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Modelling trends in spatial market integration in the post-liberalized era: A case of maize markets in Kenya

By

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Thesis submitted in partial fulfilment of the requirements for the degree

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DECLARATION

I declare that the thesis, which I hereby submit for the degree of Doctor in Philosophy in Agricultural Economics at the University of Pretoria, is my own work and has not been previously submitted by me either in whole or in part for degree purposes at any other university.

Parts of the thesis have been published and submitted for publications in peer review journals.

SIGNATURE…………………………

DATE: April 2019

Name: Raphael Gitau Kanyingi

DEDICATION

I dedicate this to my late parents, Raphael Kanyingi Gitau and Lucy Wanjiru Kanyingi. Their love, patience, selfless support, and motivation, over time, have laid the foundation for the discipline and application necessary to complete this work.

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Finally, I give glory to God for his abundant blessings.

Raphael Gitau Kanyingi
Pretoria South Africa
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ABSTRACT

MODELLING TRENDS IN SPATIAL MARKET INTEGRATION IN THE POST-LIBERALIZED ERA: A CASE OF MAIZE MARKETS IN KENYA

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Kenya has continued to be beleaguered by high and unstable food prices since 2009. This is despite the stabilization and decline in world food prices. The government perceived the persistent high food prices as a failure by the markets, and therefore embarked on implementing various trade and marketing policies aimed at stabilizing food prices. In order to discern the causes of persistent high food prices in Kenya, this study pursued three objectives: (1) to examine the degree and extent of spatial market integration across the domestic, regional and world markets; (2) to examine the effects of government policy interventions on spatial market integration across domestic, regional and world markets; and (3) to examine the effects of shifts in domestic commodity supply and demand dynamics on maize price formation.

Results from the study indicated that 13 out of 14 market pairs from the domestic markets were integrated. Market pairs that were further apart were less integrated, compared with the market pair closer to each other. All the domestic and regional markets had a long-run relationship and were integrated. Shocks in the domestic markets were eliminated faster than shocks emanating from the regional markets were. In addition, the domestic markets were better integrated with the Ugandan markets than the Tanzanian markets. The domestic and the world markets were integrated and had a long-run relationship. Shocks emanating from the regional markets dissipated faster, compared with shocks emanating from the world markets.

Regarding the effects of government policy interventions, the markets were less integrated during the regime of heavy government interventions, as compared with the regime of minimal

policy intervention. The policy interventions to stabilize food prices not only failed, but also further exacerbated the situation by leading to a low extent and degree of market integration.

Regarding the local dynamics in demand and supply, the decision by farmers to plant maize was less influenced by the price incentive. Just as with most staples, maize was highly inelastic to changes in price and income. Rainfall and technology (high-yielding variety) adoption played an important role in maize production as it contributed to a significant decline in imports and maize prices. The removal of an import tariff during the time of poor harvest helped to shield consumers from high food prices. The removal of the fertilizer subsidy was detrimental to food security, as maize prices increased significantly, while the cost of food imports were 20% higher compared with the cost of the subsidy.

The government should endeavour to create a conducive policy environment that allows markets to operate freely, thus reducing uncertainty. Interventions in the market by the government should be transparent and strictly adhere to market forces. Such interventions should aim at deepening regional trade through collective action by regional governments for tackling challenges that hinder arbitrage in the regional trade. To ensure that consumers benefit from lower food prices, the government should lift the GMO import ban and remove the import duty on maize.

