfully increased effectiveness and efficiency of data acquisition, storage, analysis, and this can also be an advantage to agricultural value chains. This would enable all stakeholders to easily get updated information and thus make more effective decisions in their farming activities (Dubey et al., 2020). The limited use of ICT in agriculture is manifested in centralized management, centralized databases for storing agribusiness data, with a high risk of single-point failure, cyber-attack, asynchronous inaccuracy, censorship, data corruption, and scientific misconduct. Today, Blockchain technology provides a distributed database that maintains the constantly increasing list of data records that are verifiable by all actors in a value chain (Bhusal, 2021).

1.1.1 Maize Value Chain Performance

The maize crop serves as a cash crop and staple diet and is consumed directly by many as a first meal option around the world (Njogu, 2019). The reviewed literature shows Low-And Middle Income Countries (LMICs) experience several constraints from the production to the consumption and marketing of maize. Small scale farmers (SSFs) face multiple constraints by participating in the value despite their importance in maize production in the Sub-Saharan region (SSA) region which is highlighted below.

In Mozambique, Mango et al. (2018) found maize traders experienced variable costs for transportation, storage and fumigation, packing, hiring labour, overheads and devaluation of capital assets. In Malawi, high trade margins and in-between costs were experienced in the maize value chain due to increased costs of transportation. In Ghana, Agyekumhene et al. (2020) observed that the maize value chain has often faced unfair conditions; mistrust, uncertainties, conflicts, and defaults. In Zambia, Kaliba (2021) found that the maize value chain experienced a power balance shift due to interference from government agencies and high government officials. This interference was labeled as 'unpredictable' by chain actors and non-state stakeholders.

In Nigeria, Ater, Aye, and Daniel (2018) found that constraints to maize value addition were in marketing, input costs, offloading and on-loading costs, and access to input. Other constraints included limited funds, high transportation costs, and limited access to processing equipment, limited transportation systems, and high product costs. Olusegun et al. (2020) study in Nigeria found that maize was profitable to value chain stakeholders but the amount and percentage of profit varied as processors had the highest profits and farmers the least.

In Mozambique, Adam et al. (2018) found that female maize producers were less engaged in post-production processes indicating dominance of men in the value chain In Ethiopia, maize value chain constraints included lack of working capital, interruptions in supply during the seasons, small trading units, mistrust among cooperatives, poor quality control, and bad infrastructure (Rashid et al., 2010). Osei et al. (2015) research revealed youth were excluded from the maize value chain.

In Tanzania, Manase (2018) found that maize chain sustainability suffered from storage and warehouse facilities, level of education, price instability, limited infrastructure, capital inadequacy, and market structure. These threats to maize value chain sustainability results in some participants quitting and abandoning the activity to perform other works. Adamy et al. (2020) noted that men dominated the higher levels of the maize value chain as participation of women was limited to maize production as women experienced challenges in participating in higher levels of the value chain in Tanzania. Women were limited in expanding their business, decision making as men were the major decision makers.

In Kenya, the maize value chain has had its share of problems ranging from contamination of maize from Aflatoxin that resulted in 125 deaths and 317 cases of hepatic failure. The scandal in the importation of maize from South Africa which was later revealed that the stock was imported by South Africa the previous year when they were experiencing food shortages (Lesiit, 2020). According to Kirimi (2011), the classic food price dilemma which is how to keep farm prices high enough to provide production incentives for farmers while at the same time keeping them low enough to ensure poor consumers' access to food is a challenge facing the maize value chain.

Additionally, Kamau and Nyongesa (2017) findings showed that low produce prices, poor rural roads, high farm input prices, and poor market information are the major challenges facing the maize farmers in Bungoma County. Olumeh, Adam, Otieno, and Oluoch-Kosura (2018) found that male and female households marketed and produced less kilograms of maize and male led households were more commercialized in contrast to female headed households. The most dominant channel for selling maize produced was through the farm-gate and this was reported among more than half of the sample.

The above literature indicates that the maize value chain suffers from power imbalances, mistrust and conflict among stakeholders, high production costs, gender and youth exclusion in the value chain, high prices for inputs, and low prices for products, poor communication, in this research, these constraints and challenges were used to measure maize value chain performance.

1.1.2 Blockchain Technology

Bhusal (2021) commented that agriculture is the least digitized industry that missed out to take advantages of the internet, due to lack of connectivity. To address the problems of tracing, food safety, and building trust among the stakeholders in the supply chain some initiatives have been taken in recent years with the use of Information and Communication Technology (ICT). The emergence of blockchain technology (BCT) can be traced to management of the digital cryptocurrency as it promotes the traceability and trading of financial assets (Yermack, 2017). Nevertheless, BCT has evolved and has created value in insurance, manufacturing, and marketing industries (Hooper & Holtbrügge, 2020) and is seen as being promising and revolutionary (Bumblauskas et al., 2020) for the agriculture and food sector contributing positively to challenges in supply chain and value chains (Köhler & Pizzol, 2020). Agriculture is one of the areas where BCT could bring a revolution by solving the existing problem of Agri-product fraud, its traceability, price manipulation, and lack of customer trust in the product (Bhusal, 2021).

Several studies (Köhler & Pizzol, 2020; Tiscini et al., 2020; Chen et al., 2020) have determined that BCT is in its infancy in the agri-food industry and Liu, Long, Song, and He (2020) agree there is need for research on BCT in the agricultural sector due to experiences in information asymmetry, mistrust, and traceability issues which BCT can help solving by promoting accountability and verifiability (Lindén & Persson, 2021). BCT has been proposed as a solution in low-trust settings where participants are not able to trade directly or lack a reliable middleman. BCT thus allows data to be exchanged and verified with no participation of third parties (Quiroz, Kuepper, Wachira, & Emmott, 2019).

According to Song, Sung, and Park (2019), BCT promises ability to trace products in a system and can be adapted to several functions such as inventory management, quality assurance, logistics, and forecasting. BCT serves in storing information that several actors create in the whole value-added process from seeds to sale of the final agricultural product. Xiong, Dalhaus, Wang, and Huang (2020) agree that BCT makes sure that information and data are visible to all stakeholders and all information that is recorded is immutable.

In a review of literature on BCT and sustainable supply chain management (SSCM), Berg and Myllymaa (2021) identified its features as transparency, traceability, accountability, immutability, consumer trust, auditability, data security, governance decisions, transaction cost saving, and trustless chain. In this study, transparency, traceability, immutability, and transaction cost dimensions of BCT are adopted as independent variables. The conclusion from the above and other scholars (Rejeb et al., 2020; Li, Lee, & Gharehgozli, 2021; Sekuloska, & Erceg, 2022) is that BCT consists of ensuring transparency, traceability, and immutability and saving on transaction costs for agricultural value chains.

1.1.3 Blockchain Technology and Maize Value Chain Performance

The findings from a literature review by Zhao et al. (2019) established BCT was used for enhancing agri-food value chains by advances in information communication and technologies (ICT) and Internet of Things (IoT) were being used to advance agri-food value chain management in information security, traceability, manufacturing and sustainable water management. The research was able to explain that privacy and transparency can be attained by having more information stored in BCT and helping in building trust.

In India, Kamble, Gunasekaran, and Sharma (2020) found that BCT adoption in agriculture supply chains (ASC) was motivated by the traceability component of the system followed by auditability, immutability, and provenance. Bolt (2019) also found that the transparency component of BCT enabled stakeholders in value chains to audit information and also create trust among actors.

In China, Xiong et al. (2020) revealed that BCT provided transparency among value chain actors as it allowed collection of efficient information as it recorded each step from the product creation to the consumer. In another case the African context, Adegboye (2020) investigation into agri-business value chain digitalization recommended that use of BCT would help ensure better use of farm land, increase stakeholder access in the value chain framework, food security, increase productivity, and lessen poverty and hunger. In Kenya, Moturi and Kosgei (2021) found BCT can indeed be used to trace products from the farm to the consumer.

1.2 Problem Statement

Agricultural value chains involve many different actors, such as farmers, shipping companies, manufacturers wholesalers and retailers, distributors, and groceries. Information on transactions between actors either resides on paper or private servers and databases of trusted third parties. This structure results in an increase costs to access data, subject to fraud, corruption, errors or chances of product counterfeit. This structure of agricultural value chain lacks traceability, security of product information, trust among actors, and confidence of customers in the product's quality (Bhusal, 2021).

In an attempt to solve these problems, BCT has been hailed as a panacea for ensuring value chains in the agricultural sector are able to provide access to information among actors, secure information, enhance trust, and provide traceability of product. A task force set up by the Kenyan government on BCT and emerging technologies made the recommendations that these technologies had the potential to modernize the food value chain and increase food security (Moturi & Kosgei, 2021). Maize is a staple food source for a majority and its value chain has been marred by poor participation of actors, corruption, fraud, and contamination of maize. Hence, the promises of BCT to provide traceability reduce costs to access information, reducing chances of manipulation of data, and minimizing chances for fraud or mistrust among actors need further investigation in the maize value chain.

Several studies have delved into the relevance of BCT in agricultural value chains. Moturi and Kosgei (2021) investigated stakeholders' willingness to use BCT and found the majority agreed that BCT was significant for traceability in the horticultural sector. Lesiit (2020) examined the role of BCT to increase safety and traceability in the agricultural industry, finding that it enhanced food integrity and safety by providing traceability and allowing actors in the value chain trace fast food crises or fraud. However, these studies have not explored the influence of transparency, traceability, immutability, and transaction costs as BCT components that can contribute to performance of the maize value chain.

1.3 Research objectives

The general objective and specific objectives are outlined here.

1.3.1 General objective

The purpose of the study was to explore how blockchain technology benefits can be used to enhance maize value chain performance in Kenya.

1.3.2 Specific objectives

The study was guided by these specific objectives;

i. To assess influence of blockchain traceability on maize value chain performance among smallholder farmers
ii. To evaluate effect of blockchain transparency on maize value chain performance among smallholder farmers
iii. To measure influence of blockchain transaction cost on maize value chain performance among smallholder farmers
iv. To analyse influence of blockchain immutability on maize value chain performance among smallholder farmers

1.4 Research questions

These research questions were answered;

i. How does blockchain traceability influence maize value chain performance among smallholder farmers?
ii. How does blockchain transparency influence maize value chain performance among smallholder farmers?
iii. How will blockchain transaction cost influence maize value chain performance among smallholder farmers?
iv. How does blockchain immutability influence maize value chain performance among smallholder farmers?

1.5 Significance of the Study

1.5.1 Regulators and policy makers

Presently, there exists no regulatory framework on BCT; this study is thus of importance to ICT regulators as it contributes to the existing discussion in using the technology in the agricultural food chain and gives insight into how guidelines to implement and promote BCT in the future.

1.5.2 Research and Development Organisations

The existing evidence shows that BCT use in the agricultural industry is receiving considerable interest from the government and other agencies in the agricultural sector. The study is therefore of importance to the various agricultural Research and development (R&D) organisations as findings will provide a glimpse into how BCT can be leveraged to solve value chain problems. Such information is crucial for these organisations to conduct research to make BCT use in agricultural value chains in Kenya a reality.

