EFFECT OF MAIZE SOURCING STRATEGIES ON FIRM INCOME IN KENYA'S MILLING SECTOR

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EGERTON UNIVERSITY

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DECLARATION AND RECOMMENDATION

Declaration

I hereby declare that this thesis is my original work and has not been presented in this university or any other for the award of a degree.

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Recommendation

This thesis has been submitted with our approval as university supervisors.

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DEDICATION

I dedicate this thesis to my daughter Mitchell Mutanu, my husband Robert Kioko, my late father Samson Nzaka, my mother Beatrice Nzaka, my siblings and my colleagues for their support and consistent prayers.

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ABSTRACT

Maize is a staple food in Kenya, and the maize milling industry plays a critical role in ensuring national food security. However, fluctuations in local maize supply and prices have led to increased reliance on imported maize, raising concerns about the operational sustainability and income of milling firms. This study examines the effect of maize sourcing strategies, local versus combined (local and imported), on the income of maize milling firms in Kenya. The research aimed to characterize the structure of maize milling firms, identify factors influencing their sourcing decisions, and analyse the income implications of these sourcing strategies. Data was collected from 106 firms using semi-structured questionnaires, analysed with descriptive statistics, a bivariate probit model, and two-stage least squares (2SLS) regression to assess determinants of sourcing decisions and their impact on firm income. Findings revealed that 60.38% used only locally produced maize, while 39.62% used a combination of both locally produced and imported maize. Additionally, large firms prefer a balanced approach of both local (50%) and combined (50%) sourcing, while medium and small firms predominantly rely on local maize. Micro firms mostly source locally (84%) but exhibit slight variability, with some (16%) adopting combined sourcing. Larger firms invest in advanced milling technologies and skilled labour, while smaller firms generally use simpler, cost-effective technologies and semi-skilled employees. Key factors influencing sourcing decisions include employee skill levels at 5% significance level for both the sourcing strategies, monthly sales (5%), government subsidies (10%), import licenses (1%) and access to maize from the National Cereals and Produce Board (NCPB) (5%). Firms using both local and imported maize report higher sales at 1% significance level, higher revenue (at 5%), and higher gross margins (5%), than those relying solely on local sources, while financial constraints and firm location also influence sourcing choices at 5% significance level, with financially constrained firms more likely to source locally. The study concludes that, despite higher associated costs, combined sourcing provides financial benefits, particularly for smaller firms. Recommendations include supporting technology upgrades for smaller firms to improve production efficiency, assessing the impact of subsidies and NCPB purchases to balance local and combined sourcing, and providing targeted subsidies to reduce transport and procurement costs for micro and small firms, ultimately enhancing the economic stability of the maize milling sector and contributing to Kenya's food security.

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LIST OF ABBREVIATIONS

AGRA	Alliance for a Green Revolution in Africa
CIMMYT	International Maize and Wheat Improvement Center
CMA	Cereal Millers Association
CO_2	Carbon (IV) Oxide
COVID-19	Coronavirus Disease
DMU	Decision-Making Unit
EAC	East African Community
EAGC	East Africa Grain Council
ECOSOC	United Nations Economic and Social Council
FAO	Food and Agriculture Organization of the United Nations
FAOSTAT	Food and Agriculture Organization of the United Nations Statistical Database
FNSAP	Food and Nutrition Security Action Plan
GDP	Gross Domestic Product
GHG	Green House Gas
GM	Gross Margin
IIA	Independence of Irrelevant Alternatives
KALRO	Kenya Agriculture and Livestock Research Organization
KIPPRA	Kenya Institute for Public Policy Research and Analysis
KNBS	Kenya National Bureau of Statistics
MNL	Multinomial Logit
MNP	Multinomial Probit
MVP	Multivariate Probit
NCPB	National Cereals and Produce Board

SADC	Southern African Development Community
SDG	Sustainable Development Goals
TAAT	Technologies for African Agricultural Transformation
TR	Total Revenue
TVC	Total Variable Costs
UGMA	United Grain Millers Association
UN	United Nations
USA	United States of America
USAID	United States Agency for International Development
2SLS	Two-stage Least Squares regression
MDOMS	Miller's decision on maize source

CHAPTER ONE

INTRODUCTION

1.1 Background Information

Maize is a vital component of the global diet, accounting for 42% of the world's food calories and 37% of protein intake (Erenstein *et al*., 2022). Despite efforts to increase production, maize supply often falls short of demand, especially in developing countries, leading to reliance on imports. Kenya, where maize is the most important food crop and a staple for over 36% of the population's caloric intake, exemplifies this challenge. Maize supply in the country has struggled to keep pace with demand over the past decade due to rapid population growth, climate variability affecting yields, and reduced arable land from urbanization and land fragmentation. Additionally, rising input costs and reliance on traditional farming methods have limited productivity improvements, contributing to recurring supply shortfalls (Abodi *et al*., 2022).

The Kenyan maize market faces significant production fluctuations and marketing challenges, resulting in recurrent shortfalls. For instance, total production decreased from 36.7 million bags in 2021 to 34.3 million bags in 2022, a 6.5% reduction attributed to climate-related factors, including irregular rainfall, increased temperatures, and drought. The demand for maize as of 2020 was estimated at over 50 million bags and projected to reach 60 million by 2025. This demand is driven by human consumption and industrial uses, such as animal feed and biofuels. This demand continues to pressure local production, forcing an increased reliance on imports, which rose from 483.4 thousand metric tons in 2021 to 790.3 thousand metric tons in 2022 (FAOSTAT, 2024; Technologies for African Agricultural Transformation [TAAT], 2020; Tarus, 2019).

The growing reliance on imports, especially from neighboring countries such as Uganda and Tanzania, has disrupted local maize markets, causing market distortions and significant price fluctuations that negatively impact local milling firms (Kirimi *et al*., 2018). The EAC Common Market Protocol, implemented in 2010, aimed to facilitate regional trade but has contributed to price pressures and market disruptions (Olingo, 2016). In 2022, half of the small-scale milling firms shut down due to maize shortages (Andae, 2022), while large-scale firms also faced operational cutbacks (Bii, 2023).

Research indicates that maize importation adversely affects both the operational efficiency and profitability of milling firms, increasing their vulnerability to international market fluctuations. Despite efforts to boost local production, demand consistently outstrips supply due to factors such as population growth, urbanization, and the rising use of maize in industries (Abodi *et al*., 2021; Alessandro, 2015). Challenges such as inadequate infrastructure, high transportation costs, and inefficiencies in distribution further complicate the balance between local production and imports, as noted by Short *et al*. (2019) and the Kenya Institute for Public Policy Research and Analysis (KIPPRA, 2017).

It is therefore essential to explore how maize sourcing strategies, particularly the trade-offs between local sourcing and combined sourcing (local and imported maize), influence the profitability of Kenya's maize milling firms. This study addresses the following research questions: 1) What are the characteristics of maize milling firms in Kenya and their current sourcing practices? 2) What factors influence sourcing decisions among maize milling firms? 3) How do sourcing strategies impact the income of these firms? As critical contributors to Kenya's food security, maize milling firms supply a staple product to the market. However, their operations face challenges due to volatility in maize supply and prices (Khamila *et al.,* 2019). Balancing the need for imports with boosting local production is key to stabilizing their operations and ensuring consistent supply (Fintrac Inc., 2015).

Despite significant research on maize production and trade, a gap remains in understanding the specific impacts of local versus combined sourcing on the performance of milling firms. This study not only explores these trade-offs in depth but also aims to provide practical insights for policymakers to support the maize milling sector. While imports help fill supply gaps, they can increase costs and affect profitability. Conversely, an over-reliance on local production, without addressing yield or efficiency issues, may fall short of meeting demand, leading to continued shortages and price fluctuations (Olson *et al*., 2022).

Addressing the complexities in maize sourcing is crucial to both the sustainability and profitability of milling firms. This research offers a detailed analysis of these trade-offs to support effective decision-making in policy and trade strategies for a more resilient maize milling sector.

1.2 Statement of the Problem

Maize plays a crucial role in Kenya's food security, yet local production has persistently fallen short of meeting national demand. Despite government interventions, such as the introduction of high-yielding and genetically modified maize varieties, input subsidies, and improved storage and distribution policies, the supply gap remains significant. This shortfall has led to an increased reliance on maize imports, raising concerns about the operational sustainability and income of maize milling firms. The implications of choosing between sourcing solely from local production and combining local with imported maize have not been thoroughly investigated in the Kenyan context. There is limited empirical evidence on how these sourcing strategies affect the income and strategic decisions of maize milling firms. This study addresses this knowledge gap by examining the effects of sourcing strategies on the income of maize milling firms in Kenya, providing insights essential for informed decision-making and policy formulation.

1.3 Objectives

1.3.1 General Objective

The general objective was to enhance the economic welfare of maize milling firms in Kenya by analysing the effect of maize sourcing strategies on firm income in Kenya's milling sector.

1.3.2 Specific Objectives

i. To characterize maize milling firms in Kenya and determine their current maize sourcing practices.
ii. To analyze the factors influencing maize sourcing decisions among maize milling firms in Kenya.
iii. To assess the effect of maize sourcing strategies on the income of maize milling firms in Kenya.

1.4 Research Questions

i. What are the characteristics of maize milling firms in Kenya and their current maize sourcing practices?
ii. What are the factors that influence maize sourcing decisions among maize milling firms in Kenya?
iii. What is the effect of maize sourcing strategies on the income of maize milling firms in Kenya?

1.5 Justification of the Study

Maize is central to Kenya's food security and economic stability, providing a substantial portion of the caloric intake for the population and serving as a primary input for maize milling firms. However, frequent shortfalls in local maize production have led to a growing dependence on imports to meet domestic demand, posing strategic and operational challenges for milling firms. This study addresses these challenges by first characterizing the structure and sourcing practices of maize milling firms in Kenya. It further explores the key factors influencing their sourcing decisions and evaluates the impact of sourcing strategies on firm income. Understanding these dynamics is essential; not only for improving firm operations but also for ensuring a stable maize supply chain that supports national food security objectives. The findings will be valuable for managers in the maize milling industry, policymakers, and government officials tasked with aligning firm-level decisions with Kenya's broader goals for food security and economic resilience. This study also aligns with Article 43(c) of the Constitution of Kenya (2010), which guarantees the right to adequate food, and supports the EAC Vision 2050's objective of boosting agricultural productivity in the region. Additionally, it contributes to Sustainable Development Goal 2 (SDG 2) by providing insights essential for ending hunger, enhancing food security, and promoting sustainable agriculture. Ultimately, this research aims to guide the development of policies and strategies that bolster Kenya's maize milling sector and reinforce the country's commitment to food security and economic stability.

1.6 Scope and Limitation of the Study

This study used quantitative data from maize milling firms in five key regions of Kenya: Nairobi/Central, Rift Valley, Eastern/Northeastern, Western/Nyanza, and Coast, to assess the effects of trade-offs between importing maize and relying on local production during the year 2023. While the number of maize milling firms was limited, they were widely distributed across the country. A significant limitation encountered was the reluctance of private companies to share certain information due to competitive concerns, which was addressed by providing respondents with an ethical and consent form that assured confidentiality and specified that the information would be used solely for this study. To further protect privacy, unique identifiers replaced company names or respondent identities. Additionally, sensitive questions related to revenue were avoided; instead, estimates were derived from available data on costs and production volumes. Although the cross-sectional research design provided a detailed view of current sourcing practices and their immediate impacts, it limited long-term trend analysis. By addressing these limitations, the study provides valuable insights into the maize milling industry's current state and highlights areas for policy intervention to enhance food security and economic stability.

1.7 Operational definition of terms

Tradeoffs: A situation of choosing between or balancing both importation of maize and dependence on locally produced maize to improve the economic well-being of milling firms.

Local maize production: Maize produced in Kenya and sold to milling firms within the country.

Imports: Refers to maize that purchased from foreign countries.

Food security: When all people always have physical, social, and economic access to sufficient, safe, and nutritious food that meets their food preferences and dietary needs for an active and healthy life.

Tradeoff Analysis: An approach used to determine the effect of increasing one or more key factors and simultaneously decreasing one or more other key factors in a decision.

Millers: Maize milling firms

Economic welfare: Overall good of firms, measurable in monetary terms, obtained through the optimal allocation of resources.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

This chapter begins with an overview of the maize milling sector in Kenya. It examines the imports of maize and the trends in maize importation in Kenya. This chapter reviews literature on the sustainability of maize production in Kenya, price differentials in the maize sector, and trade-offs within the sector. It also presents the theoretical framework underpinning the study. Finally, the chapter concludes with a conceptual framework that illustrates the interrelationship of variables identified according to the study's objectives.

2.2 An Overview of the Maize Milling Sector in Kenya

Maize holds a critical position in Kenya, serving both as a staple food and a versatile industrial raw material. The primary products derived from maize processing include corn starch, corn oil, maize flour, animal feed, ethanol, and biofuels, with maize flour and animal feed dominating the market in Kenya (Khamila *et al*., 2019; Orhun *et al*., 2013).

According to Ndichu *et al.* (2015), Kenya hosts 120 to 150 registered maize milling firms, with a notable presence in urban areas such as Nairobi and Mombasa. Key industry associations include the East African Grain Council for larger firms and the United Grain Millers Association for medium-scale enterprises (Masoud, 2013).

The industry is led by a few large-scale firms like Mombasa Maize Millers, Unga Limited, Pembe Group, and Eldoret Grains, which collectively control over 70% of the milling capacity. These large firms possess significant maize stock storage capabilities, enabling them to buffer against seasonal supply fluctuations and utilize formal imports during local shortages. In contrast, medium and small-scale firms operate at lower capacities and often engage in self-branding and packaging (Fintrac Inc., 2015).

Geographically, the distribution of maize milling firms shows that the Nairobi/Central region hosts most maize milling firms (35.9%), driven by high population density and demand for milled maize flour. The Eastern/North- Eastern region follows with 26.9%, while the North and South Rift regions contribute 25.7%. Conversely, the Coast and Nyanza/Western regions have lower concentrations at 7.6% and 3.8%, respectively, influenced by preferences for local posho mills among small-scale farmers in Nyanza/Western (Khamila *et al*., 2019).

The maize milling industry is pivotal in Kenya, where maize flour, particularly used to make the staple dish ugali, is integral to the diet of many households (Gwirtz & Garcia-Casal, 2014). However, frequent maize shortages disrupt industry operations, leading to production cuts and operational shutdowns (Andae, 2022). Consequently, the industry faces critical decisions regarding tradeoffs between importing maize and depending on locally produced maize.

This outlines the essential role of the maize milling industry in Kenya's economy and food security landscape, highlighting the challenges posed by maize shortages and the strategic decisions firms must make regarding importation versus local production. This underscores the significance of this study in addressing critical gaps and informing sustainable development strategies in Kenya's maize sector.

2.3. Maize Importation in Kenya

International trade in agricultural products, particularly maize, has grown significantly since the 1980s, with many developing countries becoming net importers of cereals and staples (Chen & Villoria, 2019). Maize is a crucial commodity in global agricultural trade, with the United States as the leading exporter and China as the largest importer. Other major importers include Mexico, Japan, Egypt, Spain, Colombia, and the Netherlands (Statista, 2023). North Africa and the Middle East also feature prominently among the top maize importers globally.

Sub-Saharan Africa exhibits diverse patterns in maize trade dynamics, characterized by substantial import reliance in Eastern and Southern Africa compared to lesser dependence in West and Central Africa (Smale *et al*., 2013). Kenya, which historically exported maize in the 1970s and 1980s, has transitioned to a net importer due to domestic production fluctuations and increasing demand (Tarus, 2019). Informal imports from neighbouring countries significantly supplement official maize import statistics, indicating a more complex trade landscape (Abodi *et al.*, 2021; Short *et al*., 2019).

Kenya's reliance on maize imports underscores vulnerability to domestic shortages, prompting government interventions such as subsidies and tariff waivers to stabilize prices and ensure adequate supply (Mwangi, 2020). Key stakeholders influencing maize importation include millers and traders, who navigate market dynamics shaped by governmental policies (Ndirangu, 2022).

Figure 1 illustrates trends in domestic maize production and imports. Research by Abodi *et al.* (2022) highlights negative economic impacts of maize importation on domestic welfare, despite government measures to promote regional imports during shortages. Challenges persist regarding the economic viability and competitiveness of imported maize compared to domestic production (Andae, 2022).

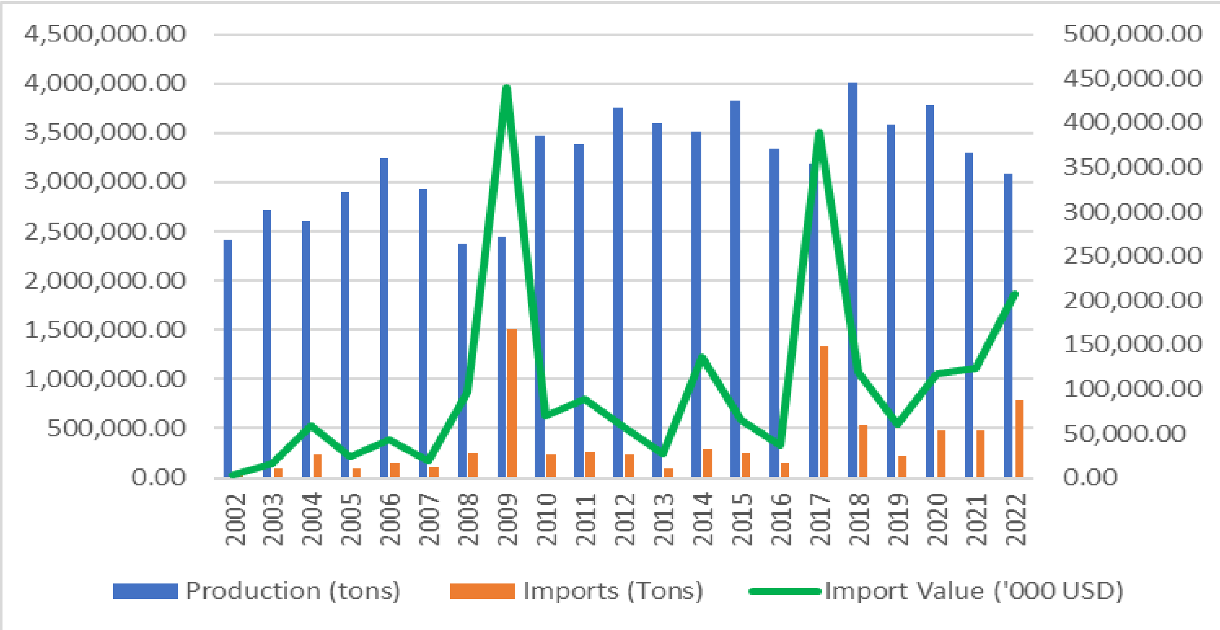

Figure 1; Maize production and import trends in Kenya (FAOSTAT, 2024)

2.4 Domestic Maize Production and Its Challenges in Kenya

Globally, maize stands as the predominant cereal crop, with production reaching approximately 875 million tons in 2012. The United States, Brazil, and China are among the top producers, underscoring maize's significance as a staple food and industrial raw material (Ranum *et al.,* 2014). However, the global demand for maize has surged due to its essential roles in livestock feed and bioethanol production, particularly in developed nations. This increased demand has led to persistent supply deficits, with developing countries importing up to 7% of their maize requirements (Shiferaw *et al*., 2013).

In Kenya, maize holds a central position, accounting for over 51% of all staple foods produced. The country cultivates approximately 1.5 million hectares of maize annually, yielding around 3 million metric tons, while per capita consumption averages 98kg per year (KALRO, 2022; Kang'ethe, 2011; Tarus, 2019). Click or tap here to enter text.Despite these efforts, Kenya consistently faces production shortfalls, evident in the deficit where annual demand in 2017 reached 52.8 million bags against a production output of 37 million bags (Abodi *et al.,* 2021; Tarus, 2019).

Kenya's maize production predominantly relies on rain-fed agriculture, exposing farmers to significant risks associated with climate variability. Additionally, factors such as high production costs, insecure land tenure, pest outbreaks, and the recent COVID-19 pandemic have exacerbated production challenges (Kirimi *et al*., 2018; Wokabi, 2013). These constraints have highlighted the inadequacy of traditional farming practices in meeting Kenya's growing maize demands.

Critically, while Kenya depends on maize imports from neighbouring countries like Uganda and Tanzania to supplement domestic production, this dependency raises concerns about the long-term sustainability and economic viability of the maize sector (AGRA, 2021; Kirimi *et al*., 2018; Nyoro *et al*, 2004). Small-scale farmers in Kenya face higher costs for labour, fertilizers, and seeds compared to their counterparts in these countries, contributing to the economic disparity and import reliance.

Moreover, the current policy landscape in Kenya, including subsidies and governmental interventions, aims to stabilize maize prices and ensure food security. However, the effectiveness of these policies in enhancing local production and reducing import dependency remains uncertain (Owino & Waweru, 2022). Additionally, sustainable farming practices and technological innovations, such as conservation agriculture and improved seed varieties, are underexplored avenues that could potentially bolster Kenya's maize production capacity amidst climate change and economic challenges (Khumalo *et al*., 2024). These gaps in literature emphasize the need for this study to investigate the trade-offs between maize sourcing strategies (importation and local sourcing) in Kenya, aiming to enhance agricultural sustainability, food security, and economic resilience.