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LIST OF ACRONYMS

AAK	Agro-chemical Association of Kenya
ADF	Augmented Dickey Fuller
AEZ	Agro-Ecological Zone
AFC	Agricultural Finance Cooperation
AIC	Akaike Information Criterion
CA	Communication Authority of Kenya
CAPRI	Common Agricultural Policy Regionalised Impact
CGA	Cereal Grower Association
CIMMYT	International Centre for Improving Maize and Wheat
COMESA	Common Market for Eastern and Southern Africa
CPI	Consumer Price Index
EAC	East Africa Community
ECM	Error Correction Model
EPP	Export Parity Price
ESA	Eastern and Southern Africa
EU	European Union
FAMIS	Food and Marketing Information System
FAO	Food and Agriculture Organization
FCRI	Food Crop Research Institute
FEWS-Net	Famine Early Warning System Network
FRS	Food Relief Services
GAP	Global Agricultural Perspective System
GDP	Gross Domestic Product
GIEWS	Global Information and Early Warning System
GMO	Genetically Modified Organisms
HQ	Hanna-Quinn Information Criterion
ICT	Information Communication Technology
IMF	International Monetary Fund
IPP	Import Parity Price
KACE	Kenya Agricultural Commodity Exchange
KEPHIS	Kenya Plant Health Inspectorate Services

KMD	Kenya Metrological Department
KNBS	Kenya National Bureau of Statistics
KPSS	Kwiatkowski-Phillips-Schmidt-Shin
KSC	Kenya Seed Company
LASSO	Least Absolute Shrinkage and Selection Operator
MIS	Market Information System
MLND	Maize Lethal Necrosis Disease
MOALF	Ministry of Agriculture, Livestock and Fisheries
MPB	Maize and Produce Board
NBA	National Biosafety Authority
NCPB	National Cereal and Produce Board
OLS	Ordinary Least Square
OPV	Open Pollinated Varieties
PBM	Parity Bound Model
PCPB	Pest and Control Product Board
PP	Phillips–Perron
RATIN	Regional Agricultural Trade Intelligence Network
ROW	Rest of the World
SAPs	Structural Adjustment Programs
SC	Schwarz information criterion (SC)
SGR	Strategic Grain Reserve
SMS	Short Message Service
SSA	Sub-Saharan Africa
STAK	Seed Trader Association of Kenya
TAR	Threshold Auto-Regression
TECM	Threshold Error Correction Model
USA	United States of America
USDA	United State Department of Agriculture
WB	World Bank
WB	Wheat Board
WSC	Western Seed Company
WWI	First World War
WWII	Second World War

CHAPTER 1: INTRODUCTION

1.1 BACKGROUND

The stagnation in food production, the outpacing of production by consumption, and high and volatile food prices have become a concern to policy makers and policy analysts in Sub-Saharan Africa (SSA). Stable and affordable food prices play a critical role in many developing economies. There are welfare gains associated with stable and affordable food prices. Food prices have a strong multiplier effect on non-farm rural enterprises, labour and other interlinked sectors. The majority of the rural and urban poor households in developing economies spend a large proportion of their expenditure on food. Studies have shown that households are willing to forgo a portion of their income to stabilize food prices. High and unstable food prices threaten to reverse the gains achieved in poverty reduction strategies, as resources meant for development are diverted to address price hikes (Haggblade et al., 2008; Diao et al., 2008; World Bank, 2009; Abott et al., 2011;Bellemare et al., 2013).

The unprecedented high world food crisis witnessed during 2007/08 brought sharp a focus onto the effects of high food prices in developing economies. The world food price hikes were manifested across many developing economies through an increase in incidents of hunger, malnutrition, food aid, food riots and food-insecure populations. The majority of governments in the developing economies instituted several emergency measures, which included food aid, input subsidies, tax adjustments and policy instruments, to mitigate the harm caused by this phenomenon. Despite a decline in world food prices, many countries in the East and Southern African (ESA) region continued to be plagued by persistent high and volatile food prices after 2008 (Minot, 2014; OECD-FAO, 2016).

In Kenya, the trend in food inflation exhibited an upward trend from 2009. This upward trend continued, despite the stabilization in world food inflation and its subsequent decline. International food prices stabilized in 2009. Food prices in Kenya continued to rise from 2009 to 2011, and remained high thereafter (Nzuma, 2013). The author noted that the maize and wheat consumer price indexes (CPI) in Kenya were higher than the global CPI. Following the decline in international high food prices, food prices in Kenya continued on an upward trend, with a rapid increase in food inflation, as compared with non-food inflation. The gap widened especially after 2009 (ReSAKSS, 2009; Karugia et al., 2010; Nzuma, 2013). David et al. (2016) noted that Kenya and Mozambique recorded the highest maize prices in the ESA between 2008 and 2014. The prices in Kenya and Mozambique for a ton of maize were US$ 390 and 410, respectively, while in the rest of the countries in the region, the price was less than US$ 300 per ton.