1.5.3 Maize farmers

The study benefits maize farmers as it provided useful information on how some of the challenges they experience in the value chain can be addressed using this technology. The findings and recommendations from the study can spur further interest in implementing BCT in the maize value chain.

1.5.4 Consumers

The study may be of benefit to consumers as BCT provides the ability to trace food products from specific sources and this enhances the safety and health standards of the products that reach a consumer.

1.5.5 Retailers

To retailers, the ability to trace the source of maize products may enable them to provide assurance to consumers on the quality of product and also makes it possible for them to seek accountability from suppliers thereby safeguarding their enterprise by reducing economic losses and wide-spread loss of consumer trust.

1.5.6 Scholars and Academia

To researchers, the study builds on the existing knowledge and literature on BCT adoption in the larger agricultural sector while also making suggestions for further research on BCT application in agricultural value chains.

1.6 Scope of the Study

There are several Counties that produce maize for Kenya; because of the varied areas where our study sample organisations ply their trade, limiting to a specific County would have stifled the study’s ability to achieve geographical objectivity. Therefore, this study took a macro level view and thus included state and non-state agencies that are engaged in research and market development of the maize value chain. There are several benefits that come from utilizing BCT, from these, the study focuses on transparency, traceability, transaction costs and immutability as the concepts measure BCT. The maize value chain performance was measured by the different challenges that face it including: Power imbalances, Health and safety, Mistrust and conflict among actors, High production costs, gender and youth exclusion, and low pricing. In terms of participants, there are several actors in the value chain from research and development (R&D), input suppliers, traders, consumers, millers, and retailers. However, data collection was from experts in the various state and non-state agencies involved in research and market development for the maize value chain. The study was conducted from January 2023 to June 2023.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

This chapter explores the existing empirical literature on the study variables by beginning by identifying, describing, and justifying relevant theories that were adopted in this research. The empirical literature was presented from a global, regional and local perspective identifying the findings, research gaps, and the gaps that this study filled in the summary and knowledge gap. The conceptual framework of the study is also included.

2.2 Theoretical framework

Kitchel and Ball (2013) define a theoretical framework as a complex statement or assertion that explains or predicts phenomena and is aimed at answering how, why or what causes a phenomena or why it occurred. This study bases its theoretical framework on Diffusion of Innovation Theory (DoI).

2.2.1 Diffusion of Innovation Theory

The DoI is associated with Rogers (1995) who argued that an innovation moves in a setting across time from a macro perspective. Diffusion is a process of an innovation adoption by individuals, society or organizations over the span of time (Rogers, 1995). This means that innovation in technology is related to the innovation itself, social systems, time, and communication channels. The DoI describes five categories of adopters consisting of laggards, late majority, early adopters, and innovators (Rogers, 2003).

There are 5 main features of an innovation which influences its adoption rate and these are complexity, relative advantage, observability, compatibility, and trialability. The compatibility features are related to the extent of perception towards an innovation matching the existing needs and values of likely users. Complexity describes the extent to which innovation is seen as less complicated to comprehend and utilize. Relative advantage speaks to the extent of an innovation to be useful. Trialability explains with what ease the innovation can be tried while observability speaks to the extent to which an innovation's outcomes can be seen by others (Ayim et al. 2020).

Despite BCT frequent discussion, its actual diffusion seems to be varying for different industries. According to Bhusal (2021), BCT shows a promising approach to foster a safer, better, more sustainable, and dependable agri-foods system in the future. However, BCT use in agriculture is in the initial phase and faces various issues like cost of implementation, privacy, security scalability, performance, and infancy; it can bring a revolution in the agriculture industry.

In their study on diffusion of BCT in selected industries, Grover et al. (2019) found that agriculture sector did not contain literature evidence of conceptual and practical implementation of BCT. However, studies signals BCT can create disruptive innovation in the agriculture field. Disruptive innovation refers to innovation that transforms expensive or highly sophisticated products or services to those that are more affordable and accessible to a broader population (Chen & Li, 2022). Thus, in agricultural value chains, BCT can be a disruptive innovation to enhance low level actors in the maize value chain.

The DoI has been criticized for implying that it's beneficial for an innovation to be adopted and diffused by all farmers. However, farmers only adopt innovation that is useful for them. The DoI has been accused of individual-blame bias when the responsibility for not adopting is put on farmers but can be the fault of poor or unclear communication or the innovation is not appropriate (Bakkabulindi, 2014).

Despite these weaknesses, the DoI has been adopted in several studies (Chen et al., 2020; Vu, Ghadge, & Bourlakis, 2021; Ayim, Kassahun, Tekinerdogan, & Addison, 2020) on adoption of innovations among farmers. In these studies, the constructs of relative advantage, compatibility, simplicity, observability, and trialability are utilized to identify acceptance of technologies and innovation among farmers. The DoI theory is thus useful for this study as the triability dimension provided a basis for reaping the anticipated benefits of BCT on the maize value chain and its overall performance.

Thus, the statements asked respondents on complexity, relative advantage, observability, compatibility, and trialability of BCT components in the maize value chain. BCT is a technology that has become popular since the early 2010s and is being adopted in diverse sectors. In the agricultural sector, BCT is being used albeit still in early infancy; especially in the developing world. However, the use of this technology will diffuse over time to be adopted in enhancing various agricultural and food systems including the maize value chain.

2.3 Empirical literature

Empirical literature is the process of gathering and assessing primary information that is from first-hand experiences or observation from the field. This empirical literature is gathered from and presented in a global, regional, and local setting and is presented in terms of findings that agree, those that disagree, and those that are inconclusive in regard to the relationship between BCT and value chain performance. The first strand of research shows that BCT is useful for agricultural value chains.

2.3.1 Traceability and value chains

Most studies have been done in the livestock value chain and are included in this review. In the United States, Buskirk et al. (2013) conducted a study on traceability for beef production in an institution's value chain by using Radio frequency identification (RFID) of beef animals and sharing data to two dimensional (2D) barcodes on beef packages and carcasses. The field work included displaying 2D barcodes to 347 consumers from which 16 % scanned codes to see the farm-of-origin website. The outcome from these experiences showed that customers had an increase in value on food selection, traceability systems that were able to differentiate products contributed to economic rewards to value chain actors. Utilizing traceability systems in agricultural value chains was found to increase development of regional food systems and contributed to better services by connecting farmers and consumers.

In Portugal, Cruz and da Cruz (2020) research was aimed at proposing a platform based on BCT to enable fish lots tracing forth and back in the whole fisheries value chain to match the consumer demand and society transparency of fish products in the entire value chain. The researchers implemented a combined process of all operators by adopting a smart contract on the Ethereum blockchain. Some of the derived benefits included improving communication and the coordination among actors in the value chain and enhancing the integrated process. It was concluded that BCT matched the traceability where each user was able to have a copy of the information and this allowed them to collaborate even when there was no complete trust among them.

Using a similar approach to examine the chances for traceability in the pig value chain, Mutua, Lindah, and Randolph (2020) employed a desk review approach from which the experience of the researchers and the results were employed to inform the traceability system design for smallholder farmers. The adoption of BCT for traceability in the value chain would reduce disease problems thereby contributing to increase in production and further ensuring safety and quality of pork sold in the local market. For smallholders, individual identification would be achieved as farmers could get pigs from several farms and would keep a few at a time such as one or two and sell at different time periods.

Using a pilot of testing a livestock identification and traceability system (LITS), Mutua et al. (2018) randomly identified and selected animals at a local market using specific coded ear tags. The information on source, ownership, identification was collected and posted on an online database. The outcome showed that the traceability system was able to classify animal sources with noticeable extraordinary drug excess levels in tissues. From these findings, the LITS was vindicated as an important tool for undertaking surveillance for food safety and animal health. The findings were also able to show the barriers of deploying it in a beef value chain due to low incentives for its utilisation.

Other studies have been done on vegetable value chain. In Kenya, Gichure, Wahome, Karuri, and Karantininis (2013) evaluated flow of information along the organic fresh produce value chain by employing a participatory research design of organic outlets and farmers using a two-step method which involved selection of fresh produce value chain and assessing its traceability. Traceability was found to be low as most actors were smallholder farmers who had no traceability system that was functional. Personnel perception and organisational activities drove this traceability with quality management certifications, food safety training, documentation, quality systems monitoring as some of the organisational factors.

Using a sample from the horticultural sector in Kenya, Moturi and Kosgei (2021), investigated the existing traceability systems in its supply chain to assess the level of stakeholders' readiness to leverage the huge prospects BCT offers. The sample consisted of top management in horticultural firms, ICT workforce, users, and consumers selected by stratified random sampling under a descriptive research design.

The results indicated that perceptions on BCT were ranked as effective in the value chain by its actors. The findings are important for this study as it shows that BCT can indeed be used to trace products from production to consumers. However, the study was conducted in the horticultural sector and its premise was on the supply chain and not value chain.

2.3.2 Transparency and value chains

Several studies that have investigated transparency in agri-food value chains have adopted a literature review approach. One such study is Zhao et al. (2019) reviewed current status of BCT such as its main uses in agri-food value chain, recent development, and encounters from an all-inclusive perspective. The outcome of the study showed that BCT along with advances in ICTs and IoT were being used to advance the agri-food value chain management in information security, traceability, and manufacturing and sustainable water management. The research was able to explain that privacy and transparency can be attained by having more information stored in BCT and helping in building trust.

Using a similar approach in China, Mol (2014a) investigated emerging challenges for transparency in agricultural value chains and their effects. The review identified 4 ideal forms of value chain transparency and this can often be combined: regulatory management, public, and consumer transparency. The author stated that value chain transparency will have to focus on whether value chain transparency for whom, by whom, and with what environmental and social sustainability outcomes for various actors across the globe. In a later research, (Mol, 2014b) investigated to what degree and how transparency practices and institutions on food products and production played a function in governing food safety and quality among the four ideals of food chain transparency. The study found that China's food transparency was in its formative phases in terms of governing domestic product safety and quality and food production in relation to global food chains.

Going in another direction; other studies have examined the impact of BCT. Kamilaris et al. (2019) assessed how BCT had impacted food supply chain and agriculture by focusing on current initiatives and projects in Spain and Cyprus. The study established that each action along the food chain was enhanced when BCT was adopted as information was recorded into the technology and this served as an immutable approach to storing information that was readily accepted by all stakeholders in the chain. The data stored for each of the transactions was validated by the stakeholders in the food supply chain and this resulted in consensus among all participants. Transparency in food supply chains was achieved by adoption of BCT but its use among farmers and systems was hampered by several challenges and barriers. These challenges centered on policies, regulatory frameworks, education, and technical aspects.

Likewise, Hirbli (2018) assessed palm oil traceability in Indonesia using several case studies of BCT applications in value chains. One major constraint was palm oil traceability in the plantations. Tracing back palm oil to smallholder farmers employing the present certifications such as the Roundtable on Sustainable Palm Oil (RSPO) was proved as not efficient. The study was able to gain knowledge on how value chain sustainability can be achieved by creating incentives and increasing transparency to various stakeholders. BCT was found to provide smallholder farmers with a rigid traceability system by which digital or physical separation may be difficult to overcome.