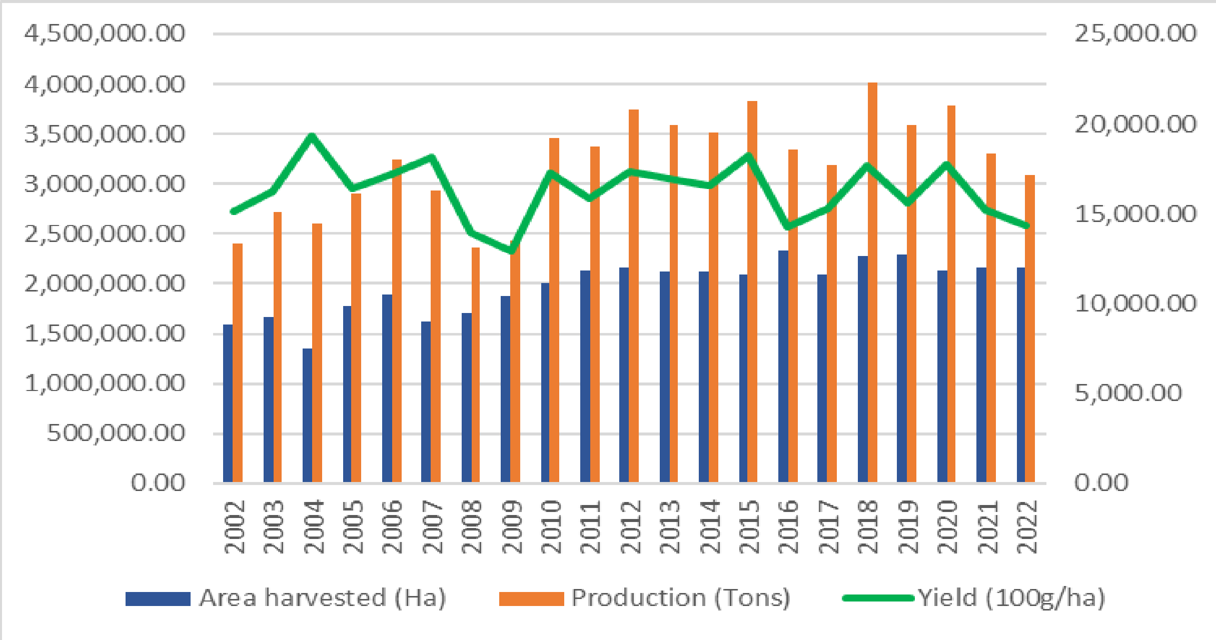

Figure 2; Maize production and yield trends in Kenya (FAOSTAT, 2024)

2.5 Economic Implications of Price differentials in Maize Production and Importation

Maize is the leading global staple cereal in terms of annual production, exceeding one billion metric tons (Erenstein *et al*., 2022; García-Lara & Serna-Saldivar, 2018). The global area under maize cultivation is approximately 197 million hectares. Recent studies emphasize maize's importance as both a food crop and an economic commodity, influencing food security and trade balances (Erenstein *et al*., 2022). These studies provide a solid foundation for understanding the global context of maize production, which is crucial for analyzing Kenya's specific situation.

In Kenya, maize yields average sixteen bags per acre for small-scale systems and twenty bags per acre for large-scale systems, with an estimated production cost of KES. 26,000 per acre. This cost encompasses land preparation, farm inputs, crop management, transport, and marketing (Samuel, 2022). However, recent data indicates significant variations due to season and region. Farmers have reported inflated input prices and high labor costs, leading to reduced maize production (Ndirangu, 2022). Drought, crop failures, COVID-19 impacts, and desert locust invasions have worsened these issues (Otieno, 2023). While these studies provide valuable data, they often lack a critical examination of policy effectiveness in addressing these challenges.

In 2020, Kenya imported 273.5 thousand tons of maize, valued at KES 7.5 billion (approximately $67.9 million). Importation costs depend on duties, taxes, fees, and charges, which depend on factors such as volume, customs laws, and required public services. Additionally, transportation costs have a significant effect on the overall cost of imported maize (Infotrade, 2022). Existing literature adequately describes these costs but often fails to explore the economic implications of these expenses on local production and food security comprehensively.

The elevated costs of maize production and importation contribute to elevated maize flour prices, negatively impacting consumer welfare (Ndirangu, 2022). Moreover, Kenya's substantial wage bill for ensuring food security through maize importation affects its terms of trade (Agritrade, 2014). Balancing maize importation with local production is crucial for economic welfare. Policy discussions suggest investing in agricultural infrastructure and supporting small-scale farmers to enhance local production (MoAF&L, 2019). However, the analysis of how these policies is implemented and their actual effectiveness remains inadequate.

Significant research gaps include understanding the long-term economic impacts of maize price fluctuations on rural livelihoods and food security. Additionally, comprehensive studies on policy effectiveness in reducing production costs and improving yields are lacking. Future research should focus on sustainable farming practices and technological innovations to boost productivity and reduce import dependency.

2.6 Tradeoffs in Maize Sourcing Strategies

Maize is a critical food crop globally, with rising demand driven by rapid population growth and production shortfalls. In Kenya, maize productivity has declined, necessitating reliance on imports to bridge the supply gap (Marenya *et al*., 2021). Recent figures indicate that annual maize production averages 40 million bags, falling short of the 52 million bags required, resulting in over-importation, market gluts, and price drops that adversely affect local farmers (Muchira, 2019).

Kenya faces a food price dilemma, balancing incentives for maize producers with the need to keep prices affordable for consumers (Ariga *et al*., 2010). The question arises: should Kenya prioritize imports or enhance local production? The competitiveness of domestic production is further challenged by higher production costs faced by small-scale farmers compared to those in neighboring countries. For instance, in 2021, Tanzania exported approximately

152,880 metric tons of maize to Kenya, accounting for 57% of imports, while Uganda contributed 43% (Rotich, 2021).

Despite subsidies and market interventions, the sustainability of Kenya's maize sector remains precarious, with importation resulting in significant economic losses. In 2021**,** Kenya's maize imports from Tanzania were valued at about $167.5 million, while exports to Tanzania were $158 million, indicating a net economic loss that impacts maize producers and consumers alike (Abodi *et al*., 2022; AGRA, 2021).

A balanced approach is crucial, emphasizing both maize imports and enhanced local production to improve economic welfare and ensure food security. This study will explore these trade-offs to inform policy decisions that foster sustainable development in Kenya's maize sector.

2.7 Empirical and analytical Review

Huang *et al*. (2019) conducted a study on the environmental and socioeconomic trade-offs of importing crops to meet domestic food demand in China. They used a unique crop-specific nitrogen budget database to assess the impacts of crop trade on sustainability concerns such as nitrogen pollution, cropland area, food supply independence, and trade expenditures. The study found that crop imports allow China to meet domestic demand while reducing nitrogen pollution and cropland use. However, increased food imports result in high trade expenditures and expose the country to greater risks in international markets. The economic benefit of avoiding nitrogen pollution through crop imports was lower than the trade expenditures. Consequently, the study recommended optimizing crop trade portfolios to shift domestic crop production from nitrogen-intensive crops to nitrogen-efficient ones. This finding is relevant to Kenya's context, where maize importation may reduce certain environmental pressures but could also increase economic vulnerabilities.

Lu *et al.* (2003) used a simulation model to analyse the economic and environmental trade-offs of sustainable agriculture cropping systems. Gross margins were used to measure the profitability of different cropping systems, while risk analysis assessed farmers' adoption of these systems. The results indicated that cover crop-based systems with zero nitrogen inputs offered higher margins, whereas organic systems had lower profit variability across years. However, all systems experienced nitrogen runoff exceeding threshold levels, highlighting the challenge of controlling nutrient losses while maintaining profitable production. The study recommended further research to develop improved systems that reduce or eliminate these trade-offs. This approach of balancing profitability and environmental sustainability can guide strategies for optimizing maize production and importation in Kenya.

To determine the trade-offs between food production and greenhouse gas mitigation in Norwegian agriculture, Blandford *et al*. (2014) used the detailed economic model Jordmod to examine the impacts of a 30% cut in greenhouse gas emissions from agriculture. The study found that a CO2 tax on agricultural activity would reduce agricultural production, particularly GHG-intensive products like beef and mutton. Conversely, rewarding farmers for carbon sequestration through agroforestry would intensify production, increasing emissions per unit of land. The study concluded that intensification of production is required to meet the food needs of an expanding global population while contributing to GHG mitigation, implying higher output per unit of land but lower emissions per unit of agricultural produce. This insight into the balance between production intensity and environmental impact is pertinent to the maize importation debate in Kenya, where increasing local production efficiency could mitigate some negative impacts of import reliance.

Marenya *et al*. (2021) applied a mixed logit model to estimate maize farmers' willingness to sacrifice yields for agronomic or consumption traits in western Kenya. The study found that stress tolerance traits against drought and striga weed had significant willingness to sacrifice yields, and traits related to storability had comparable or sometimes higher willingness to sacrifice yields. The study recommended that breeding programs should focus on drought and striga tolerance, as well as storability traits, suggesting that advanced grain storage technologies could enhance food security despite lower yields. These findings emphasize the importance of considering local production traits that address specific challenges faced by Kenyan farmers.

Naudin *et al*. (2014) studied trade-offs between biomass use and soil cover in rice-based cropping systems in Madagascar using digital imaging to measure the relationship between mulch quantity and soil cover. The results showed that biomass production varied significantly between hillsides and valleys and between cover crops and farmers' management practices. Soil cover was not linearly related to mulch quantity. The study concluded that decisions on biomass removal depend on local biophysical conditions, biomass characteristics, and farmers' goals for their farm systems. This localized approach to managing agricultural trade-offs can be applied to the Kenyan context, where diverse conditions affect maize production practices.

Klapwijk *et al.* (2014) proposed a combination of approaches to quantify and analyse trade-offs in agricultural systems. The study highlighted that participatory approaches could define meaningful objectives and indicators but are not suitable for quantifying trade-offs. Empirical and econometric approaches can quantify the current state of agricultural systems but are not suitable for predicting outcomes beyond the original data range. Simulation models can quantify difficult-to-measure indicators and explore the dynamic nature of trade-offs. Optimization models can assess potential synergies and alleviate trade-offs but have limited applicability when sociocultural traditions play a key role. Therefore, the study recommended using a combination of approaches for trade-off analysis and emphasized its use for discussion support rather than decision support. This comprehensive approach to trade-off analysis can be valuable in characterizing and quantifying maize importation and local production trade-offs in Kenya.

These studies illustrate the complex trade-offs involved in agricultural production and highlight the need for optimized strategies to balance environmental, economic, and social factors. This underscores the importance of investigating the effects of trade-offs between maize importation and dependence on local production in Kenya. Characterizing and quantifying maize importation by milling firms and identifying sector challenges will aid in developing strategies to improve economic welfare and food security. This research aims to provide insights into the effects of tradeoffs between maize importation and local production on the income of maize milling firms and to propose informed strategies that address both the benefits and risks associated with these trade-offs.

2.8 Theoretical and Conceptual Framework

2.8.1 Theoretical Framework

The Tradeoff Theory

Several theoretical frameworks can be used to explain the sourcing decisions of maize milling firms in Kenya. Among them are Contingency Theory**,** Supply Chain Risk Management (SCRM) Theory**,** and Trade-Off Theory**.**

Contingency Theory suggests that firms make decisions based on situational factors, such as resource availability, market conditions, or operational capabilities. This implies that the choice to rely solely on local maize or to import when necessary is contingent on the specific circumstances each firm faces. While this theory helps explain why firms might adopt different sourcing strategies, it does not offer a structured approach to evaluating the costs and benefits of these decisions. It focuses on adaptability to circumstances rather than on optimizing economic outcomes (McAdam *et al*., 2019).

Supply Chain Risk Management (SCRM) Theory, on the other hand, emphasizes the importance of managing risks within the supply chain. In this context, firms may import maize during local shortages to mitigate supply risks and ensure operational continuity. While SCRM theory provides insights into how firms address the risk of disruptions, it does not emphasize the cost-benefit analysis required for decision-making. It is primarily concerned with minimizing supply risks rather than optimizing sourcing decisions for profitability (Grötsch *et al*., 2013).

The Trade-Off Theory, particularly in its dynamic form, offers a more comprehensive framework for understanding how firms balance the costs and benefits of sourcing decisions. The theory posits that firms aim to find an optimal balance between competing alternatives, such as using local maize versus importing maize during shortages (Dang *et al*., 2012). The decision to import maize, despite its higher costs (including tariffs, transportation, and currency risks), is balanced against the benefit of maintaining consistent production and avoiding operational disruptions. The dynamic version of the theory accounts for the fact that firms may deviate from the optimal decision due to changing market conditions but will adjust over time to converge toward an optimal strategy (Dudley, 2011). This theory, therefore, provides a more robust explanation for how firms systematically weigh their options to maximize income over the long term.

In this study, the Trade-Off Theory is applied to explain the sourcing decisions of maize milling firms. The theory predicts that firms will optimize their decisions by trading off the costs and benefits of local and imported maize. For instance, the marginal benefit of importing maize decreases as the firm increases its imports, while the marginal cost of importing rises (Jahanzeb *et al*., 2013).. The optimal sourcing decision is reached by balancing these costs and benefits to maximize income.

The theory is outlined below.

$$Y_i = \beta k + W_i + \varepsilon_i \qquad \text{Eq 1}$$

Where Y_i = the firm's income for a given alternative i

W= explanatory variable's vector

ε_i = residual error term

2.8.2 Conceptual framework

The conceptual framework illustrates the interrelationship of variables and how they relate according to the objectives of the study. The characteristics of maize milling firms and the intervening variables affect the firms' decisions on whether to use both imported and locally produced maize or solely rely on locally produced maize. This decision, in turn, impacts the income of the maize milling firms. The characteristics of the maize milling firms included the size of the firm, the years of operation, the location, the production capacity, the total number of employees and the technology used in milling. The intervening variables affecting the firms' decision included the government subsidy programs on maize, government purchases through the NCPB, tax waivers, import licenses, import duties, domestic price of maize and import price of maize. These relationships are illustrated in the figure below.

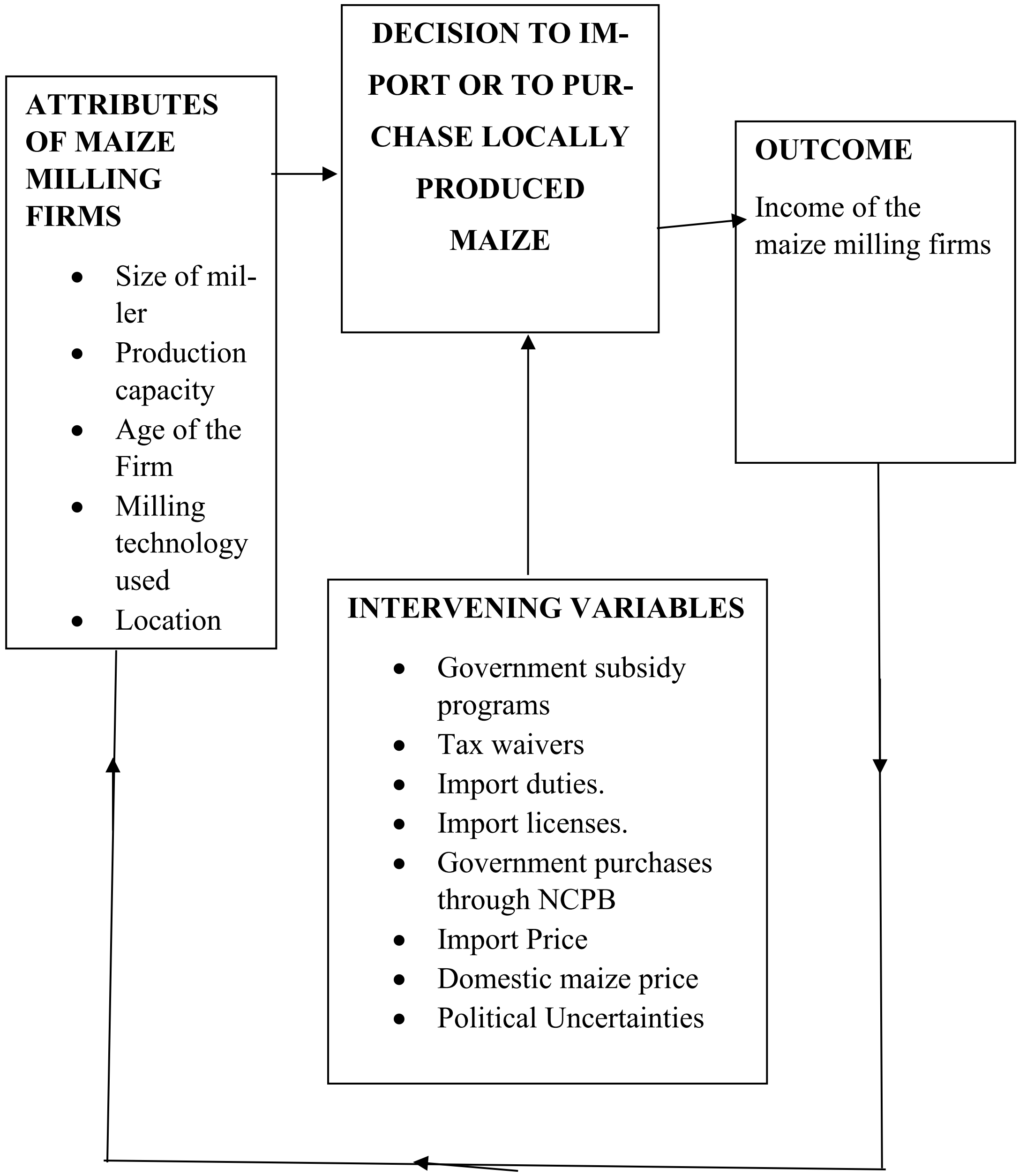

Figure 3; Conceptual framework

CHAPTER THREE

METHODOLOGY

3.1 Introduction

This chapter provides information on the processes, approaches, tools, and methods that were used in the study. It includes the following sections: the description of the study area, the research design, the sampling procedure and sample size determination, the data, and data collection methods and finally the analytical framework.

3.2 Study area

The study was conducted in the Republic of Kenya, with a focus on key maize-producing regions and the locations of maize milling firms. These specific areas are central to understanding the trade-offs between local maize production and importation, which directly impacts the operations and income of maize milling firms.

Kenya's major maize-growing regions, which were visited for this study, include: Trans Nzoia, Uasin Gishu, Bungoma, Kakamega, Nakuru, Laikipia, Kiambu, Meru and Kirinyaga. These regions are known for their fertile soils and favourable climatic conditions, making them highly productive for maize cultivation. In these areas, maize is the primary crop, with small-scale farming systems contributing 70% of the total production and large-scale systems contributing 30% (KNBS, 2023; Ntarangwi, 2024).

The areas where most maize milling firms are located include Nairobi, Machakos, Mombasa, Kisumu, and Kilifi. These milling firms are strategically located to ensure efficient sourcing of raw materials from the maize-producing regions. The decision-making process of these firms, whether to rely on locally produced maize or imported maize, is influenced by various factors, including production costs, availability, and government policies (De Groote & Kimenju, 2012).

By focusing on these specific maize production areas and the locations of milling firms, the study aims to provide a comprehensive understanding of the trade-offs between local maize production and importation. This approach will help identify optimal strategies for sourcing maize that enhance economic welfare and food security in Kenya.