Prices play an important role in the economy. They equilibrate demand and supply, and act as the most efficient allocator of resources, especially when they reflect circumstances of scarcity. Therefore, a clear understanding of why prices change the way in which the different players are affected, either along the marketing chain or across space, may help in mitigating high and volatile food prices. Well-functioning markets guarantee smooth trade flow and exchange of food products between surplus and deficit regions, as well as mitigating famine and facilitating the design of successful price-stabilization policies. Well-functioning markets act as a driver for escaping poverty by poor households, provide opportunities for welfare improvement, and ensure a well-functioning economy (Ravallion, 1986; Dercon, 1995; Baulch, 1997b; Fackler and Goodwin, 2001; Krishna et al., 2004;Abunyuwah, 2008; Ihle et al., 2009; Abunyuwah, 2013).

The ESA region has continued to be plagued by high and volatile food prices, despite a decline in international food prices. Theoretically, the decline in international food prices ought to have been transmitted to domestic markets in the ESA region. Hence, other factors are in play that may explain the continued unabated high food prices in the region. Domestic markets and, in some cases, regional markets, play a significant role in the movement of the staple food across the ESA region. Therefore, domestic factors, and to some extent regional factors, play a crucial role in the determination of staple food prices. These factors may be market specific, such as demand and supply shock, or macroeconomic specific, such as capital flow and policy shocks. In addition, the region is self-sufficient or almost self-sufficient in staple foods such as maize. Hence, international staple markets have had little or no effect on domestic markets. A combination of all these factors might explain why the region has continued to face volatile and high food prices (Benson et al., 2008; Cudjoe et al., 2010; Gilbert and Morgan, 2010;Gilbert,2010;Minot, 2011; Baltzer, 2013; Minot, 2014). Focusing greater numbers of studies on gaining an understanding of the local dynamics in demand, supply, policy shocks and improving domestic and regional markets would improve food security, facilitate the smooth flow of food from the surplus to the deficit regions, and stabilize food prices.

Market reforms in most countries in Africa were instituted in the late 1980s and early 1990s. The objectives of the reforms were to ensure optimal resource allocation. Prior to liberalization, the governments were the major players in the market, as they set commodity prices and distributed most commodities. Over the two and half decades after liberalization, the reduction in government intervention in agricultural markets and the entry of private traders has been witnessed in the ESA regions (Jayne and Jones, 1997; Nyoro et al., 1999; Meyers, 2008; Myers, 2013). The development of market mechanisms that reduce the vulnerability of the rural and urban populations to price instability has continued to be a major challenge facing many governments in the ESA region following market reforms. Soaring high food prices exacerbated the exposure of price instability to vulnerable urban and rural poor population. Market integration and efficiency studies have gained more attention in literature for the purpose of understanding the effects of market reform on the economy. The objectives of these studies have been to understand the impact of market-oriented reforms on the spatial, intertemporal extent and competitiveness in the developing economies (Baulch, 1997b). The impacts of market reform on market integration and efficiency in SSA have yielded mixed results. Some studies found improved market integration after liberalization (Badiane and Shively, 1998; Loy and Wichern, 2000; Baffes and Gardner, 2003; Rashid, 2004; Van Campenhout, 2007; Ikudayisi and Salman, 2014), while other studies found no improvement (Poulton et al., 1998; Negassa et al., 2004; Fafchamps, 2004; Lutz et al., 2006; Negassa and Myers 2007). As noted by Abdulai (2007), though liberalization was necessary, it was not sufficient for the achievement of structural changes in market integration, and a holistic approach was necessary if researchers were to understand and address the issue of low market integration.