2.3.3 Transaction costs and value chains

Case studies have been used to examine value chain performance. In Mozambique, Leonardo, Bijman, and Slingerland (2015) undertook 2 case studies in an effort to recommend an analytical framework that focuses on the transaction and production approaches of farmers. The study was done among smallholder farmers of maize who also cultivated sesame and sunflower. The findings revealed that majority of the farmers participated in spot markets where farmers were selling maize to several buyers due to the lack of asset specificity and low uncertainties in the farmer-buyer exchange and this form of setting had the lowest cost transaction but was not effective for maize farmers to participate in the value chain and increase their income.

While also taking interest on smallholder farmers, Severine et al. (2014) examined effects of transaction costs on their contribution in international value chains in Tanzania. The study was guided by the TCT focusing on tenure systems, land ownership, marketing systems, institutions, and dependence of households on agricultural farming and topography. Using a questionnaire, document review, observation checklist; the outcome revealed various components that described smallholder farmers and the institutions they operated in as the major cause of high transaction costs. The study established that the main cause of smallholder farmer failure to engage in global markets was having a small parcel of land which was fragmented, presence of opportunistic local buyers, ineffective farmer organisations, and Inefficiency in institutions.

Limiting their study to traceability through use of mobile phones; Soysa (2008) investigated agricultural value chain traceability indicating farmer enhancement of livelihoods and incomes to lessen waste by providing feedback in Sri Lanka. The system consisted of text messages sent to farmers every day and these messages provided information of the quantity of disallowed goods and the reasons for rejection to taking sudden, corrective action. The findings revealed that search and information costs for these activities before using mobile phones was extremely high and had contributed to major losses to farmers and the processors.

Moving away from descriptive research design, Okoye et al. (2016) adopted a multi-stage research design to assess how cassava smallholder participation was affected by transaction cost in central Madagascar. The study adopted a multi-stage research design that employed random sampling to choose 240 cassava farmers from 6 districts which were selected randomly in the first stage. In the second stage, two villages were randomly selected from these districts from which 12 communities with 20 farmers from each were selected in the final sample size of 240 farmers. The findings showed that market and transportation costs had a negative effect on market participation for smallholder farmers thus excluding them from the value chain.

Using a similar method in China, Lu (2006) adopted a 2-stage value chain model to investigate vegetable value chain competence at marketing and production phases collecting data from 84 vegetable (tomato) producers. The assessment provided a good chance for vegetable producers to identify at which stage they should reach high yields and higher incomes. The study unearthed that transaction costs had a major influence on value chain efficiency. There were varied transaction costs on various marketing chains and direct sales chains incurred the highest transaction costs and resulted in lower value chain efficiency. The study recommended for the adoption of BCT to enhance efficiency in the vegetable production value chain by reducing transaction costs.

Other studies that have adopted quantitative research approach in Kenya include Baraka, Mburu, and Muriithi (2019) investigation into participation in markets using a Heckman 2-step analytical model to evaluate the impact of size of these costs on profits for farmers. Negotiation-related and indirect evaluation had a positive relationship with vegetable sale direct from urban markets while indirect data transaction costs had a negative relationship. There was a positive relation among high indirect information transaction costs and profits were revealed and thus recommended good market data systems to enhance farmer profits.

Moving from a sample of perishables to grains, Macharia et al. (2014) assessed how maize smallholder farmers participated in the market due to transaction cost effects. Adopting a multistage sampling approach, 196 farmers from Kwanza district, Trans Nzoia County were selected from 3 villages randomly selected from each location. In each of these villages, respondents were chosen using systematic random sampling process matching the location size. Semi-structured questionnaires were used to gather information which was analysed using Tobit regression models. The results unearthed that time taken to receive payments, sorting maize costs, market rent costs, market searching costs, and information for demand and prices, transport cost from the farm to the market affected farmers market participation.

2.4.4 Immutability and Value Chains

The lack of practical studies exists on determining immutability and value chain performance. However, studies have adopted analytical research; one such study was done in Vietnam, Tran and Trinh (2021) where a Strength, Weakness, Opportunity, and Threat (SWOT) analysis of BCT for sustainable supply chains (SSCs) of agri-food was adopted. Using the interpretive research design to synthesize literature and sensibly persuade research conclusions. The study found that conventional agri-food supply chains represented challenges of information asymmetry also referred to as information failure which resulted in power imbalances in transactions. The potential of BCT in the Vietnamese agricultural sector would limit this imbalance of information amongst collection and personal action thus increasing accountability and lessening bureaucracy.

In a similar literature review approach; research in Italy on the barriers and answers for increasing agricultural value chain decision making was done by Hernandez et al.

(2017). The study established that present growth in uncertainty and risk was affecting agri-business actor decision making more so in regard to dealing with major commodities such as pricing. Hence, if the SCM is enhanced in the industry; it would result in enhancing their business situation. It was the study's conclusion that ICTs in solving problems in agriculture aimed to increase access to information, sharing, variety, and present a needed contribution to farmers and presented a high chance of increasing efficient decision making.

Taking a different approach, Shange (2014) analysed opportunities and challenges for smallholder farmer value chain combinations in both public and private sector organisations in South Africa. A qualitative methodology using semi structured questionnaires targeting 20 key public and private sector organisations working with smallholder farmers from which 17 representatives were interviewed. The study found that food standards and information asymmetry were huge constraints for smallholder farmers to be integrated into international value chains. Smallholder farmers did not have information on appropriate market channels to adopt or how to continuously produce products of retail standards resulting in sale of produce at lower prices thus leading to non-profitability. This evidence shows that agricultural value chains do present challenges for small holder farmers and these are barriers that adoption of BCT can help in overcoming.

Likewise, Atetwe (2016) conducted a qualitative study on value chain performance and analysis of a food company using observation checklists and interview guides in Kenya. The respondents were the heads of various departments in the company. The findings revealed inadequate data sharing was one of the factors leading too poor value chain performance of the firm. The input from employees in decision making was not sought as all decisions were made from the top hierarchy and shared to staff. It was the study's conclusion that as an SME, the firm should not have unneeded bureaucracy on sharing information. The study recommended that SMEs in food production should formalize their value chains by adoption of emerging technologies such as BCT to overcome information sharing and decision making challenges in their value chains.

Deviating from qualitative and adopting a quantitative research approach, Kising'u (2016) conducted research to determine what factors influenced participation of youth in agricultural value chain initiatives in Machakos County. The motivation for the study was the lack of information on pricing that most smallholder farmers face. A descriptive survey design was adopted and targeted 1,740 members from which 96 respondents were enlisted using stratified proportionate sampling from each of the four locations. The study found that awareness of value chains had a positive and significant effect on participation in value chains but the respondents indicated having moderate knowledge and information on the value chains.

2.4 Literature Review Summary and Knowledge Gap

The review was conducted from sourcing published articles and dissertations from which the relationships between the variables were highlighted along with the findings. In these studies, research gaps were also identified and these are summarized in Table 2.1.

Table 2.1: Literature Review Summary and Knowledge Gap

Author	Topic	Main findings	Research gap	How the study will fill the gap
Buskirk et al. (2013)	A traceability model for beef product origin within a local institutional value chain	A traceability system capable of differentiating products that contribute to economic rewards to value chain participants	The study does not mention BCT in terms of the value chain; the study focused on the beef value chain	The study will focus on BCT importance in performance of maize value chain
Cruz & da Cruz (2020)	Transaction costs magnitudes, market participation, and smallholder profitability in rural-urban vegetable supply chain	BCT was suited for tracing where all actors can have access to information but constraints in IT infrastructure are present	The study was conducted in the fish value chain; the study adopted a desk review approach	The study does not collect primary data to show the experience and usefulness of the BCT on traceability on the perspective of producers
Hirbli (2018)	Palm Oil traceability: Blockchain meets supply chain	BCT increased traceability and created incentives to the	The study was a desk review of the palm oil value chain	The study will focus on BCT importance in performance of maize value

		different stakeholders		chain by collecting field data to make inferences
Gichure et al. (2013)	Traceability among Smallholders in the Organic Fresh Produce Value Chain: Case of Nairobi.	Traceability was limited since majority of stakeholders were smallholders who had no functional traceability system	The study was limited to organic food markets	The study makes no mention of blockchain technology on value chain.
Mutua et al. (2020)	Possibilities of establishing a smallholder pig identification and traceability system in Kenya	Adoption of BCT for increased production and the system could help ensure the quality and safety of pork sold in domestic market	The study was a desk review of the pig farming value chain	The study will focus on BCT importance in performance of maize value chain by collecting field data to make inferences
Mutua et al. (2018)	Piloting a livestock identification and traceability system in the northern Tanzania–Narok–Nairobi trade route.	The traceability system identified and enhanced food and animal health safety	The study was limited to a specific system developed for tracing beef value chains	The study will focus on BCT importance in performance of maize value chain by collecting field data to make inferences
Mol (2014a**)**	Transparency and value chain sustainability	Value chain transparency will have to concentrate on questions of value chain transparency by whom, for whom and with what	This was a desk review on the importance of transparency in value chain sustainability; the study does not focus on BCT	This study focuses on the value chain performance component by collecting field data on expected benefits of BCT
Mol, (2014b)	Governing China's food quality through transparency: A review	The value chain transparency institutions in China were distinct from those in developed market economies is the	The study does not make mention of blockchain technology and value chain performance and	This study focuses on the value chain performance component by collecting field data on expected

		lack of active participation of different from the private sector	its importance for farmers.	benefits of BCT
Zhao et al. (2019)	Traceability in agricultural markets: Using ICTs to improve traceability of Gherkins: Presentation of initial learnings	Transparency and privacy was attained with more information stored in the blockchain and helping in building trust	The study does not attach the importance of BCT for farmers in the value chain. It was also a desk review and did not collect data	This study focuses on the value chain performance component by collecting field data on expected benefits of BCT
Lu (2006)	A Two-Stage Value Chain Model for Vegetable Marketing Chain Efficiency Evaluation: A Transaction Cost Approach	Transaction costs have a significant influence to the efficiency of value chains in Nanjing area in general.	The study was limited to the vegetables value chain and did not make any mention of BCT	This study focuses on the value chain performance component by collecting field data on expected benefits of BCT
Leonardo et al. (2015)	The Windmill Approach: Combining transaction cost economics and farming systems theory to analyse farmer participation in value chains	Farmers adopted lowest cost transaction but were not effective for maize farmers to participate in the value chain and increase their income.	The study was conducted among maize farmers who also cultivated soybeans and sunflower	This study focuses on maize farmers and performance of value chains based on benefits from BCT
Severine et al. (2014)	Why transaction costs impede smallholder farmers' participation into export organic markets	Several factors were found for high transaction costs and the major constraint was limited participation of smallholders in international markets	The study does not attach the importance of BCT for farmers in the value chain. It was also a desk review and did not collect data	This study focuses on the value chain performance component by collecting field data on expected benefits of BCT
Soysa (2008)	Traceability in agricultural markets: Using ICTs to	Information and search costs for this activity prior to the use of	The study was limited to the influence of mobile phone	This study aims to examine the benefits of