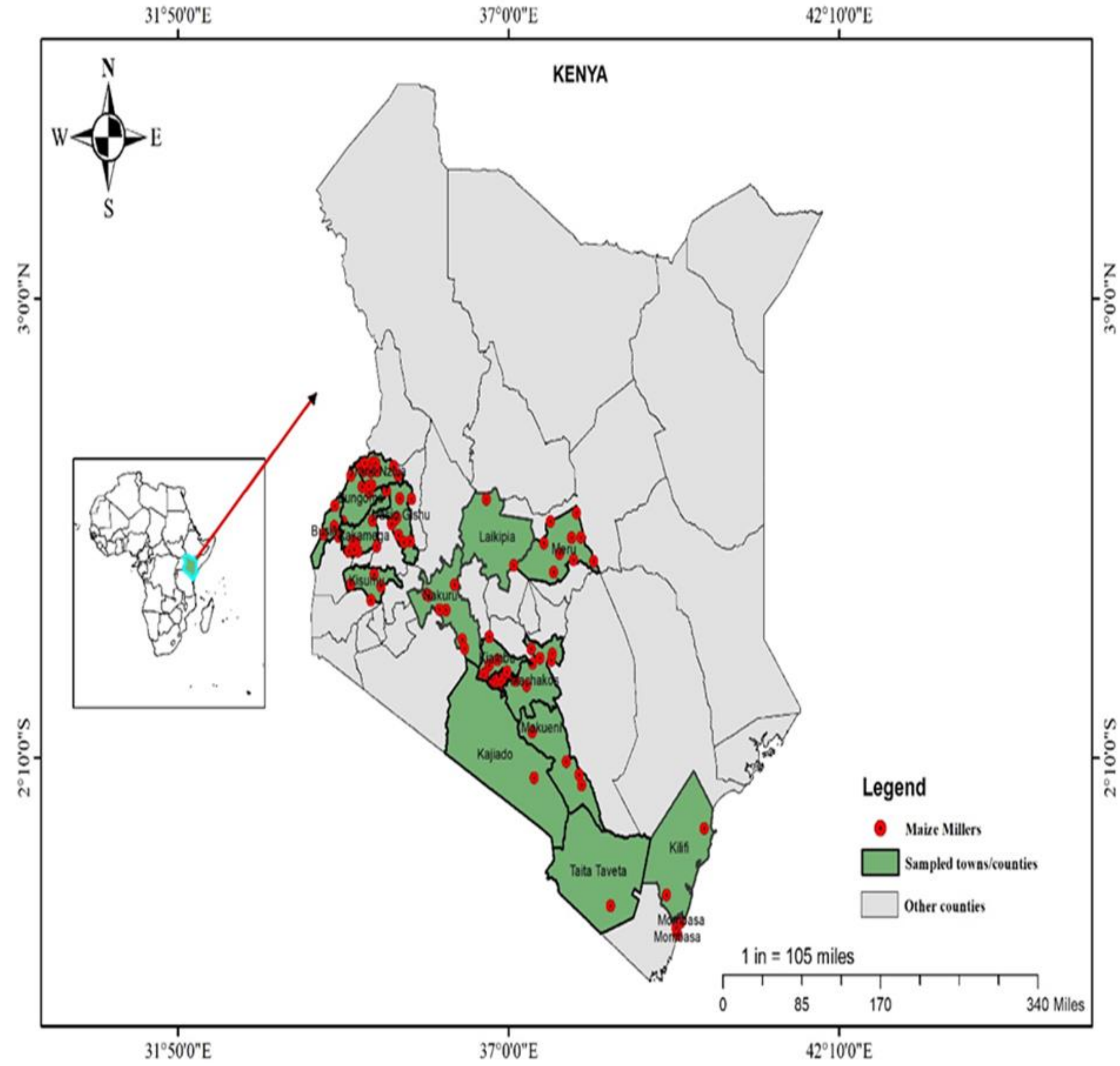

Figure 4; Map of study area (Naftaly, 2021)

3.3 Research design

This study employed a cross-sectional research design to explore the trade-offs between maize importation and dependence on local production by maize milling firms in Kenya. Quantitative methods were used to analyse numerical data, allowing for the quantification of these trade-offs, the assessment of relationships between variables, and the development of strategies to address sourcing challenges.

Data was gathered at a single point in time from a sample of firms across urban and peri-urban regions. This approach was ideal for examining current sourcing practices, assessing their impacts on firm income, and identifying patterns in trade-offs between local and imported maize. The cross-sectional design provided valuable insights into these dynamics, helping to inform strategies aimed at enhancing the firms' economic performance and supporting food security.

Overall, the combination of quantitative methods and the cross-sectional design offered a solid framework for investigating the sourcing decisions of maize milling firms in Kenya, providing a basis for formulating conclusions and recommendations aimed at improving economic welfare and resilience.

3.4 Study Population

The study focused on registered maize milling firms in Kenya that produce packaged flour, as this segment was among the most affected by the maize supply shortage. Given that the total population of maize milling firms in Kenya is finite, estimated at 150 firms (Khamila *et al*., 2019), a census approach was adopted. This method was appropriate to eliminate sampling errors and ensure a high level of precision in capturing the characteristics of each firm.

The unit of analysis for this study was maize milling firms, categorized by size based on their daily production capacities. This categorization aligned with the diversity within the sector and allowed for an analysis of operational scale, technology, and capacity variations among the firms (Enzama *et al*., 2017). Specifically, four main categories were used: micro (posho-mill) firms with a capacity of less than 10 MT/day, small-scale firms producing 11 to 20 MT/day, medium-scale firms producing 21 to 50 MT/day, and large-scale firms with capacities exceeding 50 MT/day. This structure facilitated a detailed understanding of the production capacities and operational differences within the sector.

Maize mills were categorized into five geographic regions: Nairobi and Central, Rift Valley, Western and Nyanza, Eastern and Northeastern, and the Coast, based on their locations. This categorization was based on proximity and similarity in consumption patterns, level of urbanization and ethnic communities inhabiting them.

The Nairobi and Central region comprised of six counties namely, Nairobi, Kiambu, Murangá, Kirinyaga, Nyandarua and Nyeri. In the Rift Valley region, Laikipia, Nakuru, Uasin

Gishu, and Trans Nzoia counties were chosen due to their high concentration of maize mills. Similarly, Busia, Bungoma, Kakamega, and Kisumu counties in the Western and Nyanza regions were included for the same reason. In the Eastern and Northeastern regions, the focus was on Meru, Machakos, Makueni, and Kajiado counties, while Mombasa, Kilifi, and Taita Taveta counties were the key areas in the Coast region. These locations were identified based on the distribution of maize mills within each region.

3.5 Response Rate

According to Mugenda (2010), a response rate of 50% is deemed adequate, 60% as good and 70% as exceptionally good. The study targeted a total of 168 maize milling firms producing packaged maize flour. Complete data was obtained from 106 maize milling firms through personal interviews and online surveys. This accounted for 63.1% response rate which was deemed sufficient to proceed with the study.

3.6 Data and Data Collection Methods

The study utilized both primary and secondary data sources. Secondary data were gathered from relevant publications, journals, newspaper articles, books, and government sources such as handbooks, reports, published statistics, planning documents, policy statements, and other official documents. This secondary data provided context and background information.

Primary data collection involved personal interviews conducted during physical visits to maize milling firms. Interviews were held with middle and line-level management staff, including managers, owners, directors, accountants, supervisors, and machine operators. For firms where physical interviews were not feasible, online surveys were administered to key staff. A semi-structured questionnaire guided the personal interviews and online surveys.

To ensure questionnaire reliability and relevance, pretesting was conducted in three companies located in Thika. The questionnaire captured data on firm attributes such as size, years of operation, production capacity, quantity of maize traded, and proximity to maize supply areas. Additionally, it collected data on factors influencing the firms' decisions to import maize or purchase locally produced maize.

3.7 Analytical Framework

Objective 1: To Characterize Maize Milling Firms in Kenya and Determine Their Current Maize Sourcing Practices.

Descriptive statistics addressed this objective. Data on both qualitative and quantitative variables provided insights into individual miller attributes, influencing factors, and challenges. The means, standard deviations, percentages, and frequency distributions were determined for firms using only locally produced maize versus those using both locally produced and imported maize. ANOVA's and chi-square tests then compared the differences between these two groups.

Objective 2: To Analyze the Factors Influencing Maize Sourcing Decisions among Maize Milling Firms in Kenya.

The Bivariate Probit model analyzed this objective. This is a joint model for two binary outcome variables whose error terms are assumed to be correlated (Seyoum, 2018).The model was specified on the assumption that the maize milling firm's decision-making process is a simultaneous process in which an individual firm chooses among a stream of alternatives that maximizes the firm's utility rather than on a set of conditionally independent choices. Additionally, factors that influence the firm's decision to use both locally produced and imported maize link to the factors influencing the decision to use locally produced maize only. This would cause modelling problems related to endogeneity (Zaefarian *et al*., 2017). The implication of such endogeneity would be inconsistent estimates from a standard probit model and inaccurate inference.

The maize milling firm's decision to use only locally produced maize or both locally produced and imported maize can be examined separately as functions of a common set of explanatory variables using a univariate probit regression model. Alternatively, other methods such as Tobit regression and the Heckman two-step model may be employed to analyze the two decisions. However, the bivariate probit model yields better, and more efficient parameter estimates since it considers the potential correlation between the disturbances of the two decisions (Wooldridge, 2002).

The equations below illustrate the model,

$$Y^*_{i1} = \alpha_1 X_{i1} + \varepsilon_{i1} \qquad \text{Eq 2}$$

$Y^*_{j2} = \alpha_2 X_{j2} + \varepsilon_{j2}$ Eq 3

Where $Y^*_{i1}= 1$, if $Y^*_{i1}> 0$ and 0, if otherwise

$Y^*_{j2}= 1$, if $Y^*_{j2}> 0$ and 0, if otherwise

ε_{i1} and ε_{j2} are joint normal with means zero, variances one and covariance ρ.

$$\begin{bmatrix} \varepsilon_{i1} \\ \varepsilon_{j2} \end{bmatrix} X \sim N \left(\begin{bmatrix} 0 \\ 0 \end{bmatrix} \begin{bmatrix} 1 & \rho \\ 1 & \rho \end{bmatrix} \right)$$

$Y_{i1}= 1$ was if the miller chose to use both locally produced and imported maize and 0 if otherwise, $Y_{j2}= 1$ was if the miller chose to use locally produced maize and 0 if otherwise. X_1 and X_2 were the vectors of the explanatory variables used in estimating the model. α_1 and α_2 were the vector of the parameters estimated by the model and ε_1 and ε_2 were the random error terms.

Y^*_{i1} and Y^*_{j2} are the latent variables representing the unobserved perceived utility derived from the firm's decision to use both locally produced and imported maize or the decision to use locally produced maize, respectively. Therefore, the outcome $Y_{i1}= 1$ arises when the latent variable $Y^*_{i1}> 0$ whereas Y_{i2} is observed if and only if $Y_{j2}= 1$. Eq 4 illustrates the joint probability of the model.

$P (Y_1= i, Y_2 = j) = F (\alpha'_1 X_1, \alpha'_2 X_2, \rho)$ Eq 4

This resulted in different observations with unconditional probabilities as shown.

$Y_1= 0, Y_2 = 1$; prob $(Y_1= 0, Y_2 = 1) = F (-\alpha'_1 X_1, \alpha'_2 X_2, -\rho)$

$Y_1= 1, Y_2 = 1$; prob $(Y_1= 1, Y_2 = 1) = F (\alpha'_1 X_1, \alpha'_2 X_2, \rho)$

The first probability refers to firms that used local maize only while the second probability refers to firms that used both local and imported maize. The coefficients (α'1, α'2, ρ) were determined through maximum likelihood estimation.

Table 1; Description of variables

Variable	Description	Unit	Measurement	Expected sign
Dependent Var				
Local_Sourcing	If firm used locally produced maize only	Dummy	1: Yes 0: No	+/-
Combined_Sourcing	If firm used both locally produced and imported maize	Dummy	1: Yes 0: No	+/-
Log_of_Gross_Margin	Proxy of income obtained from milling operations	Continuous		+/-
Independent Vars				
Maize_Sourcing_Strategy	Miller's decision on maize source	Dummy	1: use locally produced maize only 0: use both locally produced and imported maize	+/-

Age_of_Firm	No. of years firm has been in operation	Continuous	Years	+/-
Total_employee_numbers	No. of employees in firm	Continuous	Persons	+/-
Average_selling_price	Mean Selling price per ton of maize flour	Continuous	KES	+/-
Average_monthly_sales	Mean quantity of maize flour sold per month	Continuous	Tons	+/-
Average_production_cost	Mean cost of maize flour production per month	Continuous	KES	+/-
Production_capacity	Daily production capacity	Continuous	Tons	+/-
Milling_Technology	Milling technology used by firm	Categorical	1: Hammer 2: Attrition 3: Roller 4: Automated	+/-
Qty_purchased	Quantity of maize grain purchased	Continuous	Tons	+/-
Duties	If import duties affect the firm's deci-	Dummy	1: Yes 0: No	+/-

	sion			
Waivers	If tax waivers affect the firm's decision	Dummy	1: Yes 0: No	+/-
Licenses	If import licenses affect the firm's decision	Dummy	1: Yes 0: No	+/-
Total_Cost_of_Maize	Total cost of procuring maize either locally or through import	Continuous	KES	+/-
NCPB_purchase_influence	If government purchases through NCPB affect the firm's decision	Dummy	1: Yes 0: No	+/-
Subsidy	If maize subsidies affect the firm's decision	Dummy	1: Yes 0: No	+/-

Objective 3: To Assess the Effect of Maize Sourcing Strategies on the Income of Maize Milling Firms in Kenya.

Gross margin calculations facilitate a comparison of revenues between firms using only local maize and those using both local and imported maize, accounting for variations in firm capacity. Gross margin is the difference between gross production value and variable costs (Semerci *et al*., 2014). Gross margin analysis typically assumes fixed costs are not included, focusing only on variable costs directly tied to production. This assumption helps in evaluating short-term profitability but may limit insights into long-term sustainability. It also implies that fixed costs do not impact short-term profitability and that changes in gross margin primarily reflect operational efficiency related to variable costs. The formula for calculating gross margin is as follows.

$$GM_i = TR_i - TVC_i$$

Where GM = Gross margin

TR = Total Revenue (per month in KES)

TVC = Total variable costs incurred (per month in KES)

For (i= 0,1), either firms that use both locally produced and imported maize or firms that use locally produced maize only.

Equation 7 shows the detailed formular.

$$GM = \sum P_y Y - \sum P_x X \qquad \text{Eq 7}$$

Where P_y = Unit price of maize sold per ton

Y = Quantity of maize sold in tons

P_x = Unit cost per ton of maize purchased locally or imported

X = Quantity of maize purchased locally or imported in tons

A t- statistic test showed the mean differences between the two alternatives. The formular for the t-test is shown by equation 8.

$$t = \frac{\bar{X}_1 - \bar{X}_2}{\sqrt{S^2 (1/n_1 + 1/n_2)}} \qquad \text{Eq 8}$$

Where t = t value

X_1 and X_2 = means of the two alternatives

S^2 = pooled standard error of the two alternatives

n_1 and n_2 = the number of observations for each alternative

The gross margin analysis, however, does not consider other important costs such as administrative costs that could affect profitability (Fani *et al*., 2015; Firth, 2002). Given this limitation, a two-stage least squares regression model analyzed the effect of these tradeoffs on the milling firms. The firms' income served as a measure of the impact of their maize source decision. To determine the choice of maize source, the milling firms had two classifications: those that purchased only domestically produced maize (labelled as 'local only),' and those that purchased both locally and imported maize (labeled as 'both local and import).

The firms' decision on the choice of maize source may influence the income that the firm obtains from its milling operations. Additionally, the income that a firm gets may also influence their decision on the choice of maize source. As a result, simultaneity occurs and the error terms between the dependent and independent variables becomes correlated leading to endogeneity problems (Zaefarian *et al*., 2017).In this case, ordinary least square (OLS) regression is not capable of producing consistent parameter estimates. According to Semadeni *et al*. (2014), endogeneity can produce severely biased and inconsistent results. Other methods can address endogeneity problems including, but not limited to, generalized method of moments (GMM), Heckman-two step procedure and Two-stage Least Squares regression (2SLS). However, the 2SLS provides a more efficient estimator (in the class of IV estimators) under conditional homoscedasticity. It also provides consistent and asymptotically normal estimators of the model under assumptions of valid instruments and exogeneity of the instrument variables (Maydeu-Olivares *et al*., 2019). Therefore, the 2SLS regression model was suitable for this study.

The 2SLS employs an instrumental variable (IV) approach whereby an instrumental variable replaces the problematic endogenous variable in the model. The instrumental variable must meet the relevance condition, meaning it must be strongly correlated with the endogenous regressor. This is assessed in the first stage of the 2SLS. Additionally, it must meet the exogeneity condition, which requires that the instrument is not correlated with the error term in the second stage of the model (Wooldridge, 2002). Equation 9 shows the general structural equation for the model.

$$Yi = \alpha_1 S + \alpha_2 X_i + \varepsilon_i \qquad \text{Eq 9}$$

Where Yi = income obtained by the maize milling firms

S = milling firm's choice of maize source

α = parameters estimated

X_i = explanatory variables

In the first stage of the 2SLS, the endogenous variable (S) was regressed on all the exogenous variables and a set of instrumental variables, and the results of this regression obtained.

$$S = \beta_1 Z_i + \beta_2 X_i + \mu \qquad \text{Eq 10}$$

where S represents the endogenous variable (miller's decision on maize source)

$\beta$is a vector of coefficients

X_1 is a vector of exogenous covariates.

Z_i is a vector of instrumental variables that have an impact on the miller's decision but not on the income of the firms.

μ is the random error term

In the second stage, the predicted value from Equation 10 replaced the original endogenous variables in the structural equation. This allows for the estimation of Equation 11 using OLS, resulting in efficient coefficient estimates.

$$Yi = \alpha_1 \hat{S} + \alpha_2 X_i + \varepsilon_i \qquad \text{Eq 11}$$

The F-test evaluated the validity and quality of the instruments in the model. According to Stock *et al*. (2002), the weak instrument hypothesis is rejected if the F-test value exceeds ten. The Durbin and Wu-Hausman tests confirmed the endogeneity of the proposed variable.

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 Introduction

This chapter presents analysis of findings regarding the study objectives and discussions of the same. The first section discusses the descriptive results comprising of maize milling firms' characteristics, their distribution in Kenya and their sources of maize. The second section discusses the empirical results of bivariate probit model and gross margin analysis. The results indicate that 44% of the maize milling firms obtain their maize from local sources only while 56% obtain their maize from both local sources and importation from other countries.

4.2 Structure and Context of Maize Milling Firms in Kenya

4.2.1 Categorization of Maize Milling Firms

The maize milling firms were sub-divided into two groups, Local only and combined. The Local only group represents maize milling firms that used locally produced maize in their milling operations, while the combined group represents firms that used a combination of locally produced and imported maize. Out of the total 106 respondents, 60.38% used only locally produced maize, while 39.62% used a combination of both locally produced and imported maize. Firm size appears to influence sourcing strategy: larger firms were evenly split, with 50% sourcing maize locally and 50% sourcing from both local and imported sources. In contrast, medium and small firms showed a strong preference for local sourcing, with all respondents in these groups relying solely on local maize. Micro firms, representing the posho mill category, showed a slight variance, with 84% using combined sources and 16% using local only sources. These sourcing patterns suggest that larger firms may have more flexibility in their supply chains, likely due to greater financial and logistical capacity, while smaller firms are more constrained to local sourcing. Overall, the results indicate that the supply of maize in the country has not been sufficient to meet the demand, and as a result, some millers have had to rely on imports from other regions (Masoud, 2013; Rotich, 2021).

Table 2: Maize sourcing strategy according to firm size

Firm Size/ Maize Sourcing Strategy	Local only	Combined	$\chi 2$
Large	50%	50%	7.673*
Medium	100%	0	
Micro (posho mill)	16%	84%	
Small	100%	0	
Total	39.62%	60.38%	

Pearson chi2(3) =7.6734 Pr=0.053

4.2.2 Distribution of maize milling firms in Kenya

The distribution of maize milling firms by size varies significantly across regions, indicating regional differences in the scale of milling operations. The micro (posho mill) firms dominate the maize milling industry, accounting for 40.75% of all firms across all regions. This high percentage suggests that small-scale milling operations are prevalent, particularly accessible to local communities and likely responsive to local demand (De Groote & Kimenju, 2012).

In terms of regional distribution, micro firms have the highest representation in Western/Nyanza (54.50%), Coastal (50%), Eastern/Northeastern (50.62%), Rift Valley (50%), and Nairobi/Central (45.05%). This shows that micro firms are well-dispersed across the country, with slightly higher concentrations in Western/Nyanza, Eastern, and Rift Valley.

Small firms make up the second-largest category overall, comprising 26.42% of the total. These firms are relatively evenly distributed across regions, with the highest concentrations in Western/Nyanza (31.76%), Rift Valley (30.50%), and Coastal (30.33%). This relatively even spread suggests that small firms serve regional needs across different parts of the country but do not have as high a presence in Nairobi/Central (20.32%) (Ouma *et al*., 2006; Samuel, 2022; Tarus, 2019).

In contrast, large and medium firms are far less common, with large firms accounting for only 21.89% of the total and medium firms for 10.94%. Large firms are most concentrated in Nairobi/Central (25.63%), possibly due to better infrastructure, access to markets, and availability of skilled labor in urban areas. Similarly, medium firms are relatively scarce and distributed more sparsely across all regions, with slightly higher percentages in Eastern/Northeastern (10.00%) and Rift Valley (10.12%) (De Groote & Kimenju, 2012; Samuel, 2022; Statista, 2024).

Overall, the data suggests that micro and small-scale milling operations dominate the maize milling sector, especially in rural and less urbanized regions. Large-scale operations are concentrated mainly in Nairobi/Central, which aligns with its status as a major commercial and logistical hub. These patterns highlight the importance of micro and small firms in ensuring maize milling accessibility across the country, while larger firms are better positioned in urban centres for efficiency and scale advantages.