	improve traceability of Gherkins: Presentation of initial learnings	mobile phones had been prohibitively high contributing to huge losses to farmers and processors	and the value chain	BCT to the maize value chain
Okoye et al. (2016)	Effect of transaction costs on market participation among smallholder cassava farmers in Central Madagascar	Market and transportation costs had a negative effect on market participation for smallholder farmers thus excluding them from the value chain	The study was limited to Madagascar's cassava market	This study focuses on the value chain performance component by collecting field data on expected benefits of BCT
Baraka et al. (2019)	Transaction costs magnitudes, market participation, and smallholder profitability in rural-urban vegetable supply chain	The increase in transaction costs have a negative effect on profitability among smallholder farmers	This study was limited to the vegetable value chain and did not show the importance of BCT to value chains	The study does not however explore the influence of BCT on value chain performance for smallholder farmers.
Macharia et al. (2014)	Effect of transaction costs on smallholder maize market participation: Case of Kwanza District, Trans Nzoia County, Kenya.	Cost of sorting maize, and cost of rent paid to the market, cost of searching for market information on both prices and demand situations, transport cost affect profitability	The study was focused on relationship between transaction costs and market participation; the study does not include the benefits of BCT	This study aims to examine BCT benefits for maize value chain performance
Atetwe (2016)	Value Chain Analysis and Performance of the Kenyan Good Food Company.	Poor information sharing was another factor that caused poor value chain performance	The study was conducted in the informal sector and not the agricultural sector	This study focuses on the immutability function of BCT in maize value chain performance

Tran & Trinh (2021)	Blockchain technology for sustainable supply chains of agrifood in Vietnam: a SWOT analysis	Traditional agri-food supply chains represented challenges of data asymmetry also referred to as data failure which leads to imbalance in power transactions	The study adopted a desk review and case study approach and did not collect primary information from respondents	This study focuses on the immutability function of BCT in maize
Kamilaris et al. (2019)	The Rise of Blockchain Technology in Agriculture and Food Supply Chains	Data stored in BCT for every transaction is vindicated by business stakeholders thus creating consensus among all actors	The study adopted a desk review and case study approach and did not collect primary information from respondents.	This study will ask respondents how the BCT would enhance performance of smallholder farmers in the value chain
Kising'u (2016)	Factors influencing Participation of youth in agricultural value chains in Kenya	Youth indicated having moderate knowledge and information on the value chains	The study did not examine the importance of technology in value chains or specify the value chain under discussion; it did not examine importance of technology in value chains or specify the value chain under discussion	This study will focus on maize value chain
Hernandez et al. (2017)	Constraints and answers for increasing value chain decision making in agricultural production	Risk and uncertainty information affected agribusiness stakeholders' decision-making on prices	The study was dependent on secondary data	This study will ask respondents how the BCT would enhance performance of smallholder farmers in the value chain
Shange (2014)	Opportunities and challenges for integrating smallholder	The study found lack of access to information to adequate markets	The study was conducted among public and private	This study will seek perceptions from private

	farmers in the value chain	resulted in non-profitability for smallholder farmers	institutions and did not include the perspective of smallholder farmers	and public institutions as well as smallholder farmers

Source: Researcher (2023)

2.5 Conceptual framework

Kitchel and Ball (2013) defined a conceptual framework as a visual presentation showing the interaction among variables showing that a relationship is present but there is no rationale in this relationship. Figure 2.1 shows the assumed relationship between the independent and dependent variables where each of the variables has its sub-variables which were instrumental in variable operationalization.

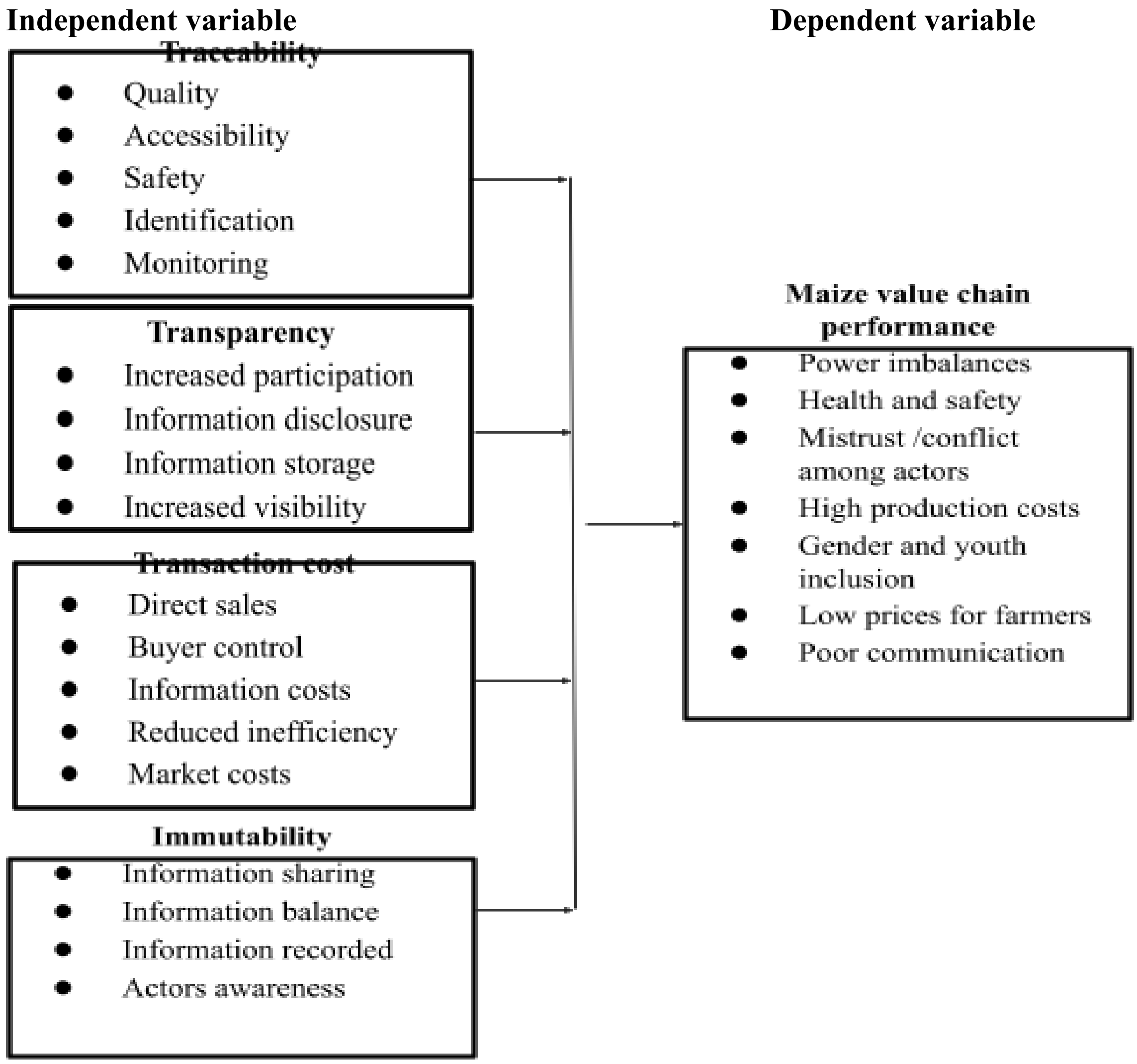

Figure 2.1: Conceptual Framework
Source: Researcher (2023)

Table 2.2: Operationalization of variables

Variables	Indicators	Scale of measurement	Supporting literature
Traceability	• Quality • Accessibility • Safety • Identification • Monitoring	5 – Point Likert scale	Hirbli (2018); Cruz & da Cruz (2020)
Transparency	• Increased participation • Information disclosure • Information storage • Increased visibility	5 – Point Likert scale	(Mol, 2014b) (Mol, 2014a)
Transaction cost	• Direct sales • Buyer control • Information costs • Reduced inefficiency • Market costs	5 – Point Likert scale	Severine et al. (2014); Leonardo et al. (2015)
Immutability	• Information sharing • Information balance • Information recorded • Actors awareness	5 – Point Likert scale	Kamilaris et al. (2019); Atetwe (2016)
Maize value chain performance	• Power imbalances • Health and safety • Mistrust /conflict among actors • High production costs • Gender and youth inclusion • Low prices for farmers • Poor communication	5 – Point Likert scale	Kamau & Nyongesa (2017); Ater et al. (2018) Kaliba (2021); Osti et al. (2015); Lesiit, (2020).

Source: Researcher (2023)

CHAPTER THREE
RESEARCH METHODOLOGY

3.1 Research Philosophy

This positivist research philosophy was used; according to Park, Konge, and Artino (2020), positivism is dependent on the functional association that can be explained among explanatory and outcome factors. Its aim is to create causal relationships that can help in making prediction on a subject under study. It is positivists' argument that knowledge must and can be created objectively without any bias from participants and researchers influencing this creation (Park et al., 2020).

Positivism relies on the hypothetico-deductive method to verify a prior hypothesis that are often stated quantitatively, where functional relationships can be derived between causal and explanatory factors (independent variables) and outcomes (dependent variables) that ultimately lead to prediction and control of the phenomena in question (Kaliyamurthi, 2021). Based on this description of the positivist design, it was adopted as the research examined BCT variables (independent variables) viability on solving constraints facing the maize value chain and thereby increasing its performance (dependent variable). Secondly, it aimed to determine causality between the two variables without any interference or bias from the researcher.

3.2 Research Design

The guide or framework used in analysis, execution, and designing of a study is referred to as a research design and is also a plan for answering hypothesis or a research question (Jongbo, 2014). The study adopted a descriptive correlation design which aims to describe the relationships between variables (Sousa, Driessnack, & Mendes, 2007). This design is used when the objective is to see how a change in an explanatory variable can be used to anticipate changes in a response variable (Sousa et al., 2007). The design was suitable as the research aims to explore how changes in BCT can be used to solve maize value chain performance.

3.3 Population and Study Setting

A population of interest in a study refers to the groups, persons, organisations, or other elements that are of interest to a researcher and are important to understand and to which or whom the findings may be inferred (Casteel & Bridier, 2021). The population of the study was staff from organisations in maize research and market development.

3.3.1 Target Population

In defining a target population, there is need to consider the units of observation and the unit of analysis. The units of observation for this study are state and non-state agencies that either have high interests in maize production or high interests in BCT's potential in agriculture. Using the 2019 Maize Industry Taskforce report (Government of Kenya, 2019) and industry knowledge, the researcher was able to identify these agencies listed in Table 3.1.

Table 3.1: Target population

Organisation	Respondents
National cereal and produce board	3
Agriculture and Food Authority	3
Kenya Bureau of Standards	3
Kenya Agricultural and Livestock Research Organization	3
Information, Communication, and technology Authority	3
International Maize and Wheat Improvement Center	3
United Grain Millers Association	3
Agricultural Finance Corporation	3
Agricultural Development Corporation	3
One Acre Fund	3
Apollo Agriculture	3
60 Decibels	3
Boston Consulting Group	3
IOHK: Input Output	3
Total	**44**

Source: (Government of Kenya, 2019).