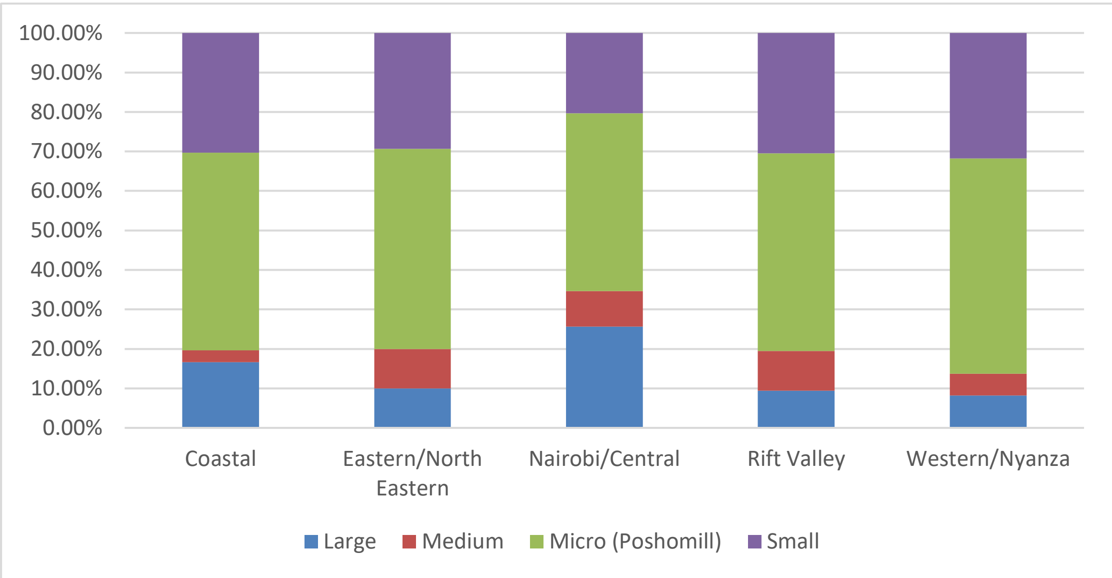

Figure 5; Distribution of maize milling firms in Kenya

The highest proportion of the respondents who participated in the personal interviews and online surveys were top-level management including managers (36.79%), directors (14.15%) and owners (10.38%). Additionally, middle-level management employees including supervisors and production leads represented 8.49% and 7.55% respectively. Other respondents included accountants, machine operators, mechanical engineers, salespersons, and secretaries, respectively.

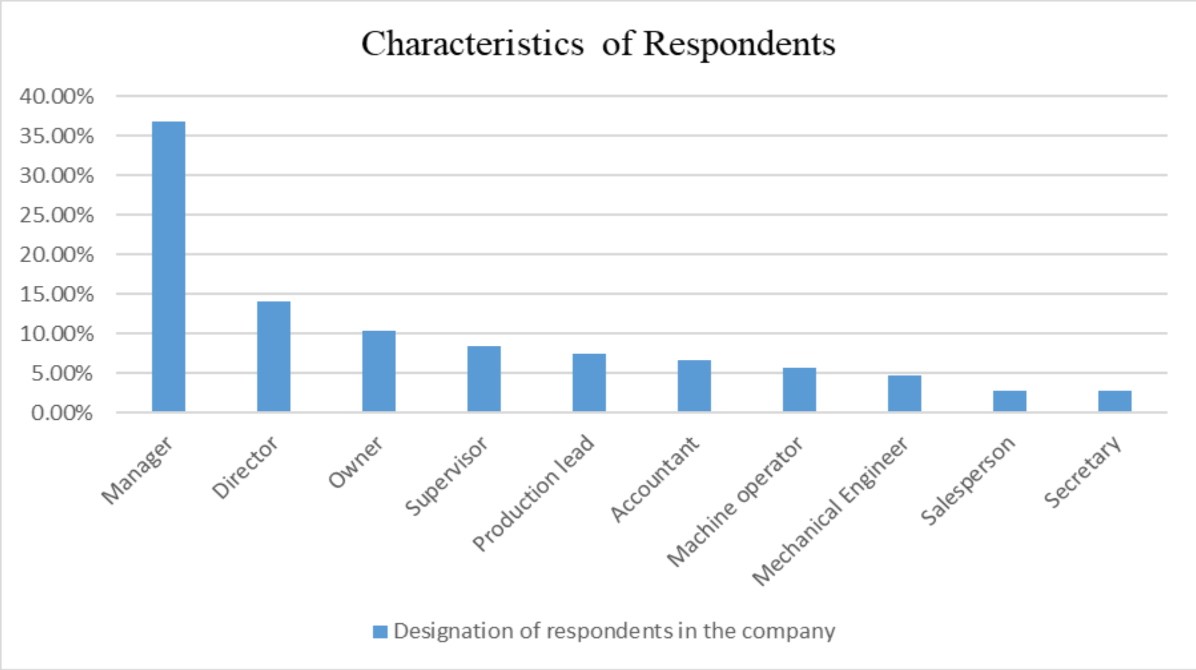

Figure 6: Designation of respondents in the company

4.3 Characteristics and nature of maize mills in Kenya

4.3.1 Firm size, milling technology used and employee skill level.

The maize milling firms exhibit a diverse range of sizes based on their daily production capacity (Enzama *et al*., 2017). Out of the 106 sampled firms, the largest group comprises 40.75%, consisting of micro (posho-mill) firms with a daily capacity of less than 10 MT/day. 26.42% of the surveyed firms were small-scale, producing between 11 and 20 MT/day. In contrast, 21.89% were large-scale firms with a capacity exceeding 50 MT/day, while 10.94% were medium-scale firms, operating within the range of 21 to 50 MT/day.

Figure 7 reveals distinct trends in milling technology usage across firm sizes. Large firms show a strong preference for advanced technologies, with none utilizing Hammermill, Colloidal Mill, or Attrition Mill under the Local sourcing strategy. Instead, 50% use Roller Mill, and the remaining 50% employ Automated PLC systems. In the Combined strategy, the trend shifts slightly, with 12.50% using Roller Mill and 87.50% opting for Automated PLC. This pattern reflects the need for large firms to operate at high efficiency and consistency to meet greater demand. The financial capability of these firms also allows them to invest in sophisticated technologies like Automated PLCs, which enhance productivity and reduce the need for manual oversight (Cappelli *et al*., 2020).

Medium-sized firms exhibit a comparable technology preference, with no usage of Hammermill, Colloidal Mill, or Attrition Mill. Here, 87.50% use Roller Mill, while 12.50% utilize Automated PLC under the Local sourcing strategy. Medium firms balance the need for efficiency with financial feasibility, with Roller Mills providing an affordable, efficient option (Enzama *et al.*, 2017; Khamila *et al.*, 2019). However, they sometimes adopt Automated PLCs to handle diverse input sources, where consistency across maize qualities becomes more important.

Micro firms (posho mills) show a broader range of milling technologies under the Local sourcing strategy, with 54.55% using Hammermill, 9.09% using Colloidal Mill, 27.27% utilizing Attrition Mill, and 9.09% employing Roller Mill. The Combined percentages show slight variations, with 36.96% using Hammermill, 8.70% opting for Colloidal Mill, and 30.43% preferring Attrition Mill. This diversity suggests micro firms, often operating on limited budgets and serving local markets, rely on simpler, cost-effective machines like Hammermills and Attrition Mills that suit small-scale production (Nasir, 2005). The variety also indicates efforts by some micro firms to cater to specific consumer preferences or diversify products within financial constraints.

Small firms, under the Local sourcing strategy, show more diversity, with 38.10% using Hammermill, 14.29% using Colloidal Mill, 14.29% opting for Attrition Mill, 4.76% utilizing Roller Mill, and 19.05% employing Automated PLC. Small firms prioritize affordability, making Hammermills an attractive choice for moderate-scale production (Nasir, 2005), though the diversity suggests an attempt to manage production technology within their financial means.

Overall, the figure 7 illustrates that larger firms tend to favor Automated PLC technologies due to their need for high productivity and output consistency, while smaller firms show a clear preference for Hammermill technology, which is both affordable and straightforward to use. The impact of sourcing strategies is also evident, as the differences between Local and Combined sourcing percentages highlight how these strategies influence milling technology choices. This comprehensive view reveals that larger firms are more likely to adopt advanced milling technologies, while smaller firms typically rely on traditional methods. This is consistent with (Parvand & Rasiah, 2022) who found that firm's size is a significant factor influencing the milling technology used by firms. Understanding these dynamics offers valuable insights for guiding business decisions and policy formulations within the milling sector.

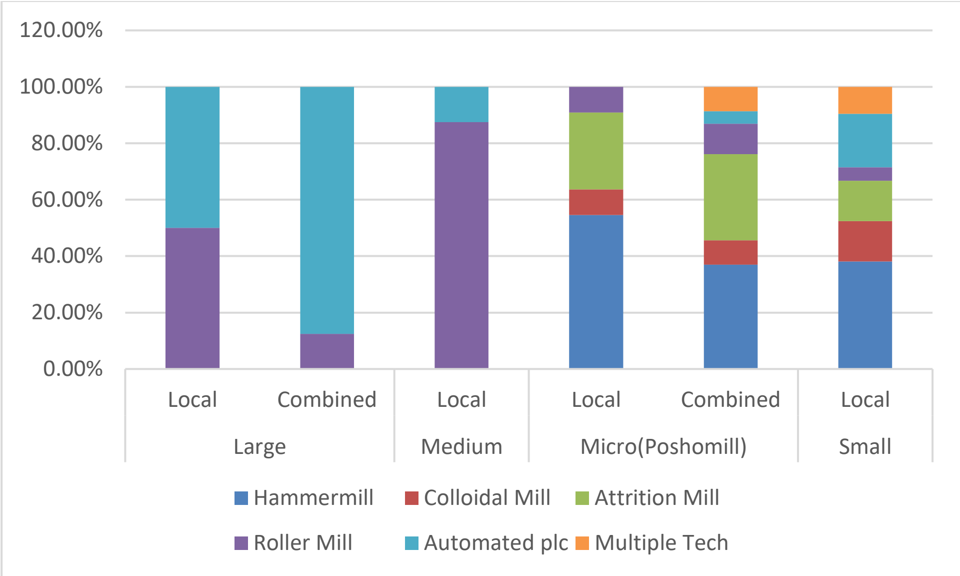

Figure 7; Milling technology used by firms according to firm size and maize sourcing strategy

The distribution of employee skill levels (Highly Skilled, Semi-skilled, Skilled, and Unskilled) varied across different firm sizes and maize sourcing strategies (Figure 8 below).

For large firms, the skill distribution differs between Local and Combined sourcing strategies. Under the Local sourcing strategy, most employees (46.15%) are Skilled, followed by Unskilled (30.77%), Highly Skilled (13.38%), and Semi-skilled (7.69%). This pattern suggests that large firms sourcing maize locally prioritize skilled labour but also rely significantly on unskilled workers. In the Combined strategy, the Skilled category is even more prominent, accounting for 62.50% of the workforce, with a decrease in Unskilled workers (18.75%) and minor percentages for Highly Skilled (12.50%) and Semi-skilled (6.25%) workers. This shift implies that Combined sourcing in large firms may correlate with a higher demand for skilled labor to handle the complexity of diversified sourcing.

Medium firms also emphasize Skilled labor, particularly under the Local sourcing strategy, where Skilled employees constitute 45.45% of the workforce. The second-largest group is Highly Skilled workers at 27.27%, followed by Unskilled (18.18%) and Semi-skilled (9.09%) workers. This distribution highlights a notable presence of both Skilled and Highly Skilled employees, indicating that medium firms may prioritize advanced skills to support their operations, even with local sourcing.

Micro firms, under the Local sourcing strategy, show a distinctive trend with 50% of employees being Semi-skilled, 30% Skilled, and 20% Unskilled, with no representation of Highly Skilled workers. This breakdown suggests that micro firms rely heavily on semi-skilled labour for local operations, with little to no demand for highly skilled employees. However, with Combined sourcing, the emphasis on Semi-skilled workers increases further to 61.54%, while Skilled workers account for 25.64% and Unskilled workers 12.82%. The absence of Highly Skilled labour indicates that micro firms generally focus on practical skills relevant to smaller-scale, localized operations.

Small firms sourcing locally demonstrate a similar pattern to micro firms, with 56.52% of employees being Semi-skilled, followed by Skilled (30.43%) and Unskilled (13.04%) workers, and no Highly Skilled workers. This distribution suggests that small firms, like micro firms, prefer Semi-skilled labour, which likely aligns with the simpler operational requirements of small-scale firms. The lack of Highly Skilled workers highlights a practical approach in staffing, focused more on operational roles than specialized skills.

In summary, larger firms tend to employ more Skilled and Highly Skilled workers, particularly when using Combined sourcing strategies, which may reflect the complexity and scale of their operations. In contrast, micro and small firms rely heavily on Semi-skilled labour, especially under local sourcing, indicating a preference for practical skills suited to smaller-scale production. This table underscores how firm size and sourcing strategy can shape the skill composition of the workforce, with larger firms employing more skilled labor to manage advanced and diversified operations while smaller firms prioritize semi-skilled roles that match their scale and operational needs. This resonates with findings by Khamila *et al*. (2019) and Enzama *et al*. (2017) that large-scale mills used more sophisticated milling technology which required skilled personnel.

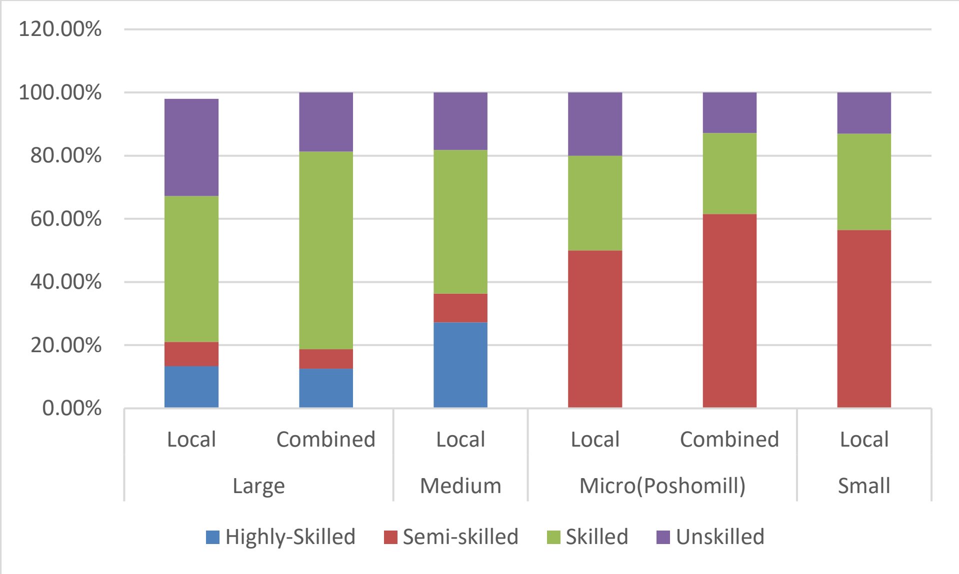

Figure 8; Distribution of employee skill level according to firm size and maize sourcing strategy

4.3.2 Duration in business, production capacity and total number of employees

The results of the ANOVA, as presented in the table 3 below, indicate that the model explaining daily production capacity is statistically significant, with an F-statistic of 5.38 and a p-value of 0.0002. This suggests that the independent variables (firm size and maize sourcing strategy) collectively account for a significant portion of the variability in daily production capacity, with an R-squared value of 0.5121, indicating that approximately 51% of the variance in production capacity can be explained by these factors.

Specifically, firm size had a significant effect on daily production capacity, as indicated by an F-statistic of 3.34 and a p-value of 0.0224. This highlights that different sizes of firms operate at varying levels of production capacity. Conversely, the maize sourcing strategy did not demonstrate a significant impact, with an F-statistic of 0.04 and a p-value of 0.8474, suggesting that sourcing strategies alone do not explain differences in daily production capacity. The interaction between firm size and maize sourcing strategy yielded a significant result, with a p-value of 0.0324. This interaction indicates that the effect of firm size on production capacity varies depending on the sourcing strategy employed.

Table 3; ANOVA and Post Hoc Analysis of Daily Production Capacity by Firm Size and Maize Sourcing Strategy

Dependent Variable	**Source**	**Partial SS**	**df**	**MS**	**F**	**P**	**R-squared**
Daily Production Capacity	Model	1,483,000	5	296,600	5.38	0.0002**	0.5121
	Firm Size	148,600	3	49,533.33	3.34	0.0224**	
	Maize Sourcing Strategy	552,482.68	1	552,482.68	0.04	0.8474	
	Firm Size # Maize Sourcing Strategy	7,215.38	1	7,215.38	0	0.0324**	
	Residual	399,200	100	3,992			
	Total	1,883,000	105	17,933.33			

(I) Firm Size and Maize Sourcing Strategy	**(J) Firm Size and Maize Sourcing Strategy**	**Mean Difference (I-J)**	**Std. Err.**	**95% Confidence Interval Lower Bound**	**95% Confidence Interval Upper Bound**
Large Firm- Local Sourcing	Large Firm-Combined Sourcing	1,887.50**	488.85	1,065.95	3,840.95
Micro Firm- Local Sourcing	Micro Firm-Combined Sourcing	810.57**	682.03	691.26	1,512.01

**, significance level at 5%

The post hoc pairwise comparisons further illuminate these findings, particularly regarding large firms sourcing locally versus those employing a combined sourcing strategy, with a mean difference of 1,887.50. This significant difference indicates that larger firms utilizing diversified sourcing strategies can enhance their production capacity. The ability to source from multiple channels likely mitigates risks associated with supply shortages, providing larger firms with a more reliable flow of raw materials necessary for uninterrupted production (Khamila *et al*., 2019; Ngotho, 2023; Otieno, 2023).

Similarly, the significant mean difference of 810.57 for micro firms sourcing locally and through combined methods suggests that sourcing strategies impact their production capacity as well. However, the effects are less pronounced than in larger firms, possibly due to limited resources and operational flexibility. This reflects a broader trend in the industry where larger firms are better positioned to navigate market challenges and optimize production through varied sourcing strategies (Ngotho, 2023).

The analysis of firm age reveals important distinctions based on firm size and sourcing strategy, with the ANOVA model achieving a moderate R-squared of 0.547 and a statistically significant p value of 0.0065 (Table 4). This suggests that approximately 55% of the variation in the age of the firms is explained by these factors. Notably, firm size alone is statistically significant in this model (p = 0.0036), indicating that firm size independently relates to differences in the years firms have been in operation. This significance implies that larger firms, on average, may have different operational timelines compared to smaller firms.

Table 4; ANOVA and Post Hoc Analysis of Age of the Firm by the Firm Size and Maize Sourcing Strategy

Dependent Variable	**Source**	**Partial SS**	**df**	**MS**	**F**	**P**	**R-squared**
Age of Firm	Model	762.71	5	152.54	3.45	0.0065**	0.547
	Firm Size	188.10	3	396.03	2.11	0.0036**	
	Maize Sourcing Strategy	34.35	1	34.35	0.18	0.6696	
	Firm Size # Maize Sourcing	26.85	1	26.85	0.14	0.7060	

	Strategy				
	Residual	233.06	100	2.33	
	Total	995.77	105	9.48	

(I) Firm Size and Maize Sourcing Strategy	**(J) Firm Size and Maize Sourcing Strategy**	**Mean Difference (I-J)**	**Std. Err.**	**95% Confidence Interval**	
				Lower Bound	**Upper Bound**
Large Firm-Local Sourcing	Large Firm-Combined Sourcing	18.00**	16.37	15.43	21.43
Micro Firm-Local Sourcing	Micro Firm-Combined Sourcing	14.46**	13.94	13.19	22.12

**, significance level at 5%

The post hoc pairwise comparisons further explain these results, particularly the mean difference of 18 years between large firms that rely solely on local sourcing and those using combined sourcing. This contrast could reflect the distinct operational strategies that firms adopt over time, with some potentially benefiting from combined sourcing to buffer against supply chain disruptions. Large firms might thus opt for combined sourcing after establishing a solid local supplier network, diversifying as they grow and seek operational resilience (Otieno, 2023).

For micro firms, the mean difference of 14.46 years between locally sourcing firms and those with combined sourcing could suggest a nuanced pattern where younger firms may explore varied sourcing earlier in their development. Alternatively, the need to adopt diverse sourcing methods might arise based on market pressures or supply constraints, with newer or smaller firms aiming to stabilize their supply chain by combining sources (Andae, 2022).

In terms of number of employees, the results indicate a significant relationship with firm size and the interaction between firm size and maize sourcing strategy, achieving an R-squared value of 0.5351 (Table 5). This suggests that approximately 53% of the variation in the number of employees is accounted for by these factors. The overall model is statistically significant (p = 0.0000), indicating that at least one of the predictors is associated with the total number of employees in the firms surveyed.

Among the factors examined, firm size is statistically significant (p = 0.0000). This result suggests that larger firms tend to employ more individuals compared to smaller firms, reflecting the general trend in which larger organizations require more personnel to manage extensive operations and resources effectively.

The interaction term between firm size and maize sourcing strategy also shows statistical significance (p = 0.0247). This finding implies that the impact of firm size on employee numbers is influenced by the firm's sourcing strategy. It indicates that the combination of these two factors is critical in understanding employment patterns within the firms.