3.3.2 Sampling Frame and Size

Taherdoost (2016) defined sampling frame as an exhaustive list from which a sample is chosen. In this case, 14 state and non-state agencies involved in the Kenya Government task force on Blockchain and Emerging Technologies were selected as the sampling frame (Moturi & Kosgei, 2021). In each of these organisations, non-probability sampling was used to select 3 respondents. Non-probability sampling methods are influenced by a researcher's own opinion and choice of a sample based on information they can provide for a study. Specifically, purposive method was used to select the organisations based on their involvement in the maize value chain; these organisations are engaged in market research and development of maize production and thus possess knowledge and experience on ICT use in the maize value chain.

Additionally, selection of members in each organisation was done by employing snowball sampling. Naderifar, Goli, and Ghaljaie (2017) define snowball as a form of convenient method of sampling adopted when it is difficult to identify subjects with the target characteristics. Snowball sampling is often employed when no sampling frame can be constructed; researchers may not construct a sampling frame if a difficult-to-reach population is to be studied. The staff or officers that have participated in ICT adoption and use in maize value chain including use of BCT are not easily identifiable in an organisation and thus snowball sampling was preferred for selecting these respondents (Kirchherr & Katrina, 2018).

3.4 Collection of data

The study used primary data which is distinguished from secondary data as it is gathered directly from respondents. In contrast to secondary data which is available for researchers, the study adopted a structured questionnaire (Appendix B) which was designed from adapting measurement of constructs from the reviewed literature. A structured questionnaire is the widely used primary data collection instrument in survey research. The use of structured questionnaire has a close relationship with quantitative analysis (Aithal & Aithal, 2020). The questionnaire had five-point Likert scale items for each of the study variables where traceability (5-items), transparency (6-items), transaction costs (9-items), immutability (6-items), and maize value chain performance (6-items), and close-ended question items on demographic information was adopted.

3.5 Analysis of Data

To ease the data analysis process, the questionnaire was pre-coded and entered into the Statistical Package for the Social Sciences (SPSS) Version 26. Analysis of data was done in two phases; the first phase was performing descriptive statistical analysis to show the trends and summarizing data for easier comprehension. The descriptive statistics used were mean and standard deviation for Likert data and frequency distributions for close-ended data.

This was followed by performing Pearson correlation analysis to determine the strength of association between the independent and dependent variables. It is appropriate for use when both variables represent either interval or ratio scales of measurement. It attempts to draw a line of best fit through the data of two variables indicating how far away all these data points are from this line of best fit (Obilor & Amadi, 2018).

Diagnostic tests were performed to determine if the dataset met the minimum assumptions to be analysed using regression analysis. These tests included checking for normal distribution of the dataset which was tested by using statistical methods rather than graphical methods. In this case, Kolmogorov-Smirnov and Shapiro-Wilk tests of normality were adopted.

Heteroscedasticity in ordinary least squares (OLS) estimation might be problematic; one problem is that covariance matrix estimators are not consistent estimators for the variances of regression coefficient estimators. Thus, resulting confidence intervals would not attain the nominal level of coverage. To check for heteroscedasticity, the Breusch–Pagan–Godfrey test was adopted.

Multicollinearity occurs when two or more predictors are correlated leading to an increase in the standard error of the coefficients; increased standard errors mean that the coefficients for some or all independent variables may be significantly different from 0 hence making some variables statistically insignificant (Dupuis & Victoria-Feser, 2013). The Tolerance and variance inflation factor (VIF) were used to check for multicollinearity problems.

In regression analysis, autocorrelation of the error terms violates the ordinary least squares assumption that the error terms are uncorrelated. The consequence is that the estimates of coefficients and their standard errors will be wrong if the autocorrelation is ignored (Uyanto, 2020). To check for this, the most frequently used statistical test for detecting autocorrelation is the Durbin-Watson test which is defined based on the ordinary least squares residuals was used.

Linearity test is used to examine whether or not there is a linear relationship between the independent variables and dependent variable, to determine the model of the relationship. Linear relation exists when the Sig. value of the linearity is less than 0.05 (Flatt, & Jacobs, 2019). The linearity test was done by undertaking a graphical analysis of a scatterplot of the residuals.

Multiple linear regression analysis was done to determine direction and magnitude of explanatory variables on dependent variable at the 95 % confidence interval. This was done by transforming the variables for each statement into a weighted mean score which was used to perform regression analysis. According to Foong, Ming, Eng, and Shien (2018), regression models are developed in various fields of application to help researchers to predict certain variables based on other predictor variables. The dependent variables in the regression model are estimated by a number of independent variables. Model utility test is a hypothesis testing procedure in regression to verify if there is a useful relationship between the dependent variable and the independent variable. Tabular presentation followed with interpretations and implications of findings provided for each of the objective findings.

$$\mathbf{Y = B_1X_1 + B_2X_2 + B_3X_3 + B_4X_4 + \varepsilon}$$

Where:

Y = Maize value chain performance

X_1 = Traceability

X_2 = Transparency

X_3 = Transaction Cost

X_4 = Immutability

ε = Error term

3.6 Ethical Considerations

The ethical considerations were upheld by following the following protocols. Following a successful defense, the research proposal was forwarded to the Strathmore University Ethical Review Board (SU-ERB) for ethical approval (Appendix D) that the study meets the necessary requirements to ensure that respondents' rights are considered. A research permit (Appendix E) was then applied for and issued from the National Commission for Science, Technology and Innovation (NACOSTI). An informed consent sheet (Appendix A) was also attached to each instrument administered

3.7 Reliability and Validity

To meet the reliability and validity of findings, a pilot study was conducted with 5 participants after which a reliability test was done. Using a Likert scale item questionnaire, the internal consistency of the instrument is vital and this was determined using Cronbach's Alpha. This test was preferred as it measures inter-item correlation of items used to measure a variable and is calculated from a value of 0 to 1 with values closer to 1 deemed acceptable to establish reliability. The advantage of this approach is that it only requires one administration of the test thus reducing costs of piloting an instrument. According to Tavakol and Dennick (2011), there exists contradicting opinions on acceptable Cronbach Alpha values but the most prominent value ranges from 0.70 to 0.95 which are considered reliable; in this case, the items were found to possess internal consistency as summarized in Table 3.2

Table 3.2: Reliability statistics

Variables	Cronbach's Alpha	N of Items
Traceability	0.991	5
Transparency	0.996	6
Transaction cost	0.996	8
Immutability	0.997	6
Maize value chain performance	0.987	6

CHAPTER FOUR

PRESENTATION OF RESEARCH FINDINGS

4.1 Introduction

This chapter presents the response rate, demographic information, descriptive statistics, and regression analysis.

4.2 Response rate

The 44 questionnaires were administered electronically after gaining personal contact information from the respondents in the respective organisations. Out of the 44 administered, all these forms were returned after a period of two months so as to avoid any margins of error reducing the sample size.

4.3 Demographic Information

The demographic information gathered included gender, education level, and working experience of respondents presented here in frequency distributions.

4.4.1 Gender

The respondents were represented by 59.0 % of male and the remaining 41.0 % were female respondents as shown by Table 4.1.

Table 4.1: Respondents' Gender

Gender	Frequency	Percent
Male	26	59.0
Female	18	41.0
Total	**44**	**100.0**

4.4.2 Education Level

Table 4.2 indicates that most respondents had a Bachelor's degree accounting for 45.4 % of the sample and this group was followed by those with Diplomas at 34.0 %, Certificate holders at 11.4 %, and postgraduate degree at 9.2 %.

Table 4.2: Respondents Education level

Education level	Frequency	Percent
Certificate	5	11.4
Diploma	15	34.0

Bachelor's Degree	20	45.4
Postgraduate Degree	4	9.2
Total	**44**	**100.0**

4.4.3 Work experience

On their years in the maize sector, more respondents had 2-5 years' experience accounting for 47.7 % of the sample followed by 45.4 % who were had 6-10 years' experience and only 6.9 % had less than 1 year experience as shown in Table 4.3. The findings show more respondents had more than 2 years working experience suggesting they had experience with performance of the maize value chain and this added to the validity of results.

Table 4.3: Respondents' Working Experience in Years

Years	Frequency	Percent
Less than 1 year	4	6.9
2-5 Years	21	47.7
6-10 Years	20	45.4
Total	**44**	**100.0**

4.5 Descriptive Analysis

This section provides information on variables where descriptive statistics were used to summarize Likert data using frequency distribution, mean, and standard deviation.

4.5.1 Maize value chain performance

Table 4.4 shows respondent felt moderately that using BCT in the maize value chain would see communication improved and information exchange between actors would be enhanced as shown by a mean score of 3.22. Using BCT in the maize value chain was also associated with the capability of resolving mistrust issues to a moderate extent as shown by a mean score of 3.20. However, respondents disagreed that BCT would be able to alleviate low pricing farmers received as shown by a mean score of 2.89. This finding implies that despite enhancing communication and information flow; BCT would not be adequate in addressing pricing constraints in the maize value chain.

Table 4.4: Maize value chain performance

Items	N	Mean	Std. Deviation
The use of BCT in the maize value chain can solve the existing power imbalances	44	3.07	1.684
Application of BCT in the maize value chain can enhance safety of maize production	44	3.16	1.595
Using BCT can assist in solving mistrust and conflict among stakeholders	44	3.20	1.604
Adoption of BCT in the maize value chain can solve gender and youth exclusion	44	3.16	1.492
Low prices offered to maize farmers can be increased by using BCT in the maize value chain	44	2.89	1.655
Using BCT in the maize value chain will enhance communication and information exchange among stakeholders	44	3.22	1.491

4.5.2 Blockchain traceability

In terms of the traceability benefits from using BCT, the respondents agree that be a useful tool to monitor the safety and health of maize products along the value chain as shown by a mean score of 3.38 and standard deviation of 1.683. There was also agreement from respondents that BCT would provide individual identification would be achieved as farmers may have different sources of maize produce and selling them at various periods as indicated by a mean score of 3.36 and standard deviation of 1.554. The respondents were neutral on BCT benefits for differentiating quality, offering access to data among actors, and ensuring safety of maize sold in markets. This implies that there is less evidence of BCT being able to solve these issues of the maize value chain.

Table 4.5: Traceability descriptive findings

Items	N	Mean	Std. Deviation
Blockchain traceability would assist in differentiating quality maize	44	3.07	1.671

products that will increase farmers monetary rewards in the value chain			
Blockchain traceability offers each stakeholder to have access to data and information thereby enhancing trust	44	3.24	1.417
Blockchain traceability benefits can make sure that safety and quality of maize sold in the market	44	3.22	1.506
Blockchain traceability provides individual identification would be achieved as farmers may have different sources of maize produce and selling them at various periods	44	3.36	1.554
Blockchain traceability would be a useful tool to monitor the safety and health of maize products along the value chain	44	3.38	1.683

4.5.3 Blockchain transparency

Table 4.6 shows respondent moderate agreement that using BCT enhance transparency as indicated by a 3.38 means score. Likewise, respondents moderately agreed that privacy would be provided for in using BCT and this would contribute to greater trust which has been a major issue in the maize value chain as shown by a 3.31 mean score. Moderate agreement was reported on ability of BCT to increase participation of downstream actors, disclosing of information for consumers, and for the public.