Table 5; ANOVA and Post Hoc Analysis of Number of Employees by the Firm Size and Maize Sourcing Strategy

Dependent Variable	**Source**	**Partial SS**	**df**	**MS**	**F**	**P**	**R-squared**
Total Number of Em-	Model	255.53	4	63.88	7.38	0.0000**	0.5351

ployees						
	Firm Size	329.09	3	109.70	9.34	0.0000**
	Maize Sourcing Strategy	58.31	1	58.31	0.02	0.8824
	Firm Size # Maize Sourcing Strategy	74.09	1	74.09	3.34	0.0247**
	Residual	202.43	96	2.11		
	Total	457.96	100	4.58		

				95% Confidence Interval	
(I) Firm Size and Maize Sourcing Strategy	**(J) Firm Size and Maize Sourcing Strategy**	**Mean Difference (I-J)**	**Std. Err.**	**Lower Bound**	**Upper Bound**
Large Firm-Local Sourcing	Large Firm-Combined Sourcing	105**	72.83	-69.57	-49.56
Micro Firm-Local Sourcing	Micro Firm-Combined Sourcing	58.88**	18.33	12.51	65.26

**, significance level at 5%

The post hoc pairwise comparisons reveal specific insights regarding the mean differences in employee numbers. For instance, the significant mean difference of 105 employees between large firms sourcing locally and those using a combined sourcing strategy suggests that larger firms leveraging diversified sourcing may have larger workforces. This can be attributed to the need for greater operational capacity and efficiency when sourcing from multiple suppliers, thereby requiring more staff to manage these complex processes (Khamila *et al*., 2019).

Similarly, the mean difference of 58.88 employees for micro firms between local sourcing and combined sourcing highlights that even at this smaller scale, sourcing strategies can significantly affect employment levels. This may reflect how micro firms utilize combined sourcing to enhance their operational resilience and potentially support growth, even if they do not employ as many people as larger firms (Mugyenyi *et al*., 2020)..

4.4 Sources of maize

The figure 9 below presents the distribution of maize sourcing locations among firms in various regions of Kenya. Analysing the results reveals distinct trends across different firm sizes.

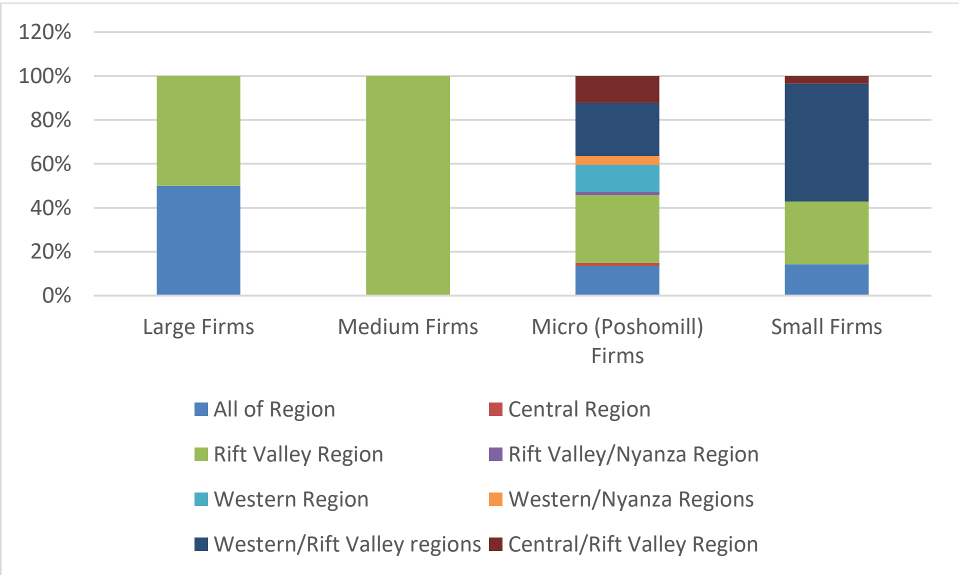

Figure 9; Domestic sources of maize

Large firms predominantly source maize from two regions: Central Region and Rift Valley Region, each accounting for 50% of their sourcing. This suggests that large firms have the capacity to source from well-established regions known for maize production, allowing them to maintain significant operational efficiency. Notably, they do not source maize from any other regions, indicating a highly concentrated sourcing strategy (Abate *et al*., 2015; Tarus, 2019).

In contrast, medium firms exclusively rely on the Rift Valley Region for their maize supply, with 100% of their sourcing originating from this area. This singular sourcing approach may reflect a strategic focus on a specific region recognized for its maize productivity. According to Ndwiga *et al*. (2013), the absence of maize sourcing from other regions could indicate a risk, as reliance on a single source may expose these firms to supply disruptions.

Micro firms show a more diversified sourcing approach compared to their larger counter-parts. Their sourcing percentages vary across several regions: Rift Valley Region (31.08%) is the most significant sourcing area, followed by Central Region (13.51%) and Western Region (12.16%). Other regions, such as Western/Nyanza Regions (4.05%) and Central/Rift Valley Region (24.32%), also contribute to their sourcing mix. This diversity allows micro firms to mitigate risks associated with supply shortages in any single region, which is crucial for their operational sustainability (Wekesa *et al*., 2003).

Small firms display a mixed sourcing pattern. A notable 53.57% of their maize is sourced from the Western/Rift Valley Region, suggesting a preference for a combination of regions known for maize production. However, they also exhibit sourcing from the Central/Rift Valley Region (3.57%). The sourcing strategies of small firms might reflect both an attempt to balance supply risks and constraints in operational capabilities compared to larger firms (Wekesa *et al*., 2003).

The results indicate that larger firms tend to consolidate their sourcing strategies in a few productive regions, while micro and small firms adopt a more diversified approach to mitigate risks. The reliance of medium firms on a single region underscores potential vulnerabilities in their supply chain, while micro firms' varied sourcing can enhance their resilience. In a context where maize supply can be affected by environmental factors, economic conditions, and regional agricultural performance, firms that diversify their sourcing locations are better positioned to maintain operational continuity.

In terms of imports, figure 10 shows that large firms exclusively source their maize from the world market, with 100% of their imported maize coming from international suppliers. This reliance on the global market suggests that large firms have the resources and logistical capabilities to import from distant sources, likely providing access to greater quantities and potentially more stable supply chains. By depending solely on the world market, large firms position themselves to avoid regional supply disruptions that may affect closer markets (FAO, 2022).

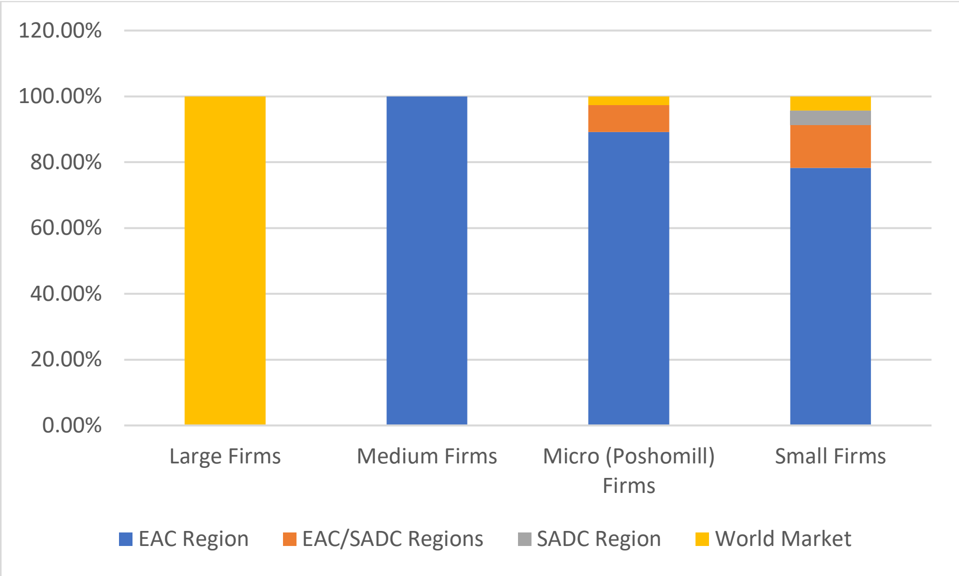

Figure 10; Import sources of maize

In contrast, medium firms source all their imported maize from within the EAC region, with 100% of their supply coming from neighbouring countries. This localized sourcing may reflect cost considerations, regulatory preferences, or logistical constraints. The reliance on a single regional source could expose medium firms to regional market fluctuations or policy changes, yet it may also allow them to benefit from reduced transportation costs and streamlined import processes within the EAC (Abodi *et al*., 2021; Nyoro & Kirimi, 2004; Owino & Waweru, 2022).

Micro (posho mill) firms display a predominantly regional sourcing strategy, with 89.19% of their imported maize coming from the EAC. A small percentage (8.11%) of micro firms' source from both the EAC and SADC regions, while 2.70% rely on the world market. This distribution indicates that, while most micro firms prefer nearby sources due to lower costs and ease of access, a few also extend their sourcing to larger markets for added flexibility. The limited percentage of micro firms sourcing from the world market suggests that only a minority have the resources to manage the complexities of international imports (Owino & Waweru, 2022).

Small firms similarly source the majority (78.26%) of their imported maize from the EAC, showing a preference for regional supply. However, a notable portion of small firms' source from the combined EAC/SADC regions (13.04%) and smaller percentages rely on the SADC region alone (4.35%) or the world market (4.35%). This diversified approach indicates that small firms, while predominantly relying on nearby regions, are more willing than micro firms to explore additional markets, likely as a strategy to manage potential supply risks or access better prices (Biswal *et al*., 2022).

4.5 Variable costs incurred in purchasing and processing maize.

4.5.1 Variable costs incurred in purchasing locally produced maize.

Figure 11 provides an overview of the variable costs incurred by firms when purchasing maize locally, organized by cost type and firm size. Each percentage represents the proportion of firms within each size category that incur a particular cost. The data illustrates the diversity in cost structures across large, medium, small, and micro (posho mill) firms, revealing how operational scale influences cost burden and management.

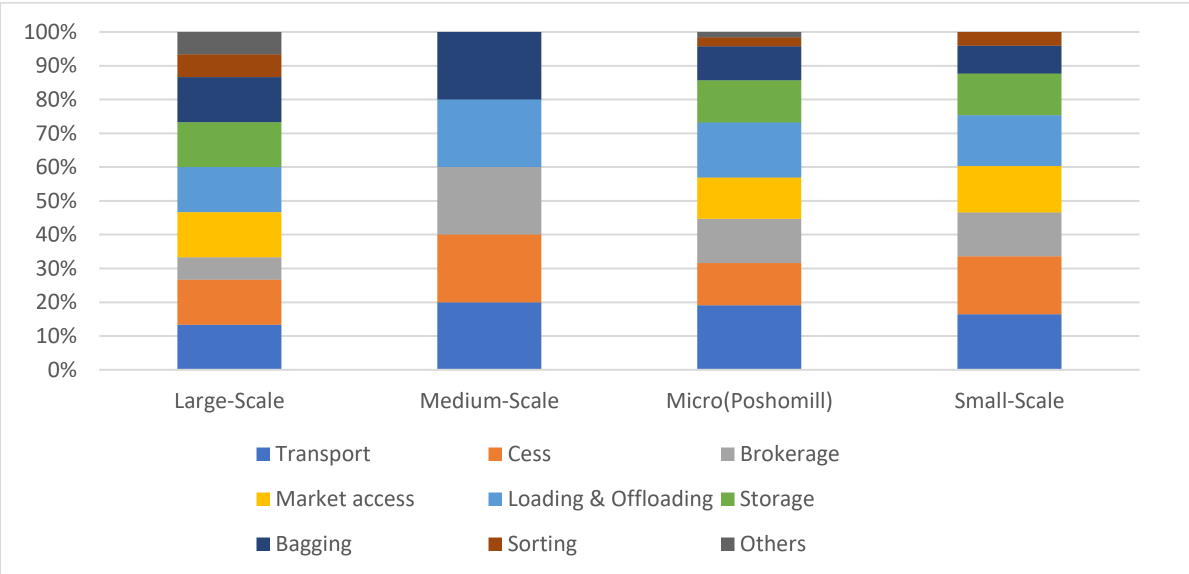

Figure 11; Variable costs incurred in purchasing local maize

Large-scale firms consistently incur nearly all listed variable costs, with 100% of them paying for transport, cess, market access, loading and offloading, storage, and bagging. Additionally, 50% of large firms incur brokerage and sorting costs and a similar proportion report other unspecified cost. The extensive cost structure reflects the scale and complexity of large firms' procurement processes, as well as their need to manage and secure high volumes of maize, which may require additional logistical and handling expenses. This is consistent with Savić *et al*. (2020) who indicate that transport costs account for a large proportion of the total variable costs of purchasing maize among large firms.

Medium-scale firms also consistently incur transport, cess, brokerage, and bagging costs (100% each), with loading and offloading as another common expense (100%). However, unlike large firms, medium firms report no costs for market access, storage, sorting, or other miscellaneous categories, suggesting that medium firms focus on essential procurement costs while minimizing expenses related to market accessibility and storage. This may indicate a more streamlined approach to sourcing, with less emphasis on activities that might involve third-party handling or longer storage times. Similarly, Ogada *et al*. (2018) reports that third-party handling increases the total cost of maize distribution by 6%, hence most firms prefer more streamlined maize sourcing strategies.

Micro (posho mill) firms incur variable costs across a wide range of categories but at lower frequencies compared to large and medium firms. Transport (98.6%) and loading/offloading (83.6%) remain the most common expenses, while cess (64.4%), brokerage (67.1%), market access (63%), storage (64.4%), and bagging (52.1%) are also notable costs but are less consistently reported. Sorting (13.6%) and other unspecified costs (8.2%) are minimal among micro firms, reflecting a cost-conscious approach to sourcing. Their lower scale of operations likely reduces the need for extensive storage and other auxiliary services, keeping their procurement focused on core logistics. Similarly, a study by Kabwe and Zulu (2017) indicates smaller firms operating on a lower scale prefer cost- conscious sourcing approaches to maximize their incomes.

Small-scale firms show a moderate frequency across most cost categories, with transport (88.9%) and cess (92.6%) being nearly universal costs, while loading/offloading (81.5%) and brokerage (70.4%) are also common. Fewer small firms incur storage (66.7%), bagging (44.4%), and sorting (22.2%) costs, with no firms reporting other miscellaneous costs. Small firms incur more costs than micro firms but do not have the comprehensive cost structure of large firms, indicating a middle-ground approach where they incur essential sourcing costs without extensive logistical add-ons. This is consistent with a study by Mahdi (2012) which shows that small-scale firms prefer cost- effective methods of sourcing raw materials to ensure sustainability of operations in the long-run.

The data suggests that large-scale firms incur the most comprehensive set of costs due to their complex sourcing needs and capacity to handle these expenses. Medium firms, in contrast, focus on essential logistics costs and avoid costs related to additional services such as storage and sorting. Micro and small firms are more selective with variable costs, minimizing auxiliary expenses to keep operations economical. This cost-saving approach aligns with their smaller operational scales and more limited resource availability. The breakdown highlights how firm size dictates both the scope of operations and the extent of costs involved in maize sourcing.

4.5.2 Variable costs incurred in maize importation.

The table provides an overview of the variable costs incurred by firms when importing maize, broken down by cost type and firm size. Each percentage represents the proportion of firms within each size category that incur a specific cost associated with importing maize. The data highlights the consistency of import-related costs across large, medium, small, and micro (posho mill) firms, reflecting the standardized expenses associated with cross-border transactions.

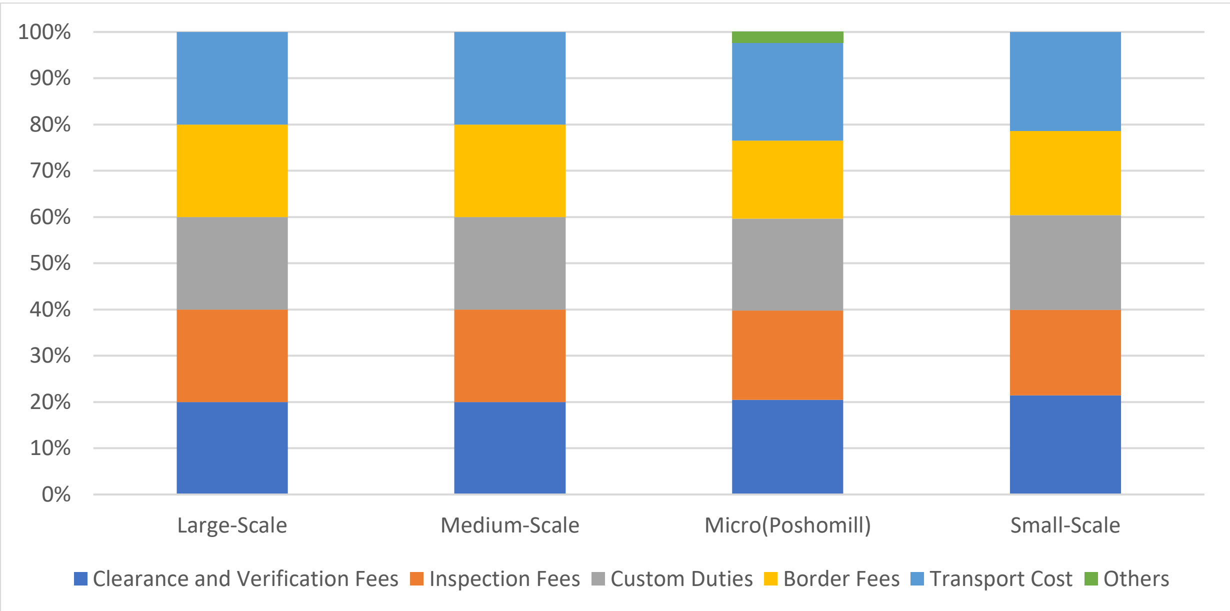

Figure 12; Variable costs incurred in maize importation

Large-scale and medium-scale firms uniformly incur all primary import costs, with 100% of firms in these categories paying for clearance and verification fees, inspection fees, customs duties, border fees, and transport costs. Neither group incurs additional miscellaneous costs in this category, indicating a streamlined import process focused on essential regulatory and logistical expenses. This uniform cost pattern among larger firms suggests that they follow established import protocols, likely due to the volume of maize they handle and the complexity of their import logistics. This is like results obtained by Masinde (2015) who found that firms that import maize in large volumes incur large import costs owing to clearance and verification fees, inspection fees, custom duties, long overhaul costs and border fees.

Micro (posho mill) firms also report high frequencies across these import cost categories, though slightly lower than larger firms. Specifically, 91.89% of micro firms incur clearance and verification fees, 86.49% pay inspection fees, and 89.19% pay customs duties. Border fees are incurred by 75.68% of micro firms, while transport costs are nearly universal (94.59%). Around 10.81% of micro firms report additional unspecified import costs, indicating that smaller firms may occasionally face unique or auxiliary fees outside the standard import requirements. This variation may be due to differing regulatory compliance processes or operational constraints specific to smaller firms. This is similar to Masinde (2015), who found that smaller scale firms import their maize through cross border trade (which is largely unreported) hence skipping most of the regulatory compliance processes.

Small-scale firms similarly report high frequencies for each primary cost, with 91.67% incurring clearance and verification fees and transport costs, 79.17% paying inspection fees, and 87.50% paying customs duties. Border fees are incurred by 77.78% of small firms, with no firms reporting additional miscellaneous costs. These figures indicate a more streamlined cost structure compared to micro firms, though still reflecting the standardized import expenses common across all firm sizes (Abodi *et al*., 2021; Short *et al*., 2019).

In summary, large and medium-scale firms face uniform import costs across all major categories, likely due to their adherence to standardized import practices. Micro and small-scale firms experience slight variability in these costs, particularly for inspection, customs, and border fees, potentially due to less frequent or lower-volume import activities. The differences in cost incidence across firm sizes may reflect scale-related differences in logistics, regulatory processes, and operational flexibility during maize importation.

4.5.3 Variable costs incurred in processing of maize.

Figure 13 below summarizes the variable costs involved in the processing of maize for firms of different sizes, including labour, packaging, fuel, utilities, and distribution. The percentages indicate the proportion of firms within each size category that incur these costs, providing insights into the cost structure across large, medium, small, and micro (posho mill) firms.

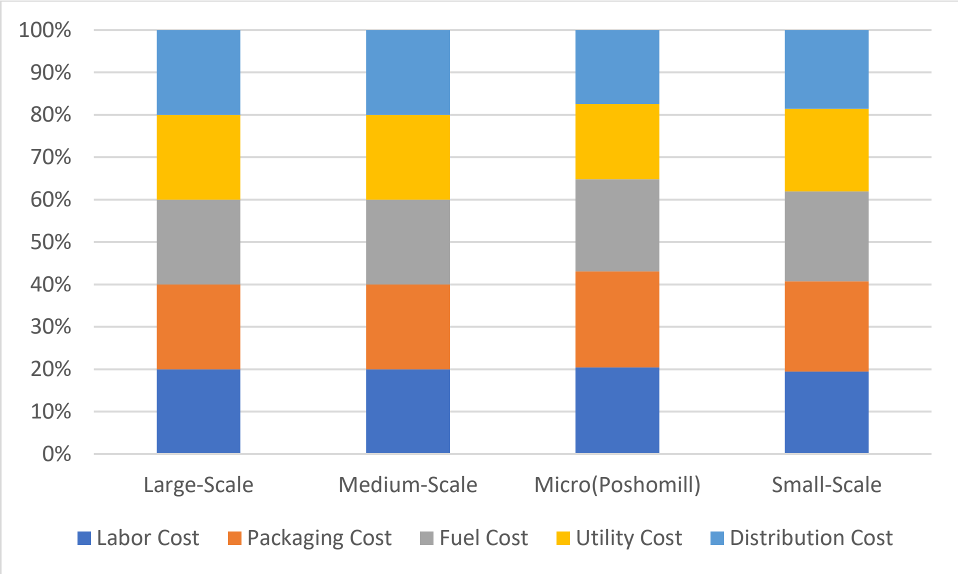

Figure 13; Variable costs incurred in processing of maize

Large and medium-scale firms consistently report incurring 100% of all processing costs. This reflects the standardized requirements for these larger firms to maintain labour, packaging, fuel, utility, and distribution expenditures, likely due to their high production capacities and established distribution networks. For these firms, the uniformity in costs suggests well-defined operational processes to meet high output demands, which inherently involve all aspects of the production and distribution chain. These results are consistent with those of Arndt *et al*. (2008) who found that large firms in Mozambique incurred high production costs to meet high output demands.

Micro (posho mill) firms exhibit slightly lower frequencies across these cost categories, with 84.93% incurring labour costs, 94.52% incurring packaging costs, and 90.41% incurring fuel costs. Utility costs are lower, incurred by 73.97% of micro firms, and distribution costs are the least frequent at 72.60%. The variation in incurred costs suggests that micro firms may have more flexible or simplified processing structures compared to larger firms, potentially due to lower production volumes or localized distribution practices that reduce reliance on certain costs like utilities and distribution. Similarly, Ulrich and Vasudevan (2006) indicate that smaller firms mostly use centralized distribution strategies to cut down distribution costs.

Small-scale firms report a similar pattern, with 81.48% incurring labor and utility costs, 88.89% incurring both packaging and fuel costs, and 77.78% incurring distribution costs. These slightly lower frequencies, particularly in utility and distribution costs, suggest that small-scale firms may also adapt their operations based on available resources or local market needs, resulting in a less comprehensive cost structure compared to large and medium-scale firms. The results obtained were consistent with those of Seleka *et al*. (2011) who found utility cost (electricity, depreciation, repair, and maintenance) to contribute only 5.19% of the total costs of production for small firms.

In summary, while large and medium firms incur all major processing costs consistently, reflecting a more comprehensive operational structure, micro and small firms demonstrate some cost variability. This pattern could be attributed to differences in production scale, resource availability, and market reach, with smaller firms potentially adopting cost-saving practices or more localized operations to manage expenses in the maize processing chain.

4.6 Major challenges affecting maize milling firms.

Figure 14 outlines the challenges encountered by firms of varying sizes, including large, medium, small, and micro (posho mill) firms. The primary issues listed include financial constraints, political uncertainties, price fluctuations, high import duties, and market access limitations.

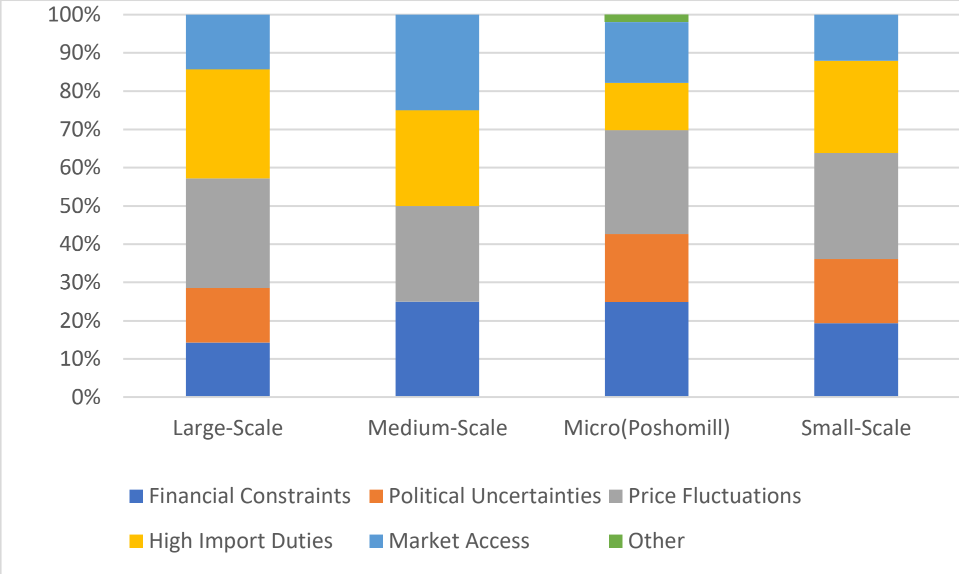

Figure 14; Major challenges affecting maize milling firms in Kenya

Large-scale firms report price fluctuations and high import duties as the most common challenges, with 100% of these firms facing both issues. This reflects the sensitivity of large firms to changes in input costs and the impact of import regulations on their operations, particularly given the scale of their imports. Additionally, 50% of large firms report challenges related to financial constraints, political uncertainties, and market access. The variability here suggests that while these factors impact some large firms, others may have more established financing, political resilience, or stronger market positions. These results are consistent with the findings of Mmeri *et al.* (2023), who found that political uncertainty has a negative significant effect on large scale private domestic investments in Kenya.

For medium-scale firms, financial constraints, price fluctuations, high import duties, and market access are universal challenges, affecting 100% of firms in this category. This consistent reporting points to these as critical barriers for medium firms, likely due to their position in the market where they may be too large for local support systems yet not as resilient as large firms. Similarly, Otieno (2023) indicates that delayed payments led to imbalances of maize stock in the larger firms thus forcing some to cut back on operations due to the lack of financial muscles to import grain amid shortage of maize in the country. Interestingly, political uncertainties do not appear to be a significant challenge for medium firms, possibly due to less exposure to political risks in their sourcing or distribution channels.

Micro (posho mill) firms face a range of issues, with 93.33% reporting price fluctuations, 85.33% experiencing financial constraints, and 61.33% noting political uncertainties. High import duties affect 42.67% of micro firms, while market access is challenging for 54.67% of them. The distribution of challenges among micro firms suggests they are highly sensitive to financial, market, and political conditions, likely due to their smaller size and limited ability to absorb market shocks. Similarly, Andae (2022) illustrates that nearly half of the small and micro maize milling firms had to shut down in 2022 due to maize supply and financial shocks. Additionally, a small proportion (6.67%) of micro firms cite "other" challenges, indicating unique issues not captured in the primary categories.

Small-scale firms report similar challenges, with 92% affected by price fluctuations and 80% by high import duties. Financial constraints and political uncertainties are also significant, impacting 64% and 56% of small firms, respectively. Market access is a challenge for 40% of small firms. These responses highlight that small firms face a multi-faceted set of challenges, particularly with financial stability and market volatility. Their costs related to imports and market access issues may be less easily absorbed due to limited operational scale (Abodi *et al*., 2021; Short *et al*., 2019).

In summary, price fluctuations and high import duties are pervasive challenges across all firm sizes, but the financial impact and resilience to these issues vary by scale. Medium firms report a broader set of universal challenges, whereas micro and small firms face a mix of financial, political, and market access constraints, highlighting the importance of tailored support for firms at different scales.

4.7 Factors influencing firm's decision to import or purchase locally produced maize.

4.7.1 Tests for multi-collinearity between variables

First, tests were conducted to determine whether the variables included in the bivariate probit model were suitable. According to Midi *et al*. (2010), multi-collinearity occurs when two or more variables are highly correlated to each other, such that they do not provide unique and independent information in the model. A high degree of correlation can therefore cause problems in the fitting and interpretation of a regression model. The variance inflation factor was used to evaluate whether multi-collinearity existed between the variables in the model. The results of the test are presented in table 6 below.

Table 6; Multi-collinearity diagnosis results for Variance Inflation factor

Variable	**VIF**

Number of years in operation	1.35
Total number of employees	1.41
Employee skill Level	1.31
Government subsidies	1.36
Average number of sales per month	1.23
Purchases of maize through NCPB	1.31
Daily production capacity	1.35
Milling technology used	1.28
Import duties	1.45
Tax waivers	1.41
Import Licenses	1.62
Mean VIF	**1.37**

The results indicate the VIF of the individual variables used in the model range between 1.23(for Average sales per month) to 1.62 (for import licenses). The average VIF for all the variables was 1.37. According to Shrestha (2020), a VIF of 1 indicates that there is no collinearity between the explanatory variables in the model, a VIF between 1 and 5 indicates moderate correlation that does not require attention whereas a VIF of more than 5 indicates severe correlation in which case parameter estimates will likely be unreliable. Similarly, Sparkman *et al*. (1979) suggests that a VIF of less than 10 is indicative of inconsequential collinearity. Based on these arguments, it was concluded that no collinearity existed between the explanatory variables used in the model since all the VIF's were found to be less than 10.

4.7.2 Test for model specification

A link test was performed to test whether the model was correctly specified. According to Siegel and Wagner (2022), model misspecification refers to all the ways in which a linear regression model would fail to represent the situation. This would result in biased parameter estimates and inconsistent standard errors. The results of the link test are shown in table 7 below.

Table 7; Model specification diagnosis results for link test

Miller's decision	Coefficient	Standard Error	P Value	Confidence Interval	
Prediction	1.709	1.116	0.129	-0.504	3.923
Prediction squared	-0.227	0.356	0.524	-0.933	0.479
Constant	-0.527	0.842	0.533	-2.198	1.144

Note: Number of observations = 104, F (2,101) = 45.88, Prob > F = 0.000, R squared = 0.4760 Adjusted R squared = 0.4656, Root MSE = 0.36392

The results indicate a prediction coefficient of 1.709 and a prediction squared coefficient of 0.356. According to Pregibon (1980), the model is correctly specified if the prediction squared has no explanatory power. Based on this, it was concluded that the model was correctly specified since it had no explanatory power.

4.7.3 Test for heteroscedasticity

The Breusch Pagan/Cook-Weisberg test was performed to test for heteroscedasticity within the model. According to Kaufman (2014), although presence of heteroscedasticity in a model result in unbiased parameter estimates, the estimates are not efficient. Additionally, tests of statistical significance cannot be relied upon leading to erroneous conclusions. The results of the test indicate X^2=0.11with a p-value of 0.7363. We therefore could not reject the null hypothesis that the error variances were equal (homoscedasticity). Therefore, it was concluded that the model was free from heteroscedasticity problems.

4.7.4 Test for omitted variables

According to Kim and Swoboda (2015), correlated effects due to omitted variables in regression models is a common thread in observational and quasi-experimental design in social and behavioral sciences. Testing for omission of relevant variables and/or specification of functional form is thus important because misspecification leads to inconsistent estimators thus rendering inferences unreliable (Godfrey & Orme, 1994). The Ramseys' test for omitted variables was performed to ensure that omitted variables were not causing model misspecification. The results indicate a value of F=2.48 and a *p*- value of 0.066 (at 5% significance level). The test was not significant. This implies that there were no omitted variables in the model.

4.7.5 Bivariate probit regression results

A bivariate probit model was used to jointly model the factors influencing the miller's decision to use locally produced maize only or a combination of both locally produced and imported maize in their milling operations. The overall fit for the model was checked using Wald test and the likelihood ratio test.

The results indicate a log likelihood of -41.415 and Wald $\chi2$ (22) of 35.84, (Prob>$\chi2$= 0.0316). This indicates that all the parameters were jointly significant, and all covariates included in the model explained the millers' decision to use locally produced maize only or both locally produced and imported maize at 5% significance interval. Additionally, the likelihood ratio test of independent equations ($\chi2(1) = 70.22$, *p* value= 0.000) rejected the null hypothesis that the residuals of the decision equations were not correlated. This indicates that the millers' decisions to use locally produced maize only or both locally produced and imported maize were likely to be interdependent, thus validating the use of bivariate probit model.

The maximum likelihood estimates for the bivariate probit model used to determine the factors influencing the millers' decision to use locally produced maize only or both locally purchase, and imported maize are presented in table 8 below. The variables employee skill level, average sales per month, licenses, government subsidies and purchases through NCPB were found to significantly influence the millers' decision to use locally produced maize only as well as the decision to use both locally produced and imported maize. Additionally, the variable daily production capacity was found to influence millers' decision to use locally produced maize only but had no influence on the millers' decision to use both locally produced and imported maize.

Employee skill level was statistically significant at 5% significance level for both the decision to use locally produced maize only and to use both locally produced and imported maize. On the decision to use locally produced maize only, employee skill level was found to negatively influencing this decision by milling firms. By implication, milling firms with low-skilled employees were likely to use locally produced maize only. This could be attributed to earlier findings of the study which indicated that majority of the milling firms that used locally produced maize only were micro to small scale firms that used less complicated technology for their milling operations which is simpler and easier to use. This is coherent with the findings of Tambunan (2011), who found that one important characteristic of micro and small enterprises in Indonesia was that they employ mostly low-skilled labor and use less sophisticated (old) technologies.

On the decision to use both locally produced and imported maize, employee skill level was found to be a significant and positive influence. This implies that firms that had highly skilled employees were likely to use both locally produced and imported maize for their milling operations. This can also be attributed to earlier findings of the study which indicated that majority of the maize milling firms that used both locally produced and imported maize were medium to largescale companies, and they used sophisticated technology in their milling operations which required skilled employees. Similarly, Khamila *et al*. (2019) and Ndichu *et al*. (2015) found out that large scale firms used more sophisticated and capital-intensive technologies and that most of the skilled employees were found in large-scale firms. This was also consistent with the findings of (Tambunan, 2011) who found that the larger the size of the firm, the more complex the production process and the more skilled employees required to generate higher productivity.

Table 8; Maximum likelihood estimates for bivariate probit regression model.

	Miller's decision to use locally produced maize only		**Miller's decision to use both locally produced and imported maize**	
Variable	**Coefficient**	**Standard error**	**Coefficient**	**Standard error**
Age of Firm	-0.0015	0.0152	0.0040	0.0153
Total number of employees	0.0010	0.0024	-0.0010	0.0024
Employee skill Level	-0.7927**	0.2564	0.7684**	0.2553
Average number of sales per month	-0.0017**	0.0008	0.0015*	0.0008
Daily production capacity	-0.0021*	0.0012	0.0020	0.0012
Milling technology used	0.0326	0.1280	-0.0050	0.1279
Import Duties	-0.5657	0.4302	0.4653	0.4280

Tax waivers	-0.6151	0.4003	0.6057	0.4001
Import licenses	-1.2929**	0.3759	1.2622***	0.3741
Government subsidies	0.8335*	0.4743	-0.6848*	0.4689
Gov't purchases through NCPB	0.7810*	0.4178	-2.7979**	0.7404
Constant	2.7786***	0.7395		
Athrho	-13.9409	496.3866		
Rho	-1.000	0.0000		

Note: Log likelihood=-41.415, Number of observations=104, Wald chi2(22) =35.84, Prob>chi2=0.0316, LR test of rho=0; chi2=70.2211, Prob> chi2=0.000; *, ** and *** denote significance at 10%, 5% and 1% respectively

The average monthly sales were found to be statistically significant at 5% and 10% significance level for firms that used locally produced maize only and those that used both locally produced and imported maize, respectively. For firms that chose to use locally produced maize only, the average monthly sales had a significant and negative influence on this decision. This implies that firms that had lower average monthly sales were likely to use locally produced maize only. This can be due to the shortage of maize in the country which resulted in a decrease in production and consequently decrease in sales per month made by the milling firms. This is consistent with the findings of Guesh (2010) who found out that the shortage of raw material supply, especially locally, led to fluctuation of sales volumes of the firm.

Moreover, the average monthly sales were found to be a significant and positive influence on the millers' decision to use both locally produced and imported maize. This implies that firms that had higher average monthly sales were likely to use both local and imported maize in their milling operations. This is possibly because the firms that were able to formally import maize were able to cushion themselves during periods of short supply in the country. The firms were therefore able to continue with production, thus obtaining higher monthly sales. This is consistent with the findings of Halpern *et al*. (2015) who found that importation of inputs increased firms' revenue productivity by 22% due to the imperfect substitution between foreign and domestic inputs. Similarly, Bas and Strauss-Kahn (2014) found that imported inputs raised firms' productivity through greater complementarity of inputs and quality transfer.

The results further indicate that import licenses had a 5% and1% significant influence on the firm's decision to use locally produced maize only and the decision to use both locally produced and imported maize, respectively. Import licenses had a significant and negative influence on the firms' decision to use locally produced maize only. This implies that firms that were not able to obtain licenses to import maize used locally produced maize only in their milling operations. According to Masinde (2015), firms that want to import maize into the country are required to obtain an entry permit from relevant government bodies as well as a plant import permit from KEPHIS. The results obtained in this study are coherent with the results obtained by Apondi (2015), who found that trade documents required partly influences the choice of trade patterns due to increase in transaction costs.

Import licenses had a significant and positive influence on the firms' decision to use both locally produced and imported maize. This implies that firms that were able to obtain import licenses were able to import maize from other countries. However, this is contrary to the results obtained by Bernini and Lembergman (2023), who found that non-automatic import licenses led to reduced imports by firms that were more exposed to the policy. Smaller firms experienced higher declines in the number of imports.

The decision by maize milling firms on whether to use locally produced maize only or both locally produced and imported maize was significantly influenced by government subsidies at 10% significance level. Government subsidies had a significant and positive influence on the firms' decision to use locally produced maize only. This implies that an increase in government subsidy programs on maize production inputs influences maize milling firms to purchase locally produced maize. This is possibly because government subsidies on maize production inputs lowers the cost of producing maize and consequently lowers the price of maize sold. These results are however inconsistent with the results obtained by Lunduka *et al.* (2013), who found that input subsidies had either no statistically significant effect on retail maize prices or, more commonly, a statistically significant but small negative effect on those maize prices. Additionally, doubling subsidy programs in Malawi and Zambia would reduce maize prices by a small margin of 1.2-2.5% and 1.8-2.8% respectively.

Moreover, government subsidies had a significant and negative influence on the firms' decision to use both local and imported maize. This implies that an increase in government subsidy programs on maize prices would lead to a decrease in the amount of maize that maize milling firms purchase domestically. This is possibly because when the government subsidizes the maize prices to farmers in a bid to ensure that farmers receive higher prices for their maize, millers will be forced to offer higher prices to maize farmers to obtain enough for their milling operations. This would force the millers to seek cheaper maize imports. This is like the findings of Njeru (2017) who indicates that an increase in the government expenditure in the purchase of maize stocks from farmers at a higher price than the market price results to an upward pressure on the market price of maize. This undermines the objective of reducing maize prices.

The results further indicate that government purchases of maize through the National Cereals and Produce Board (NCPB) had a considerable influence on the firms' decision to use either locally produced maize only or to use a combination of both locally produced and imported maize. Maize purchase through NCPB had a significant and positive influence on the firms' decision to purchase locally produced maize only at 10% significance level. This implies that as the government increases its purchases of maize from farmers through the NCPB, maize milling firms are more likely to purchase maize from the local farmers as well. This is possibly because the parastatal purchases maize at administratively determined price thus reducing price volatility of maize. Findings by Jayne *et al*. (2008) and Bii (2023) however, show a negative relationship between private sector maize milling firms and the government parastatal in purchases of maize. Their results indicate that while the government purchases maize at a set price, millers offer higher prices to maize farmers thus reducing purchases made by the government.

Moreover, the results indicate that the decision by millers to use both locally produced and imported maize is significantly and negatively influenced by government purchases of the grain through NCPB. This implies that as the government increases its maize purchases, the maize milling firms are more likely to import maize. This is possibly because the parastatal aims to offer better prices of maize to farmers by setting price floors for maize leading to an increase in the market price for maize. This forces the maize milling firms to seek cheaper maize imports. This is consistent with the results obtained by Jayne *et al*. (2008) who found that the NCPB's administered prices have, on average, raised wholesale market prices in Kitale (a major surplus production area) and Nairobi (the main urban center) by around 5%.

The firms' daily production capacity had a negative influence on the decision to use locally produced maize only. It, however, had no influence on the firms' decision to use both locally produced and imported maize. By implication, firms that had a lower daily production capacity were likely to use locally produced maize only in their milling operations. This can be attributed to the shortage in supply of maize in the country which results in high operational costs due to the inefficiency of their production capacity. The results are consistent with Adeyemi and Olufem (2016), who found that the inadequate supply of raw materials contribute to the elevated cost of production which significantly affects capacity utilization.