Table 4.6: Transparency descriptive findings

Items	N	Mean	Std. Deviation
The adoption of blockchain transparency will provide participation of downstream economic actors in value chains	44	3.00	1.692

The adoption of blockchain transparency will disclose information on regulatory and inspection bodies, and certifiers in the value chain	44	3.24	1.540
The adoption of blockchain transparency will disclose information for domestic consumers and international customers in the value chain	44	3.27	1.514
The adoption of blockchain transparency will disclose information for public (citizen-consumers), (old & new) media in the value chain	44	3.27	1.543
Transparency and privacy can be achieved as more information is stored in the BCT and creates trust among actors	44	3.31	1.621
Blockchain technology would increases transparency and creates incentives to the different stakeholders	44	3.38	1.669

4.5.4 Blockchain transaction cost

The study sought to determine respondent perceptions on BCT influence on transaction costs on the maize value chain. The standing out findings from Table 4.7 is respondents' agreement that BCT would be able to reduce inefficiency for actors in the value chain as shown by a mean score of 3.42 and 1.500 standard deviation. There was moderate agreement with the other statements.

Table 4.7: Transaction cost descriptive findings

Transaction costs	**N**	**Mean**	**Std. Deviation**
Blockchain technology has the ability to lessen direct sales which often result in high transaction costs	44	3.24	1.721
Blockchain technology has the capability to lower transaction costs for maize farmers to contribute and increase their income	44	3.13	1.502

Blockchain technology will be able to reduce the presence of opportunistic local buyers	44	3.27	1.684
Blockchain technology will be able to limit ineffective farmer organisations	44	3.09	1.607
Blockchain technology would be able to lessen inefficiency in institutions operating in the maize value chain	44	3.42	1.500
Blockchain technology would decrease information search costs for farmers	44	3.22	1.650
Blockchain technology reduces market and transportation costs by including farmers in the value chain.	44	3.09	1.676
Blockchain technology would reduce waiting time before receiving payment	44	3.07	1.572

4.5.5 Blockchain immutability

The attribute of immutability was shown to enhance its acceptance by actors in the value chain as shown by a mean score of 3.42 and 1.500 standard deviation implying moderate agreement with this item. The respondents also showed moderate agreement that BCT adoption would increase farmers' awareness of suitable markets to sell as shown by a mean score of 3.36 and 1.773 standard deviation as shown in Table 4.8. There was disagreement among respondents that BCT adoption would not enhance information sharing among farmers' value chain performance as shown by a 2.93 mean score.

Table 4.8: Immutability descriptive findings

Immutability	N	Mean	Std. Deviation
BCT immutably would enhance information sharing increasing farmers' value chain performance	44	2.93	1.572
The Potential of BCT in maize value chain would limit information imbalance thereby enhancing accountability and decreasing bureaucracy	44	3.04	1.492

The value chain information recorded to the blockchain enhances its acceptance by all actors in the chain	44	3.42	1.500
BCT immutability would enhance transparency on information provided on pricing of inputs	44	3.09	1.769
Blockchain technology would increase access to information thus enhancing efficiency in decision making	44	3.22	1.565
BCT immutably would increase smallholder farmers awareness on the suitable market channels to use or how to consistently produce product of retail standards	44	3.36	1.773

4.6 Diagnostic Tests

Diagnostic tests were done to ensure that data met minimum requirements required before undertaking linear regression analysis. These tests included checking for normality, heteroscedasticity, multicollinearity, autocorrelation, and linearity test.

4.6.1 Normality test

Table 4.9 indicates that the *p*-values for the Kolmogorov-Smirnov and Shapiro-Wilk tests were greater than 0.05 which leads to the conclusion that the data was normally distributed.

Table 4.9: Tests of Normality

	Kolmogorov-Smirnov[a]			**Shapiro-Wilk**		
	Statistic	df	Sig.	Statistic	df	Sig.
Maize value chain performance	0.143	44	0.222	0.884	44	0.110

a Lilliefors Significance Correction

4.6.2 Heteroscedasticity test

The Breusch-pagan test checked for heteroscedasticity; the rule of thumb in interpreting it is if the test statistic has *p*-value of less than 0.05, then the null hypothesis of homoscedasticity is rejected, and heteroscedasticity assumed. Thus, the *p*-values of greater than 0.05 shown in Table 4.10 imply no heteroscedasticity issue in the data

Table 4.10: Breusch-pagan and Koenker test

	LM	Sig.
BP	1.563	0.815
Koenker	6.644	0.156

Null hypothesis: heteroscedasticity not present (homoscedasticity).
If sig-value less than 0.05, reject the null hypothesis

4.6.3 Multicollinearity test

The tolerance statistic is interpreted as a value of greater than 1 indicates multicollinearity while VIF values of 10 indicate high correlation between independent variables and this would compromise the relationship established between variables. Using these criteria, Table 4.11 indicates that tolerance values were less than 1 and those of the VIF were less than 10 and thus it is concluded that there was no multicollinearity present.

Table 4.11: Collinearity Statistics

Variables	Tolerance	VIF
Traceability	0.100	1.020
Transparency	0.077	2.931
Transaction Cost	0.164	6.091
Immutability	0.085	1.800

4.6.4 Autocorrelation test

The Durbin-Watson test statistic tests for auto-correlations between errors. It tests whether adjacent residual is correlated because one of the assumptions of residual is that it should be independent. From Table 4.12, the values of Durbin-Watson are closer to 2 indicating that the assumption is satisfied. The models do not have any auto correlation problem.

Table 4.12: Durbin-Watson Statistic

Model	Durbin-Watson
1	1.951

a Predictors: (Constant), Immutability, transaction cost, traceability, transparency
b Dependent Variable: Constraints

4.6.4 Linearity test

Linear regression needs the relationship between the independent and dependent variables to be linear and it is also imperative to check for outliers since linear regression is sensitive to outlier effects. The linearity assumption was tested with a scatter plot where Figure 4.1 shows that data was spread around the same point thereby meeting the linearity assumption required for running regression analysis.

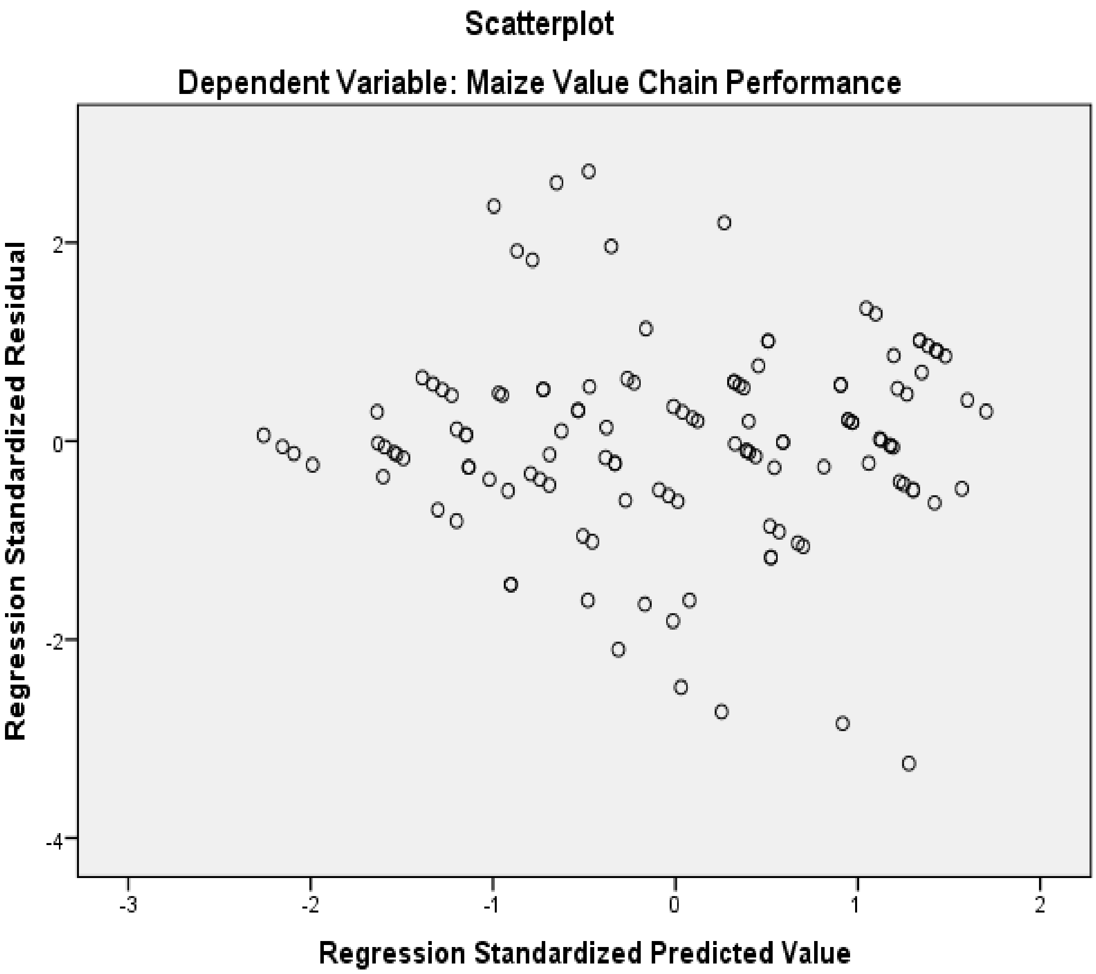

Figure 4.1: Linearity test for maize value chain performance

4.7 Correlation Analysis

Table 4.13 shows that there was a positive and statistically significant association between all BCT factors with maize value chain performance at the 99 % confidence level. Transparency (r = 0.932, $p < 0.05$) had the highest correlation with maize value chain performance followed by immutability (r = 0.917, $p < 0.05$), traceability (r = 0.890, $p < 0.05$), and transaction costs (r = 0.862, $p < 0.05$).

Table 4.13: Correlation Coefficients

		Traceability	Transparency	Transaction cost	Immutability
Traceability	Correlation	1			
	Sig.				
	N	44			
Transparency	Correlation	.943**	1		
	Sig.	0.000			
	N	44	44		
Transaction cost	Correlation	.849**	.880**	1	
	Sig.	0.000	0.000		
	N	44	44	44	
Immutability	Correlation	.917**	.934**	.910**	1
	Sig.	0.000	0.000	0.000	
	N	44	44	44	
Maize value chain performance	Correlation	.890**	.932**	.862**	.917**
	Sig.	0.000	0.000	0.000	0.000
	N	44	44	44	44

** Correlation is significant at the 0.01 level (2-tailed).

4.8 Regression Analysis

Multiple linear regression analysis was undertaken to determine influence of the model on the dependent variable including its significance as well as the individual influence of independent variables on maize value chain performance. These findings are summarized under the model summary, analysis of variance, and coefficients subsections.