4.8 The effect of maize sourcing strategies on the income of maize milling firms in Kenya

4.8.1 Gross margin analysis

In this analysis, gross margins were specifically evaluated at the micro firm level, as this was the only firm size category that demonstrated significant variability between firms that sourced maize locally versus those using a combined sourcing strategy. Focusing on micro firms allows us to examine the impact of sourcing strategy on gross margins within a subset of firms where meaningful differences were observed. Analyzing micro firms exclusively provides a clearer view of the distinct sourcing effects without the confounding variability present across different firm sizes. This targeted approach makes the results more relevant and accurately reflects the unique dynamics within micro-scale operations.

The data in table 9 shows that micro firms sourcing maize locally sold an average of 209,219 tons per month, while those using a combined sourcing strategy averaged 390,145 tons. This substantial difference is reflected in a statistically significant t-test result, indicating that firms combining local and imported sources sell considerably more volume, which may contribute to scaling efficiencies. Similarly, the selling price per ton is slightly higher among firms with a combined sourcing strategy, averaging KES 70,585 compared to KES 65,627 among locally sourcing firms, though this difference is not statistically significant.

Table 9; Gross Margin Differences between Micro Firms Using Local-Only and Combined Maize Sourcing Strategies

Variable	**Local Only Sourcing (n=12)**		**Combined Sourcing (n=63)**		**t-test**
	Mean	**SD**	**Mean**	**SD**	
Quantity sold per month (in tons)	209,219.30	50,334.30	390,145.00	60,764.80	-0.4550***

Selling price per ton (in KESs)	65,627	12,446	70,585	21,278	-0.8339
Total Revenue (KES/month)	**20,090,510**	**1,460,528**	**73,263,300**	**5,176,778**	**-0.4452****
Quantity purchased per month (in tons)	202.875	75.37	635.53	122.1616	-1.5274***
Price purchased per ton (KES)	30,923	11,032	46,348	18,159	0.8882
Total cost of maize per month (KES)	10,595,980	1,940,361	49,021,260	3,008,770	-0.9625**
Labor (KES)	8,104	747	5,650	871	0.5605
Fuel (KES)	9,019	233	6,288	864	0.2884
Packaging (KES)	8,627	596	6,015	296	0.5769
Utility (KES)	7,053	588	4,917	758	0.7116
Distribution (KES)	6,928	837	4,830	166	0.2236
Transport (KES)	10,596	951	53,158	525	0.1969
Total variable cost (KES/month)	**15,421,000**	**4,103,082**	**56,530,020**	**2,106,289**	**-2.5974*** **
Gross margin (KES/ ton)	**9,984,500**	**1,460,499**	**13,147,750**	**517,693**	**-0.4451****

*, **and *** denote significance at 10%, 5% and 1% respectively

For total monthly revenue, combined sourcing firms generated a mean of KES 73,263,300 compared to KES 20,090,510 among locally sourcing firms, a difference that is statistically significant. This substantial revenue difference highlights the financial advantage for micro firms leveraging a combined sourcing approach, possibly due to higher volumes or better pricing flexibility.

In terms of input costs, combined sourcing firms also reported significantly higher monthly quantities purchased (635.53 tons) than locally sourcing firms (202.875 tons), reflecting their greater scale of operations. This is accompanied by a higher average purchase price per ton (KES 46,348 for combined sourcing versus KES 30,923 for local), although the price difference itself is not statistically significant. Monthly maize costs were significantly higher for combined sourcing firms (KES 49,021,260) than for local sourcing (KES 10,595,980), aligning with their larger purchase volumes.

For variable costs like labor, fuel, packaging, and utility, both sourcing groups displayed relatively close means, indicating similar cost structures for basic operational expenses despite differences in sourcing strategy. However, transport costs diverged, with combined sourcing firms reporting significantly higher mean transport costs (KES 53,158) compared to locally sourcing firms (KES 10,596), likely due to the logistics involved in handling both local and imported maize.

Finally, the gross margin per ton also showed a significant difference, with combined sourcing firms achieving a higher mean gross margin (KES 13,147,750) compared to locally sourcing firms (KES 9,984,500). This higher gross margin suggests that combined sourcing firms can realize better financial returns per unit, possibly due to scale efficiencies or better profit margins associated with imported maize.

4.8.2 Effect of Tradeoffs Between Maize Importation and Local Production on Milling Firms' Income

The effect of tradeoffs between maize importation and dependence on local production on firms' income was determined using Two-Stage Least Squares regression (2SLS). The firms' income is determined by (and jointly determines) the millers' decision on whether to use locally produced maize only or both imported and locally produced maize. The Log of gross margin was used as a proxy for firms' income. Therefore, the variables Combined Sourcing and Local Sourcing (which refer to firm's decision to use both local and import maize and firm's decision to use locally produced maize only, respectively) were treated as endogenous variables in the model.

Table 10 (Column I) shows that the variable 'Financial Constraints' is significantly (5% significance level) and positively associated with the endogenous variable Local Sourcing. This indicates the suitability of the variable to be used as an instrumental variable for the latter. The results further indicate that the Quantity purchased, and Labor costs are significantly (at 5% significance level) and positively associated with the endogenous variable. This implies that as monthly sales and production costs increase, firms tend to choose to use locally produced maize only. Additionally, the variable 'Firm Location' was positively and significantly (at 5% significance level) associated with the endogenous variable Combined Sourcing; hence its suitability to be used as an instrumental variable in the second model (Table 10; Column IV). The variables Quantity Purchased and Labor Costs were also found to have a positive and significant association (at 5% significance level) with the endogenous variable. By implication, as import duties and import licenses increase, the firms tend to choose to use both locally produced and imported maize.

Diagnostic tests were first conducted to determine the suitability of the model and the variables used in the model. The Durbin and Wu-Hausman tests were done to determine whether the variables presumed to be endogenous, could instead be exogenous. The test statistics obtained were significant at 5% and 10% significance level with p- values of 0.002 and 0.070 for the Durbin and Wu-Hausman tests, respectively. The null hypothesis of exogeneity was thus rejected implying that the variable was indeed endogenous.

According to Hahn and Hausman (2005), the instrument must be strongly correlated with the endogenous explanatory variable. This correlation ensures that the instrument can effectively explain some of the variability in the endogenous variable. If the correlation is weak, it may lead to biased estimates, often referred to as the "weak instrument problem." Additionally, the instrument must be uncorrelated with the error term in the regression model. This condition ensures that the instrument does not have a direct effect on the dependent variable except through the endogenous variable. If the instrument is correlated with the error term, it will not provide valid estimates. The first-stage summary statistics were thus obtained to determine the explanatory power of the instruments. The F-statistic obtained was highly significant (Prob > F= 0.0051) at 1% significance level. This implies that the additional instruments had explanatory power for the endogenous variable and that the inference based on the 2SLS estimator was dependable since the F-statistics value (22.80) exceeds ten (Stock *et al*., 2002). The results further indicate that the instruments used in the model are not weak since the test statistic value (22.80) exceeds the critical value (16.85) at 5% relative bias (Stock & Yogo, 2005).

Table 10; 2SLS Estimates of Factors Affecting Gross Margins for Firms by Maize Sourcing Strategy

	Dependent Variable	**Dependent Variable**	**Dependent Variable**	**Dependent Variable**
	(Local Sourcing)	**(Log of Gross Margin)**	**(Combined Sourcing)**	**(Log of Gross Margin)**

Variables	Local Sourcing			Combined Sourcing		
	OLS (first stage) (I)	OLS (first stage) (II)	2SLS estimates (III)	OLS (first stage) (IV)	OLS estimates (V)	2SLS estimates (VI)
Intercept	1.0524***	23.3074***	21.8396***	1.0543***	23.3738***	21.3986***
Firm Location (Instrument)	0.1604	0.1275	0.9524	-0.1883**	0.0409*	-----
Financial Constraints (Instrument)	-0.1781**	0.1498	--------	1.7108**	1.2934	2.6107
Combined Sourcing	--------	--------	--------	------	-0.3878**	1.4934
Local Sourcing	-------	-0.3665**	1.1083	-------	--------	------
Total Revenue	-2.6814	2.4812 ***	2.0012***	-3.1414	2.4812**	2.0312***
Quantity purchased per month (tons)	-0.0127**	0.0524	0.0284	-.0013**	0.0501	0.0362*
Total cost of maize (KES)	5.3613	1.5409***	-3.9610***	-6.4813	0.0149*	-4.1910***
Labour Cost	0.2356**	-0.0801	-0.4972	0.2865**	-0.0875	-0.7618*
Packaging Cost	-0.1651	-0.0772	0.2874	-0.1128	-0.0736	0.5668
Fuel Cost	-0.1477	0.1846	0.6217*	-0.1577	0.1561	0.6236*
Utility Cost	0.0236	-0.3226**	-0.5852**	0.0509	-0.3204*	-0.6619**
Distribution Cost	0.0271	0.0456	0.2337	-0.0619	0.0274	0.3147
Age of Firm	0.0101	0.0033	0.2313	2.2606	0.0026	0.0199

*, ** and *** denote significance at 10%, 5% and 1% respectively

The results of both the OLS and 2SLS model estimates are presented in the table10, showing the factors influencing gross margins and sourcing decisions for firms using either locally sourced maize or a combination of local and imported maize. These factors include firm location, financial constraints, sourcing strategies, total revenue, quantity purchased, and various cost components, with distinct effects for firms based on their sourcing approach.

The intercept values in all models are highly significant, indicating a strong baseline level for gross margins across sourcing strategies, independent of other predictors in the model. This is consistent with previous studies that emphasize the importance of baseline profitability in agricultural firms. However, the significance of intercepts in different contexts can vary, as some research has suggested that certain operational environments may lead to differing baseline profitability levels.

In the first-stage OLS model for firms sourcing locally (Column I), the coefficient for firm location is positive but not statistically significant, while for combined sourcing (Column IV), location is significantly negative at the 5% level. This suggests that location may have a varying impact on sourcing choices, with firms in certain areas possibly finding it more challenging or less beneficial to engage in combined sourcing due to logistical or market-specific constraints. Firm location serves as an instrumental variable in the 2SLS model for combined sourcing. It was chosen because it likely correlates with the sourcing decision while being uncorrelated with the income, thus addressing potential endogeneity issues. This finding contrast with Becker-Blease *et al*. (2010), who found that location, had a more pronounced positive influence on firm profitability, suggesting that regional market dynamics may significantly shape operational outcomes.

Financial constraints are statistically significant with a negative coefficient in the local sourcing model (Column I), indicating that firms experiencing financial limitations are less likely to rely solely on local sourcing. In the combined sourcing model, financial constraints have a significant positive impact in the 2SLS estimates (Column VI). This implies that firms with financial constraints may prefer combining local and imported maize to reduce costs or manage risks associated with a single source. Financial constraints also serve as the instrumental variable for local sourcing, chosen for their expected correlation with sourcing decisions but not directly affecting gross margin, thus satisfying the necessary conditions for an effective instrument. These results align with Istan *et al*. (2021), who found that financial constraints adversely impact sourcing decisions; however, the positive correlation in combined sourcing presents a nuanced view that contrasts with Sausan (2020), who found no significant impact of financial constraints on sourcing strategies.

In the OLS model (Column V), combined sourcing has a negative effect on gross margin at a 5% significance level, whereas in the 2SLS model (Column VI), it shows a positive but non-significant impact. This shift from negative to positive suggests that combined sourcing may initially be costly, but when other factors are controlled, it potentially increases gross margin by providing flexibility in raw material sourcing. This finding contrast with previous studies like Haider and Ziaul (2010), who noted that combined sourcing consistently, enhances profitability. The initial negative impact observed here may reflect short-term costs associated with establishing a dual sourcing system, an aspect not explored in depth by earlier research.

For firms sourcing locally, local sourcing has a significant negative impact on gross margin in the first-stage OLS model (Column II), but it becomes positive and insignificant in the 2SLS model (Column III). This pattern indicates that while local sourcing might initially lower margins, it may still yield some indirect advantages in a controlled analysis setting. This finding diverges from findings by Dewi *et al*. (2021), which suggest that local sourcing typically leads to improved margins due to reduced transportation costs and improved product freshness.

The effect of total revenue on gross margin is consistently positive and significant in both the local and combined sourcing models (Columns II, III, V, and VI). This suggests that increased revenue substantially enhances gross margins, potentially by providing the financial buffer needed to optimize sourcing strategies and manage costs effectively. This finding is consistent with Alarussi and Alhaderi (2018), who found a strong correlation between revenue growth and profit margins across various sectors. However, the magnitude of this relationship can differ in different contexts, as noted by Dommari and Haranath (2022), where revenue growth did not uniformly translate to profit margin enhancement.

The quantity purchased each month has a mixed impact. In the local sourcing model (Column II), it shows a negative effect, while in the combined sourcing model, the effect is positive and marginally significant in the 2SLS model (Column VI). For firms combining sources, larger purchase volumes may improve efficiency or allow for bulk discounts, thus positively affecting gross margin. This contradicts findings from Sausan (2020), who suggested that increased purchasing did not significantly impact profitability, highlighting potential differences in market conditions or firm strategies influencing these dynamics.

In both models, the total cost of maize has a negative and significant impact on gross margin (Columns III and VI), reflecting the direct cost burden of raw materials. This consistent negative effect implies that higher maize costs reduce profitability for both sourcing strategies; a finding that aligns with the theory that input cost increases can compress profit margins. This result is supported by previous studies, such as those conducted by Becker-Blease *et al*. (2010), which similarly identified a strong negative correlation between input costs and firm profitability.

Labor cost has a significant negative impact on gross margin in the combined sourcing 2SLS model (Column VI), suggesting that increased labour expenses can erode profitability, particularly in firms managing both local and imported sources. The additional complexity of handling multiple sources may require more labour, thus increasing costs and reducing margins. This finding is corroborated by Istan *et al*. (2021), who indicated that rising labour costs negatively impacted profitability, but it contrasts with Dewi *et al*. (2021), who found that firms with efficient labour management could offset these costs, highlighting the importance of operational efficiencies.

Fuel cost is positively associated with gross margin in the 2SLS models for both sourcing strategies, though only marginally significant (Columns III and VI). This unexpected positive effect might imply that firms can pass fuel cost increases onto consumers through price adjustments, thus maintaining margins. This finding diverges from previous studies, such as those by Dommari and Haranath (2022), which suggested that fuel costs typically exert a negative influence on profitability, indicating differing market behaviours in response to cost changes.

Utility cost has a significant negative effect on gross margin in both the local and combined sourcing models (Columns III and VI), showing that high utility expenses directly reduce profitability. This suggests that utility costs are a crucial factor in determining the operational costs of firms, which can substantially impact gross margins. This is consistent with findings from Becker *et al.* (2010), which underscored the importance of managing utility costs to maintain profitability, as these costs often represent a significant portion of a firm's operating expenses.

These results illustrate the complex interplay of sourcing decisions, costs, and revenue in determining firm profitability. The variations observed between the OLS and 2SLS models underscore the importance of considering endogeneity and the indirect effects of these variables when interpreting their impact on gross margin. The use of instrumental variables, firm location, and financial constraints, supports a more robust analysis by clarifying the causal relationships involved in sourcing decisions and their effects on firm income.

CHAPTER FIVE

CONCLUSIONS AND RECOMMENDATIONS

5.1 Introduction

This chapter presents the summary of the study findings, conclusions drawn from the study, policy recommendations and areas of further research.

5.2 Summary of Key Findings

The study aimed to analyse the effect of maize sourcing strategies on the income of maize milling firms in Kenya. Specifically, the objectives were to characterize maize milling firms in Kenya and determine their current maize sourcing practices, investigate factors influencing import decisions, and assess the effect of maize sourcing strategies on the income of maize milling firms in Kenya. Data collection utilized questionnaires for guided interviews and online surveys targeting firms producing packaged maize flour. Research was conducted across five regions: Nairobi/Central, Rift Valley, Western/Nyanza, Eastern/Northeastern, and Coastal regions.

The analysis of maize milling firms in Kenya reveals diverse operational structures shaped significantly by firm size and sourcing strategy. Large firms show a balanced preference for both local and combined sourcing, whereas medium and small firms predominantly rely on local sources. Micro firms, though mostly sourcing locally, display slight variability with some adopting combined sourcing. Regionally, micro firms dominate across most areas, especially in rural zones, indicating their vital role in meeting local demand.

In terms of technology, larger firms tend to invest in advanced milling technologies such as Automated PLC systems, enhancing efficiency and capacity to meet higher demand. Smaller firms, including micro firms, generally use simpler, cost-effective technologies like Hammermills. This technological stratification underscores the resource constraints faced by smaller firms compared to their larger counterparts.

Workforce skill levels further differ by firm size, with larger firms employing more skilled labour, especially under combined sourcing. Smaller firms rely on semi-skilled labour to meet their modest operational needs. Costs incurred by firms, whether for local procurement, importation, or processing, also increase with firm size, reflecting the broader operational scopes of larger firms. Key challenges like price fluctuations, high import duties, and financial constraints are pervasive across all firm sizes, but their impact is particularly pronounced among smaller firms.

The results indicated significant determinants for sourcing decisions such as employee skill level, average monthly sales, import licenses, government subsidies, and purchases through the National Cereals and Produce Board (NCPB). Skilled labour positively influenced firms to use combined sourcing strategies, while firms with lower-skilled employees leaned toward local sourcing due to simpler technology needs. Firms with higher monthly sales or access to import licenses favoured combined sourcing, potentially for greater supply flexibility and enhanced revenue stability. In contrast, government subsidies and NCPB purchases incentivized local sourcing by stabilizing prices, though they had a negative impact on combined sourcing, likely due to upward price pressures on locally produced maize.

Further, an analysis focused on micro firms demonstrated notable differences in gross margins based on sourcing strategy. Firms using both local and imported maize reported higher sales volumes, revenue, and gross margins than those relying solely on local maize. The 2SLS model further indicated that financial constraints and firm location significantly influenced sourcing decisions, with financially constrained firms more likely to source locally. Combined sourcing was associated with higher variable costs (particularly transport), which were offset by increased sales volume and marginally higher selling prices. Despite elevated input costs, combined sourcing enabled micro firms to achieve better financial returns per unit, likely due to operational flexibility and scale efficiencies.

5.3 Conclusions

i. The maize milling industry in Kenya is highly stratified, with firm size and sourcing strategy influencing not only the choice of milling technology and labour composition but also cost structures and resilience to market challenges. Larger firms benefit from economies of scale, allowing for greater technological investment and access to combined sourcing strategies that buffer against local supply fluctuations. Meanwhile, micro, and small firms, despite their limitations, play an essential role in serving rural markets and ensuring maize milling access across regions. The prominence of challenges like price fluctuations and financial constraints highlights the sector's vulnerability to economic and regulatory pressures.

ii. The decision of milling firms in Kenya to rely on local maize only or a combination of local and imported sources is significantly shaped by firm-level capabilities and government policies. Skilled labour and high sales volumes enable firms to navigate both local and global markets, indicating that sourcing decisions are closely tied to operational scale and resource availability. Conversely, policies that support local maize production and stabilize prices, such as government subsidies and NCPB purchases, encourage firms to source locally but may inadvertently reduce the cost-competitiveness of combined sourcing. Thus, firm size, capability, and policy support jointly determine sourcing strategies, highlighting the complex landscape that maize milling firms must navigate in response to both internal capacities and external market conditions.

iii. Micro (posho mill) firms benefit financially from combined sourcing of maize, even with higher associated variable costs. This finding suggests that while local sourcing may be economically viable, it may limit firms' capacity to leverage economies of scale, especially during periods of local supply instability. The higher gross margins among firms with combined sourcing underscore the financial advantages of diversified sourcing strategies, which can buffer against supply disruptions and enhance revenue potential.

5.4 Recommendations

i. **Support for Technology Upgrades**: Small and micro firms would benefit from targeted support to adopt more efficient milling technologies. Subsidies or low-interest loans could facilitate access to advanced, affordable machinery to improve productivity.

ii. **Evaluate the Impact of Subsidies and NCPB Purchases**: Government interventions, while stabilizing local maize prices, could benefit from regular assessments to balance support for local sourcing with the operational needs of firms employing combined sourcing. Adjusting subsidies and purchase prices periodically may mitigate unintended impacts on sourcing costs.

iii. **Subsidize Key Variable Costs for Micro Firms**: Given the significant impact of variable costs on profitability, particularly transport and maize costs, targeted subsidies or logistical support could reduce cost burdens and make combined sourcing more feasible.

5.5 Areas for further research

While this study employed cross-sectional data to examine the impact of trade-offs between maize importation and local production on maize milling firms' incomes in Kenya, several avenues for deeper exploration remain.

Future research could utilize panel data to capture the dynamics of maize importation and local production decisions over time. This approach would enable researchers to assess how these decisions evolve in response to changing economic, environmental, and policy conditions. Longitudinal analysis would provide insights into the long-term effects of importation policies, market fluctuations, and technological advancements on firm profitability and sustainability.

Additionally, future research could focus on investigating the dynamic nature of firms' decision-making processes regarding maize sourcing. This includes understanding how firms adjust their sourcing strategies in response to seasonal variations in maize availability, price fluctuations, and shifts in consumer demand. Examining these factors longitudinally could elucidate patterns and strategies that contribute to firms' resilience and adaptation in the face of market uncertainties.

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APPENDICES

Appendix A: Research Questionnaire

Questionnaire for: An evaluation of effects of tradeoffs between maize importation and dependence on local production in Kenya

No…………

Dear Sir/ Madam,

My name is Priscilla Nzaka, a postgraduate student from Egerton University. In partial fulfilment of the requirement for the Master of Science in Agribusiness Management, I am conducting research titled **"Effects of tradeoffs between maize importation and dependence on local production in Kenya."** I am humbly requesting for your assistance to provide information, by filling the questionnaire below, as your views are considered important to this study. Please note that your participation is voluntary, and that any information given will be treated with utmost confidentiality. The information provided will only be used for the purpose of this study.

Date…………………

SECTION A: MILLER ATTRIBUTES

Company name:	**Respondent's name:**
County:	Designation in Co.:
Town:	Tel no:
Year of Establishment:	Email address:
Interviewer's name:	Respondent's nationality:

2. How many employees does your company have?

< 10	10-50	51-100	101-300	>500

3. What is the distribution of your employees in the company?

Male ……………...

Female ………………

4. What is the skill level of your employees?

Unskilled ☐

Semi-skilled ☐

Skilled ☐

Highly skilled ☐

5. What is the average daily production capacity of your company?

< 100 Mt/day	101-500 Mt/day	501- 700 Mt/day	>700 mt/day

6. What type of mill do you use in the company?

Type of mill	**Capacity (tons/day)**
Hammer mill	
Colloidal mill	
Attrition mill	
Others (specify)	

SECTION B: SOURCE OF MAIZE

7. How do you source your maize?

Purchase locally. ☐

Import ☐

Both ☐

8. How much do you?

Purchase locally per month (Tons) …………………….

Import per month (Tons) ………………………….

9. If locally produced, from which region do you source your maize?

Central region ☐

Rift Valley region ☐

Western region ☐

Nyanza region ☐

Coastal region ☐

10. Where do you import your maize from?

EAC region ☐

SADC region ☐

World Market ☐

Others (specify) …………………………………………………….

SECTION C: PROFITABILITY OF FIRM

11. What is the cost of purchasing one ton of maize (in KESs) from the local sources?

Minimum ……………………

Maximum ……………………

12. What is the cost of importing one ton of maize (in KESs)?

Minimum …………………….

Maximum ……………………

13. What are some of thecosts incurred in purchasing maize from local sources?

Transportation costs ☐

Cess Fees ☐

Brokerage Fees ☐

Market Levies ☐

Loading and offloading ☐

Storage ☐

Bagging ☐

Others (Specify)…………………………………………………………………

14. What are some of thecosts incurred in importing maize?

Clearance and verification fees ☐

Inspection fees ☐

Custom Duties ☐

Border fees ☐

Transportation costs ☐

Others (Specify)……………………………………………………………….

15. What is the average cost of producing one ton of maize flour (KESs)?

………………………………………………………………………………………

16. What are the variable costs incurred in the production of maize flour?

Labor expenses ☐

Packaging ☐

Fuel ☐

Utility ☐

Distribution cost ☐

17. What is the average selling price of maize per ton (in KESs)?

…………………………………………………………………………………………….

18. What are the average monthly sales of maize (in tons)?

…………………………………………………………………………………………….

SECTION D: FACTORS INFLUENCING DECISION TO IMPORT OR PURCHASE LOCALLY

18. Does government regulations influence your decision on how to source maize?

Yes ☐

No ☐

19. What are some of the regulations that influence your decision?

Purchases through NCPB ☐

Government subsidies ☐

Import duties ☐

Trade liberalization ☐

Tax exemptions/ Waivers ☐

Import licensing ☐

Standards and certification ☐

Others (specify)…………………………………………………………………………

20. How do these regulations influence your decision?

……………………………………………………………………………………..

……………………………………………………………………………………..

……………………………………………………………………………………..

21. In your opinion, is the maize supply in Kenya sustainable?

Yes ☐

No ☐

22. How has it affected your company's operations and profitability?

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………..

23.What was the impact of the COVID-19 pandemic on your operations?

……………………………………………………………………………………………..

……………………………………………………………………………………………..

……………………………………………………………………………………………..
.

24. What other challenges are facing the company?

Financial constraints ☐

Political uncertainties ☐

Price fluctuations ☐

High import duties ☐

Liberalization of maize market ☐

Others (specify)

…………………………………………………………………………………….

25. How do they affect your decision on whether to import or to purchase locally produced maize?

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………

…………………………………………………………………………………………………….

…………………………………………………………………………………………………….

…………………………………………………………………………………………………….

Appendix B; Bivariate Probit Results

```
. biprobit Localonly bothlocalimport Operating_years Total_employee_numbers Employee_skill_level Average_monthly_
> sales productioncapacity Technology Duties Waivers Licenses Subsidy NCPBpurchase_influence ,nolog cformat(%9.4f
> ) pformat(%5.3f) sformat(%8.3f)

Bivariate probit regression                     Number of obs     =        104
                                                Wald chi2(22)     =      35.84
Log likelihood = -41.415314                     Prob > chi2       =     0.0316
```

	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
Localonly						
Operating_years	-0.0015	0.0152	-0.100	0.920	-0.0314	0.0284
Total_employee_numbers	0.0010	0.0024	0.432	0.665	-0.0037	0.0058
Employee_skill_level	-0.7927	0.2564	-3.092	0.002	-1.2952	-0.2902
Average_monthly_sales	-0.0017	0.0008	-2.133	0.033	-0.0033	-0.0001
productioncapacity	-0.0021	0.0012	-1.771	0.077	-0.0045	0.0002
Technology	0.0326	0.1280	0.255	0.799	-0.2181	0.2834
Duties	-0.5657	0.4302	-1.315	0.188	-1.4089	0.2774
Waivers	-0.6151	0.4003	-1.537	0.124	-1.3996	0.1694
Licenses	-1.2929	0.3759	-3.439	0.001	-2.0297	-0.5561
Subsidy	0.8335	0.4743	1.757	0.079	-0.0961	1.7632
NCPBpurchase_influence	0.7810	0.4178	1.869	0.062	-0.0379	1.5999
_cons	2.7786	0.7395	3.758	0.000	1.3293	4.2279
bothlocalimport						
Operating_years	0.0040	0.0153	0.262	0.793	-0.0260	0.0340
Total_employee_numbers	-0.0010	0.0024	-0.397	0.692	-0.0057	0.0038
Employee_skill_level	0.7684	0.2553	3.010	0.003	0.2680	1.2688
Average_monthly_sales	0.0015	0.0008	1.924	0.054	-0.0000	0.0031
productioncapacity	0.0020	0.0012	1.641	0.101	-0.0004	0.0043
Technology	-0.0050	0.1279	-0.039	0.969	-0.2556	0.2457
Duties	0.4653	0.4280	1.087	0.277	-0.3736	1.3041
Waivers	0.6057	0.4001	1.514	0.130	-0.1785	1.3898
Licenses	1.2622	0.3741	3.374	0.001	0.5290	1.9954
Subsidy	-0.7326	0.4689	-1.562	0.118	-1.6517	0.1864
NCPBpurchase_influence	-0.6848	0.4137	-1.655	0.098	-1.4955	0.1260
_cons	-2.7979	0.7404	-3.779	0.000	-4.2491	-1.3468
/athrho	-13.9409	496.3866	-0.028	0.978	-986.8406	958.9589
rho	-1.0000	0.0000			-1.0000	1.0000

```
LR test of rho=0: chi2(1) = 70.2211                        Prob > chi2 = 0.0000

.
```

Appendix C; Diagnostic Tests for Bivariate Probit Model

```
. vif

    Variable |       VIF       1/VIF  
-------------+----------------------
    Licenses |      1.62    0.617955
      Duties |      1.45    0.689969
     Waivers |      1.41    0.709472
Total_empl~s |      1.41    0.711531
     Subsidy |      1.36    0.737543
production~y |      1.35    0.739962
Operating_~s |      1.35    0.743063
Employee_s~l |      1.31    0.762395
NCPBpurcha~e |      1.31    0.765573
  Technology |      1.28    0.784199
Average_mo~s |      1.23    0.812986
-------------+----------------------
    Mean VIF |      1.37

.

. linktest

      Source |       SS           df       MS      Number of obs   =       104
-------------+----------------------------------   F(2, 101)       =     45.88
       Model |  12.1523198         2  6.07615988   Prob > F        =    0.0000
    Residual |  13.3765264       101  .132440855   R-squared       =    0.4760
-------------+----------------------------------   Adj R-squared   =    0.4656
       Total |  25.5288462       103  .247852875   Root MSE        =    .36392

------------------------------------------------------------------------------
       MDOMS |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
        _hat |   1.709467   1.115695     1.53   0.129    -.5037715    3.922706
      _hatsq |  -.2272922   .3558603    -0.64   0.524    -.9332234     .478639
       _cons |  -.5271798   .8422684    -0.63   0.533    -2.198014    1.143654
------------------------------------------------------------------------------


. estat hettest

Breusch-Pagan / Cook-Weisberg test for heteroskedasticity 
         Ho: Constant variance
         Variables: fitted values of MaizeSources

         chi2(1)      =     0.11
         Prob > chi2  =   0.7363
```

Appendix D; Two Stage Least Squares (2SLS) Regression Results

```
. ivregress 2sls Log_Transformed_Gross_Margin Total_Revenue Quantity_Purchased Total_Cost_of_Maize Labour_Cost Packaging_Cost Fuel_Cost
Utility_Cost Distribution_Cost Age_of_Firm Averagesellingpriceofoneton ( Maize_Source_Binary= Firm_Location)

Instrumental-variables 2SLS regression            Number of obs   =         98
                                                  Wald chi2(11)   =      15.91
                                                  Prob > chi2     =     0.1443
                                                  R-squared       =     0.6514
                                                  Root MSE        =     .84115

------------------------------------------------------------------------------------------
Log_Transformed_Gross_Mar~n | Coefficient  Std. err.      z    P>|z|     [95% conf. interval]
----------------------------+-------------------------------------------------------------
        Maize_Source_Binary |     1.4934     1.1685     1.29   0.197     -.7715     3.7719
              Total_Revenue |     2.0312     1.5013    13.58   0.000     1.7412     2.3312
         Quantity_Purchased |      .0362      .0199     1.82   0.068    -2.7106      .0752
        Total_Cost_of_Maize |    -4.1910     1.2110    -3.47   0.001    -6.5610    -1.8310
                Labour_Cost |    -.7618      .4048    -1.89   0.059    -1.5625      .0911
             Packaging_Cost |     .5668      .4924     1.41   0.158     -.2238     1.3547
                  Fuel_Cost |     .6236      .3599     1.75   0.080     -.0728     1.3227
               Utility_Cost |    -.6619      .2318    -2.87   0.004    -1.1163     -.2111
          Distribution_Cost |     .3147      .2226     1.38   0.168     -.1317      .7631
                Age_of_Firm |     .0199      .0636     0.23   0.820     -.0111      .0199
Averagesellingpriceofoneton |    2.6107     1.2507     2.08   0.038     1.4708     5.0607
                      _cons |   21.3986     1.1211    19.10   0.000    19.2035    23.5962
------------------------------------------------------------------------------------------
Endogenous: Maize_Source_Binary
Exogenous:  Total_Revenue Quantity_Purchased Total_Cost_of_Maize Labour_Cost Packaging_Cost
            Fuel_Cost Utility_Cost Distribution_Cost Age_of_Firm
            Averagesellingpriceofoneton Firm_Location
```

```
. regress Maize_Source_Binary Total_Revenue Quantity_Purchased Total_Cost_of_Maize Labour_Cost Packaging_Cost Fuel_Cost Utility_Cost
Distribution_Cost Age_of_Firm Averagesellingpriceofoneton Firm_Location

      Source |       SS           df       MS      Number of obs   =        98
-------------+----------------------------------   F(11, 86)       =      1.91
       Model |  8.07119145        11  .088290132   Prob > F        =    0.0483
    Residual |  2.45942079        86  .198365358   R-squared       =    0.1967
-------------+----------------------------------   Adj R-squared   =    0.0939
       Total |  10.5306122        97  .108563013   Root MSE        =    .31363

------------------------------------------------------------------------------------------
        Maize_Source_Binary | Coefficient  Std. err.      t    P>|t|     [95% conf. interval]
----------------------------+-------------------------------------------------------------
              Total_Revenue |    -3.1414     5.6814    -0.55   0.583    -1.4413     8.1614
         Quantity_Purchased |     -.0013     6.1406    -2.12   0.037     -.0252    -8.0507
        Total_Cost_of_Maize |    -6.4813     4.5011    -0.01   0.989    -9.0211     8.8911
                Labour_Cost |      .2865      .0913     3.05   0.003      .0926      .4633
             Packaging_Cost |     -.1128      .1371    -0.84   0.401     -.3945      .1589
                  Fuel_Cost |     -.1577      .1179    -1.40   0.164     -.3804      .0651
               Utility_Cost |      .0509      .0813     0.66   0.512     -.1076      .2194
          Distribution_Cost |     -.0619      .0895    -0.79   0.433     -.2261      .0924
                Age_of_Firm |     2.2606      .0257     0.00   0.999     -.0476      .0451
Averagesellingpriceofoneton |     1.7108     4.7308     0.36   0.718    -7.6808     1.1107
              Firm_Location |     -.1883      .0817    -2.31   0.023     -.3463     -.0236
                      _cons |     1.0543      .1719     6.04   0.000      .7949     1.3982
------------------------------------------------------------------------------------------
```

```
. ivregress 2sls Log_Transformed_Gross_Margin_2 Total_Revenue Quantity_Purchased Total_Cost_of_Maize Labour_Cost Packaging_Cost Fuel_Cost
Utility_Cost Distribution_Cost Age_of_Firm ( Maize_Source_Binary= Financial_Constraints)

Instrumental-variables 2SLS regression          Number of obs     =        106
                                                Wald chi2(10)     =      12.37
                                                Prob > chi2       =     0.2611
                                                R-squared         =     0.6763
                                                Root MSE          =     .78221

-------------------------------------------------------------------------------------
Log_Transformed_G~n | Coefficient  Std. err.      z    P>|z|     [95% conf. interval]
--------------------+----------------------------------------------------------------
Maize_Source_Binary |     1.1083     1.1576     1.00   0.318     -1.0627     3.2793
      Total_Revenue |     2.0012     1.3713    14.62   0.000      1.7312     2.2712
 Quantity_Purchased |      .0284      .0018     1.58   0.115     -6.9006      .0637
Total_Cost_of_Maize |    -3.9610     1.1210    -3.54   0.000     -6.1510    -1.7710
        Labour_Cost |    -.4972       .3318    -1.48   0.138     -1.1704      .1521
     Packaging_Cost |      .2874      .3535     0.80   0.423      -.4036      .9708
          Fuel_Cost |      .6217      .3256     1.87   0.061      -.0276     1.2451
       Utility_Cost |     -.5852      .2336    -2.82   0.005      -.9931     -.1709
  Distribution_Cost |      .2337      .1914     1.20   0.229      -.1466      .6211
        Age_of_Firm |      .2313      .5887     0.39   0.696      -.0969      .0196
              _cons |    21.8396     1.0772    20.38   0.000     19.7397    23.9424
-------------------------------------------------------------------------------------
Endogenous: Maize_Source_Binary
Exogenous:  Total_Revenue Quantity_Purchased Total_Cost_of_Maize Labour_Cost
            Packaging_Cost Fuel_Cost Utility_Cost Distribution_Cost Age_of_Firm
            Financial_Constraints
```

```
. regress Maize_Source_Binary Total_Revenue Quantity_Purchased Total_Cost_of_Maize Labour_Cost Packaging_Cost Fuel_Cost Utility_Cost
Distribution_Cost Age_of_Firm Financial_Constraints

      Source |       SS           df       MS      Number of obs   =       106
-------------+----------------------------------   F(10, 95)       =      1.88
       Model |  1.88123289        10  .188123289   Prob > F        =    0.0580
    Residual |  9.52442749        95  .100257131   R-squared       =    0.1649
-------------+----------------------------------   Adj R-squared   =    0.0770
       Total |  11.4056604       105  .108625337   Root MSE        =    .31663

-------------------------------------------------------------------------------------
Maize_Source_Binary | Coefficient  Std. err.      t    P>|t|     [95% conf. interval]
--------------------+----------------------------------------------------------------
      Total_Revenue |    -2.6814     5.6414    -0.48   0.635     -1.3913     8.5114
 Quantity_Purchased |     -.0127     6.1406    -2.07   0.041      -.0249    -5.1807
Total_Cost_of_Maize |     5.3613     4.5211     0.01   0.991     -8.9211     9.0211
        Labour_Cost |      .2356      .0829     2.68   0.009       .0608      .4064
     Packaging_Cost |     -.1651      .1219    -1.31   0.192      -.4073      .0871
          Fuel_Cost |     -.1477      .1002    -1.35   0.181      -.3652      .0638
       Utility_Cost |      .0236      .0096     0.58   0.566      -.1137      .2009
  Distribution_Cost |      .0271      .0792     0.02   0.981      -.1577      .1518
        Age_of_Firm |      .0101      .0277     0.04   0.966      -.0463      .0484
    Financial_Cons |     -.1781      .0746    -2.24   0.028      -.3282     -.0198
              _cons |     1.0524      .1437     7.31   0.000       .7898     1.3647
-------------------------------------------------------------------------------------
```

```
. estat endogenous

  Tests of endogeneity
  Ho: variables are exogenous

  Durbin (score) chi2(1)          =  9.23729  (p = 0.0024)
  Wu-Hausman F(1,5)               =  5.27079  (p = 0.0701)


. estat firststage

  First-stage regression summary statistics
```

Variable	R-sq.	Adjusted R-sq.	Partial R-sq.	F(4,4)	Prob > F
Cost_of_ma~e	0.9811	0.9195	0.9580	22.8018	0.0051

```
  Minimum eigenvalue statistic = 22.8018

  Critical Values                      # of endogenous regressors:    1
  Ho: Instruments are weak             # of excluded instruments:     4
```

	5%	10%	20%	30%
2SLS relative bias	16.85	10.27	6.71	5.34
	10%	15%	20%	25%
2SLS Size of nominal 5% Wald test	24.58	13.96	10.26	8.31
LIML Size of nominal 5% Wald test	5.44	3.87	3.30	2.98

Appendix E; Publications

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Determinants of the Maize Milling Firms' Decision to Import or Purchase Locally Produced Maize in Kenya; A Bivariate Probit Analysis

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Abstract

Cyclical shortages in the supply of maize in Kenya have significantly affected operations of commercial maize milling firms in the country, forcing some to shut down. Most of the firms have been compelled to import maize from other regions, which is expensive. A dilemma therefore arises among the firms whether to import maize or use domestically produced maize and which alternative best maximizes their incomes. This study aimed to assess the determinants of the maize milling firm's decision to import or use locally produced maize. A total of 106 commercial maize milling firms that produce packaged maize flour were surveyed. Data collected was analyzed using Bivariate Probit model. Results indicate that employee skill level, average sales per month, licenses, government subsidies and purchases through NCPB were significant in influencing both the firm's decision to use locally produced maize only and the decision to use both locally produced and imported maize. Daily production capacity was found to influence the firm's decision to use locally produced maize only but had no significant influence on the decision to use both locally produced and imported maize. Based on the findings, the study recommends that micro, small and medium milling firms be sensitized to adopt advanced milling technology in their operations. Further, commercial maize milling firms should build the capacity and skill set of their employees through on-job training, employee workshops and performance appraisal programs. This will enhance production efficiency and enable firms increase their production capacity and purchase more maize from both local and import sources.

Keywords: Maize milling, Bivariate probit model, Maize, Import, Kenya

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Research Article

Tradeoffs Between Maize Importation and Reliance on Local Production: A Case of Commercial Maize Millers in Kenya

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Abstract

The supply of maize in Kenya has often fallen short of the demand resulting to an influx of cheap maize imports from neighboring countries. Tradeoffs thus arise among commercial maize milling firms whether to import or use locally produced maize in their operations and which alternative maximizes their income. This study aimed to determine the effect of tradeoffs between maize importation and reliance on local production on the income of commercial maize milling firms in Kenya. Data was collected from 106 commercial maize milling firms that produced packaged maize flour. A census of the entire population was employed and a semi-structured questionnaire used to guide personal interviews and online surveys with the respondents. Data was analyzed using descriptive analysis, gross margins and two-stage least square regression. Results indicate that firms that used locally produced maize only were majorly micro to medium-scale, had relatively low-skilled employees, lower production capacity and employed relatively less sophisticated technology. Firms that used locally produced maize only in their operations realized higher incomes and lower cost of procuring maize monthly compared to firms that used both locally produced and imported maize. Additionally, the determinants of firm's income were the miller's decision on maize source, total number of employees, total cost of maize, mean monthly sales and mean production costs. Therefore, government policies should be geared towards lowering the cost of procuring maize from both local and import sources. These include reviewing import duties on food grain, streamlining cess collection across counties and improving road infrastructure.

Keywords

Commercial Maize Milling Firms, Trade Offs, Two-Stage Least Square Regression

Appendix F; Research Permit

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