4.8.1 Influence of the model

The coefficient of determination (R^2) obtained was 0.886 which means the model explained 88.6% of variation on maize value chain performance as seen in Table 4.15.

Table 4.14: Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.941 a	0.886	0.075	0.51013

a Predictors: (Constant), Immutability, Transaction Cost, Traceability, Transparency

4.8.2 Significance of the Model

Table 4.15 shows the analysis of variance output which explains the statistical significance of the model at the 95% confidence interval. The model was found to be statistically significant ($F = 77.732$, $p < 0.05$).

Table 4.15: ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	80.914	4	20.229	77.732	.000[b]
	Residual	10.409	39	0.26		
	Total	91.323	43			

a Dependent Variable: Maize value chain performance
a Predictors: (Constant), Immutability, Transaction Cost, Traceability, Transparency

4.6.3 Regression Coefficients

Table 4.16 summarizes the regression coefficients for each independent variable influence on maize value chain performance. Traceability was found to have a 0.020 negative influence on performance of the maize value chain but this was not significant as the *p* value was greater than 0.05. Transparency had a 0.613 influence on performance of the maize value chain and this was statistically significant as the p value was less than 0.05.

Transaction costs also showed positive influence on performance of maize value chains but this effect was not significant as the p value was greater than 0.05. Lastly, immutability had 0.319 influence on performance of maize value chain but this effect was not significant as the *p* value was greater than 0.05. The conclusion from these results is that a unit increase in adoption of BCT in the maize value chain performance would result in greater transparency.

Table 4.16: Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-0.021	0.200		-0.106	0.916
	Traceability	-0.020	0.174	-0.02	-0.117	0.907
	Transparency	0.613	0.198	0.595	3.101	0.004

Transaction costs	0.062	0.134	0.061	0.463	0.646
Immutability	0.319	0.181	0.323	1.763	0.086

a Dependent Variable: Maize value chain performance

CHAPTER FIVE

SUMMARY, DISCUSSION, CONCLUSION, AND RECOMMENDATIONS

5.1 Introduction

In this chapter, a summary of each chapter is presented, discussion of each objective, conclusions of the study, and recommendations for practice and for further research.

5.2 Summary

This research explored how BCT benefits can be leveraged to enhance maize value chain performance in Kenya. The BCT benefits considered as independent variables were traceability, transparency, transaction cost, and immutability while maize value chain performance were used as proxies for performance of the maize value chain. Diffusion of innovation theory was used to underpin the research. A descriptive correlational research design was adopted in which units of observation were 14 state and non-state agencies in maize research and development, information technology development, and food safety. The units of analysis were 3 staff from each organisation that had experience, had participated, or possessed knowledge on BCT making for a sample size of 44 respondents. Non-probability sampling was used as organisations were selected using purposive sampling while snowball sampling was used to identify respondents and census sampling approach to include all 44 participants.

A structured questionnaire comprising Likert scale items was designed and administered to respondents using electronic means. Before its administration, the instrument was piloted among 5 respondents and it was determined reliable and valid.

The variable information was summarized using descriptive statistics including frequency distribution, mean, and standard deviation while effect of BCT dimensions effect on maize value chain performance was done using multiple regression analysis.

The 4 independent variables were found to explain 88.6 % of change in performance of the maize value chain and this was significant at the 95 % confidence interval. The coefficients revealed that transparency out of the four variables had a positive and significant effect on performance of the maize value chain implying that there was need for transparency in the maize value chain.

5.3 Discussion

5.3.1 Blockchain traceability and maize value chain performance

The results indicated that traceability provided by BCT in food value chains would have a negative but non-significant effect; this means that traceability did would not have any effects on the maize value chain. However, the descriptive statistics does show respondents felt that some aspects of traceability would be of importance to performance of the maize value chain. This result does not agree with other research that found positive effects of BCT to performance of value chains.

These studies include Buskirk et al. (2013) study found that utilizing traceability systems in agricultural value chains was found to increase development of regional food systems and contributed to better services by connecting farmers and consumers. Mutua et al. (2020) study that concluded adoption of BCT for traceability in the value chain would reduce disease problems thereby contributing to increase in production and further ensuring safety and quality of pork sold in the local market. Also, Lesiit (2020) found that using BCT would further traceability which would enhance food safety and integrity through higher traceability thus helping every stakeholder in the supply chain quickly trace food crises or fraud.

Despite the lack of effects on maize value chain performance; respondents agreed that traceability provides individual identification of actors would be achieved as farmers may have different sources of maize produce and selling them at various periods. This would be a plus for the maize value chain as traceability has been shown to improve communication and the coordination among actors in agricultural value chains. According to Marfuah and Yuliasih (2022) using BCT enables value chain actors to be open, reliable, transparent, neutral, and secure in tracing the entire system. In the maize value, chain, this means all participants in the chain would be able to identify the source of materials or inputs as well as source of a product by associating with a specific actor and this can be useful in taking any actions to remedy inconsistencies.

The respondents also agreed that BCT traceability would be a useful tool to monitor the safety and health of maize products along the value chain. The Kenyam maize value chain has often experienced safety issues with storage of maize through contamination indicating a lack of safety and quality standards were not met such as the Aflatoxin contaminated maize that caused 125 deaths and 317 hepatic failures among consumers. This traceability function of BCT to value chains was supported by Lesiit (2020) who determined that BCT enhanced integrity and safety of food production by having more traceability and allowing actors in the value chain to identify and response to any outbreak that may cause food crisis and fraud.

5.3.2 Blockchain transparency on maize value chain performance

Transparency was found to have a positive and significant effect on maize value chain performance as an increase in adoption of BCT in the maize value chain would yield better performance by a 0.613 factor. This finding provides support for upgrading theory that acquiring technological capabilities can allow producers to enhance their competitiveness and transition to high-value activities.

The descriptive statistics showed respondents agreed that transparency and privacy can be achieved as more information is stored in the BCT and this would create trust among actors in the maize value chain. The respondents also agreed that adopting BCT would increase transparency and create incentives for actors in the maize value chain. The finding of positive effects of BCT on value chain performance has been documented in past studies.

Kamilaris et al. (2019) research in Spain and Cyprus found evidence of transparency in food supply chains following adoption of BCT; however, its use among farmers and systems was hampered by several challenges and barriers centered on policies, regulatory frameworks, education, and technical aspects. In another study, Leng et al. (2018) results of trials on the BCT model indicated double-chain answers that promoted security and transparency of transactional information and privacy of enterprise data while also enhancing credibility of the system's efficiency. Using a test methodology of a blockchain in Kenya's food value chain, Lesiit (2020) confirmed BCT was able to provide a transparent experience to actors and decentralized the food supply chain.

The descriptive statistics showed respondents' agreement that trust was also a benefit for BCT adoption in the maize value chain. The issue of trust when using BCT was also supported by findings from Lesiit (2020) who revealed that BCT would provide solutions through digital trust; BCT's ability to document critical data in a public space while not allowing anyone to delete it while providing security to conduct transactions among untrusted parties. Also, Zhao et al. (2019) reviewed research explained that privacy and transparency can be attained by having more information stored in BCT and helping in building trust.

The respondents were neutral on whether adoption of BCT transparency would disclose information for domestic and international customers in the value chain as well as providing information for the public in the value chain. This suggests some skepticism towards what BCT use can do for consumers in gaining information on value chains. This is a sentiment that has been found in other research. One such study is Commandré, Macombe, and Mignon (2023) which found that using BCT for transparency seldom delivered on its promises; BCT often centralized control to a few actors in the value chain as these had access to the distributed ledger.

5.3.3 Blockchain transaction cost on maize value chain performance

On transaction cost benefits for BCT adoption in the maize value chain was found to have positive but insignificant effect on its performance. There is evidence from past research that adoption of BCT would reduce transaction costs associated in food value chains. In their study, Bhatia, Chaudhuri, Kayikci, and Treiblmaier (2023) findings showed that blockchain-enabled Supply Chain Finance (SCF) solutions can reduce different types of transaction costs such as costs associated with information search, negotiation and contracting costs, and costs of accessing finance.

In Australia, Gunasekera and Valenzuela (2020) found evidence that due to BCT use in grain production resulted in an increase of output by 8% over the medium term when this was done by collaborating BCT adoption with the finance sector would increase output by 10%. This provided evidence that the impact of BCT in reducing costs of transactions using a distributed ledger technology in grain production and trading.

Despite having no effect on performance of the maize value chain; the descriptive findings indicate that respondents agreed adoption of BCT would be able to lessen inefficiency in institutions operating in the maize value chain. This finding reflects the importance of efficiency in the maize value chain and has been shown to be an important factor for participation among different actors. Osei et al. (2015) research revealed that youth were pushed away from maize value chain participation due to inefficient linkages between production sites and markets. According to Severine et al. (2014), institutions in the maize value chain were inefficient and this resulted to poor performance while lack of formal barriers made it uncertain to selling of produce to specific buyers. This meant that some buyers did not participation in the value chain as they expected opportunistic behaviour from farmers and sellers and were thus excluded from the global organic value chain.

This findings may also be discussed by the lowest ranked item was that BCT would reduce waiting time for farmers to receive payment. The respondents were also shown to be skeptical based on the ability of BCT in reducing market and transportation costs by including farmers in the value chain as most respondent indicated being neutral. The respondents also took a neutral stance on BCT ability to reduce direct costs, limit ineffective farmer organisations in the value chain, decrease information search costs for farmers and reducing opportunistic local buyers.

5.3.4 Blockchain immutability on maize value chain performance

The BCT component of immutability was found to have a positive but insignificant effect on maize value chain performance. This means that immutability would not affect performance of the maize value chain implying no effect of immutability after integrating BCT into a maize value chain. There is no evidence of research that have empirically investigated and concluded that BCT adoption had a significant effect on performance of agricultural value chains.

However, this outcome goes against a plethora of studies that have promoted the idea that BCT would enhance performance of agricultural value chains. In this case, Tran and Trinh (2021) found that conventional agri-food supply chains represented challenges of information asymmetry also referred to as information failure which resulted in power imbalances in transactions. Using BCT would limit this imbalance of information amongst collection and personal action thus increasing accountability and lessening bureaucracy. Lu (2006) two-stage value chain model recommended for the adoption of BCT to enhance efficiency in the vegetable production value chain by reducing transaction costs.

The use of BCT for value chain performance has also been recommended in Africa. Shange (2014) research in South Africa found that the information asymmetry and food standards were key barriers for smallholder farmer integration into global value chains; yet, adoption of BCT would assist in in overcoming these barriers. In Kenya, Atetwe (2016) study on value chain performance recommended that food producers should formalize their value chains by adoption of emerging technologies such as BCT to overcome information sharing and decision making challenges in their value chains.

5.4 Conclusion

5.4.1 Blockchain traceability and maize value chain performance

The first objective assessed influence of traceability on maize value chain performance among smallholder farmers; findings indicated no significant effect of traceability on maize value chain performance. Thus, this study concludes that adoption of BCT technology would have no influence of maize value chain by improving traceability.

5.4.2 Blockchain transparency on maize value chain performance

The second objective evaluated effect of transparency on maize value chain performance among smallholder farmers; findings indicated a positive and significant effect of transparency afforded by BCT to improve maize value chain performance. Therefore, it is this study’s conclusion that adoption of BCT would enhance transparency in the maize value chain.

5.4.3 Blockchain transaction cost on maize value chain performance

The third objective was measuring influence of transaction cost on maize value chain performance among smallholder farmers. The regression coefficients indicated no significant influence of transaction costs on maize value chain performance. Therefore, the study concludes that adoption of BCT in the maize value chain would not reduce transaction costs for smallholder farmers.

5.4.4 Blockchain immutability on maize value chain performance

The fourth objective analysed the influence of immutability on maize value chain performance among smallholder farmers. The regression coefficients indicated no significant influence of immutability on maize value chain performance. Therefore, the study concludes that adoption of BCT in the maize value chain would not reduce tampering or making changes on information in the maize value chain by any of the actors.

5.5 Recommendations

5.5.1 Blockchain traceability and maize value chain performance

The study recommends for adoption of BCT in the maize value chain to be able to identify the source of production and selling points to provide individual identification to afford easier tracing of products that may not be safe or healthy for consumption.

5.5.2 Blockchain transparency on maize value chain performance

There was a positive effect of transparency on performance of the maize value chain. Therefore, it is recommended that there is need for introducing blockchain technology to solve the transparency challenges facing actors throughout the chain. The lack of accurate and timely data is one of the issues facing the maize value chain and adoption of blockchain technology would contribute to developing and using uniform template for real time data capture, analysis and dissemination for decision making.

5.5.3 Blockchain transaction cost on maize value chain performance

The study recommends for adoption of blockchain technology so as to reduce inefficiency in institutions operating in the maize value chain. This can be done by creating linkages between actors and processes in a blockchain where problems that arise from any of the institutions can be identified and corrected.

5.5.4 Blockchain immutability on maize value chain performance

The study recommends that blockchain technology should be adopted in the maize value chain to promote non-tampering of any information that is fed through the value chain and this can thus enhance acceptance of information by all actors in the chain.

5.6 Limitations of the Study

There are different actors in the maize value chain; however, this study was not able to include all these group of actors into the sample size and was thus limited to professionals who have first-hand experience and thus findings may not be generalizable to all actors in the maize value chain. The study was limited to quantitative methods of data collection and thus fails to provide in-depth explanations and insight on how BCT factors can improve performance of the maize value chain.

5.7 Areas of Further Study

The study focused on all BCT benefits on the maize value chain. There is need for more independent research on each of these BCT merits and the benefits it can provide for better performance of the maize value chain. This research should focus on transparency aspect as the findings indicated that it had a positive effect on performance of the maize value chain.

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APPENDICES

Appendix A: LETTER OF INTRODUCTION

Dear respondent,

<u>RE: PARTICIPATION IN DATA COLLECTION</u>

I am a postgraduate student at Strathmore Business School pursuing a Degree in Master of Business Administration (MBA). As a requisite for the award of the degree, I am carrying out a study on **LEVERAGING BLOCKCHAIN TECHNOLOGY BENEFITS TO ENHANCE MAIZE VALUE CHAIN PERFORMANCE IN KENYA.**

As a member of this organisation, you have been selected to participate in this study. The attached questionnaire has been designed to help gather data from respondents. The purpose of this letter is to kindly inform you that you have been identified as one of the respondents.

I therefore kindly request you to facilitate the collection of the necessary data by answering the questions as precisely and factually as possible. The information sought is purely for academic purposes. I assure you that the information provided will strictly be treated as confidential and will be used only for the purpose of carrying out the study. In the end of this survey, you may be asked to recommend an acquaintance that may be able to respond to the questionnaire.

Yours faithfully

Kelvin Kasimbu Nzau

Mobile: 0717187158

Email: kelvin.nzau@strathmore.edu

Appendix B: QUESTIONNAIRE

Section 1: Bio-demographic information

1. Gender

Male [ ]

Female [ ]

2. Education level

Certificate [ ]

Diploma [ ]

Bachelor's degree [ ]

Postgraduate degree [ ]

3. Working experience

Less than one year [ ]

2 – 5 years [ ]

6– 10 years [ ]

More than 11 years [ ]

Section 2: Blockchain traceability benefits

6. The following statements are based on BCT traceability potential for the maize value chain performance. Please indicate to your level of agreement on a 5-point Likert scale where 1-Strongly disagree, 2-Disagree, 3-Neutral, 4-Agree, 5-Strongly Agree

Blockchain traceability	**1**	**2**	**3**	**4**	**5**
Blockchain traceability would assist in differentiating quality maize products that will increase farmers monetary rewards in the value chain					
Blockchain traceability offers each stakeholder to have access to data and information thereby enhancing trust					
Blockchain traceability benefits can make sure that safety and quality of maize sold in the market					
Blockchain traceability provides individual identification would be achieved as farmers may have different sources of maize produce and selling them at various periods					
Blockchain traceability would be a useful tool to monitor the safety and health of maize products along the value chain					

Blockchain transparency	**1**	**2**	**3**	**4**	**5**
The adoption of blockchain transparency will provide participation of downstream economic actors in value chains					
The adoption of blockchain transparency will disclose information on regulatory and inspection bodies, and certifiers in the value chain					
The adoption of blockchain transparency will disclose information for domestic consumers and international customers in the value chain					
The adoption of blockchain transparency will disclose information for public (citizen-consumers), (old & new) media in the value chain					
Transparency and privacy can be achieved as more information is stored in the BCT and creates trust among actors					
Blockchain technology would increases transparency and creates incentives to the different stakeholders					

Blockchain transaction cost	**1**	**2**	**3**	**4**	**5**
Blockchain technology has the ability to lessen direct sales which often result in high transaction costs					

Blockchain technology has the capability to lower transaction costs for maize farmers to contribute and increase their income					
Blockchain technology will be able to reduce the presence of opportunistic local buyers					
Blockchain technology will be able to limit ineffective farmer organisations					
Blockchain technology would be able to lessen inefficiency in institutions operating in the maize value chain					
Blockchain technology would decrease information search costs for farmers					
Blockchain technology reduces market and transportation costs by including farmers in the value chain.					
Blockchain technology would reduce waiting time before receiving payment					

Blockchain immutability	**1**	**2**	**3**	**4**	**5**
BCT immutably would enhance information sharing increasing farmers' value chain performance					
The potential of BCT in maize value chain would limit information imbalance thereby enhancing accountability and decreasing bureaucracy					
The value chain information recorded to the blockchain enhances its acceptance by all actors in the chain					
BCT immutability would enhance transparency on information provided on pricing of inputs					
Blockchain technology would increase access to information thus enhancing efficiency in decision making					
BCT immutably would increase smallholder farmers awareness on the suitable market channels to use or how to consistently produce product of retail standards					

Maize value chain performance	**1**	**2**	**3**	**4**	**5**

The use of BCT in the maize value chain can solve the existing power imbalances					
Application of BCT in the maize value chain can enhance safety of maize production					
Using BCT can assist in solving mistrust and conflict among stakeholders					
Adoption of BCT in the maize value chain can solve gender and youth exclusion					
Low prices offered to maize farmers can be increased by using BCT in the maize value chain					
Using BCT in the maize value chain will enhance communication and information exchange among stakeholders					

Appendix C: LIST OF SAMPLED ORGANISATIONS

1. National cereal and produce board
2. Agriculture and Food Authority
3. Kenya Bureau of Standards
4. Kenya Agricultural and Livestock Research Organization
5. Information, Communication, and technology Authority
6. International Maize and Wheat Improvement Center
7. United Grain Millers Association
8. Agricultural Finance Corporation
9. Agricultural Development Corporation
10. One Acre Fund
11. Apollo Agriculture
12. 60 Decibels
13. Boston Consulting Group
14. IOHK: Input Output

Appendix D: ETHICAL CLEARANCE

Strathmore
UNIVERSITY

8th November 2022

Mr Nzau Kelvin,
kelvin.nzau@strathmore.edu

Dear Mr Nzau,

RE: Leveraging Blockchain Technology Benefits to Address Maize Value Chain Challenges in Kenya

This is to inform you that SU-ISERC has reviewed and **approved** your above **SU- master's** research proposal. Your application reference number is **SU-ISERC1444/22.** The approval period is from **8th November 2022 to 7th November 2023.**

This approval is subject to compliance with the following requirements:

i. Only approved documents including (informed consents, study instruments, MTA) will be used
ii. All changes including (amendments, deviations, and violations) are submitted for review and approval by SU-ISERC.
iii. Death and life-threatening problems and serious adverse events or unexpected adverse events whether related or unrelated to the study must be reported to SU-ISERC within 48 hours of notification
iv. Any changes, anticipated or otherwise, that may increase the risks or affect safety or welfare of study participants and others or affect the integrity of the research must be reported to SU-ISERC within 48 hours
v. Clearance for the export of biological specimens must be obtained from relevant institutions.
vi. Submission of a request for renewal of approval at least 60 days prior to the expiry of the approval period. Attach a comprehensive progress report to support the renewal.
vii. Submission of an executive summary report within 90 days of completion of the study to SU-ISERC.

Prior to commencing your study, you will be expected to obtain a research license from National Commission for Science, Technology, and Innovation (NACOSTI) https://research-portal.nacosti.go.ke/ and obtain other clearances needed.

Yours sincerely,

for: **Dr Ben Ngoye,**
Secretary; SU-ISERC

Cc: Prof Fred Were,
Chairperson; SU-ISERC

STRATHMORE UNIVERSITY INSTITUTIONAL SCIENTIFIC AND ETHICAL REVIEW COMMITTEE
(SU-ISERC)
08-Nov-2022
Email:ethicsreview@strathmore.edu
P.O BOX 59857-00200
NAIROBI-KENYA

Ole Sangale Rd, Madaraka Estate. PO Box 59857-00200, Nairobi, Kenya. Tel +254 (0)703 034000
Email admissions@strathmore.edu www.strathmore.edu

Appendix E: RESEARCH PERMIT

REPUBLIC OF KENYA

NATIONAL COMMISSION FOR SCIENCE,TECHNOLOGY & INNOVATION

Ref No: **875894**

Date of Issue: **01/February/2023**

RESEARCH LICENSE

This is to Certify that Mr.. Kelvin Nzau of Strathmore University, has been licensed to conduct research as per the provision of the Science, Technology and Innovation Act, 2013 (Rev.2014) in Kakamega, Nairobi, Uasin-Gishu on the topic: LEVERAGING BLOCKCHAIN TECHNOLOGY BENEFITS TO ADDRESS MAIZE VALUE CHAIN CHALLENGES IN KENYA for the period ending : 01/February/2024.

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875894

Applicant Identification Number

Director General
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