Policy makers in most developing economies are more interested in answering the question of 'why' markets are not integrated. Hence, stand-alone market integration studies may not have an impact on policy guidance, as noted by Rashid and Minot (2010). Researchers have complemented market integration studies with market-specific or complementary qualitative information for studies to contribute to policy work. Complementary studies have provided an in-depth understanding of the dynamics of policy interventions, the degree of market power exerted by different agents along the supply chain, price formation and demand, and supply shocks, among other factors. All these factors play a critical role in the dynamics of domestic markets and thus need to be considered in order to inform policy (Abunyuwah, 2012; Kabbiri et al., 2016).

In an effort to mitigate the high and volatile food prices in the ESA region, most governments have implemented a wide range of marketing and trade policy instruments. This raises the question of how successful these efforts have been in stabilizing food prices. The success of policies is dependent on a government's ability to implement specific policies. Most policies implemented in the ESA region may be characterized as erratic, highly discretionary, sudden, and inconsistent. Consequently, most policies implemented to stabilize food prices have not achieved their desired effects, as shown by various studies (Minot, 2011; D'hôtel et al., 2013; Chapoto and Sitko, 2014; Bryan, 2015; Gitau and Meyer, 2018). In addition, evidence of high price volatility was observed in the ESA region in countries where there were heavy government interventions, as compared with the countries that had minimal interventions (Chapoto and Jayne, 2009; Jayne and Tschirley, 2010; Jayne, 2012).

1.2 RESEARCH PROBLEM

Kenya has continued to face high food prices, despite a decline in world food prices. In addition, the price volatility of key staples, such as maize, was higher in Kenya than in Uganda and Tanzania. During the period between 2003 and 2012, the price volatility of maize was 0.28, 0.16 and 0.08 for Kenya, Uganda and Tanzania, respectively. (Nzuma et al., 2013). Volatile and high food prices pose a major challenge to food security, given that 32% of the Kenyan population are food poor and that 3.9 million Kenyans require emergency food at any particular time. An estimated 36% of the population in Kenya lives below the poverty line[1]. These vulnerable poor rural and urban populations spend approximately 65% of their household expenditure on food items (KNBS, 2018). Maize is a major staple crop in Kenya, and as the most common crop grown by farmers, its security is closely linked with food security (Nyoro et al., 1999; Kirimi et al., 2011).

Stable and affordable food prices ensure welfare gain because of their strong multiplier effects on non-farm rural enterprise, labour and other interlinked sectors in Kenya. By 1995, the maize

1 The poverty line used is based on the US$ 90 per day required for sustenance (KNBS, 2018)

sector was fully liberalized. Studies conducted to assess the impact of the reforms on the maize sector reported the existence of increased players along the value chain, improved competition, and a decline in maize prices, with the biggest decline being recorded between surplus and deficit regions (Jayne and Argwings-Kodhek, 1997; Nyoro et al., 1999; Nyoro et al., 2004; Kirimi et al., 2011). Despite the enumerated success of market reforms, these studies identified high transport costs, limited market information, price instability and uncertainty over government policy interventions as being the major challenges facing the post-liberalized maize sector. The high transport costs were attributed to poor roads connecting production areas and markets, and between markets.

The poor states of rural roads in Kenya have contributed to high transport costs, as identified by a World Bank study (2009). The study identified three transportation segments. The first segment was involved in transporting grains from the farm gate to the primary market. The second segment was involved in transporting grains from the primary to secondary markets, while the final segment was involved in moving grains from secondary markets to wholesaler/miller markets. The cost of transporting one ton of grain per kilometre in the second segment was 0.3 US$, compared with 0.11 US$ per ton per kilometre spent in the final segment. The high transportation costs in the second segment were attributed to the poor roads connecting these two markets. The costs reduced significantly in the final segment due to the better roads connecting the markets in these segments, as compared with the second segment.

The Kenyan public road network, comprising both classified[2] and unclassified roads, stands at 161,451 kilometres. Classified roads comprise 39%, while unclassified roads make up 61% of the total road network. Under the classified road network, 86% of the road networks is unpaved[3] while 98% is unpaved under the unclassified road network. Overall, 93% of the total road network in Kenya is unpaved. Of the total unpaved roads, 59% has been classified as being in poor condition (Kenya Roads Board, 2015). When compared with other regions, the Kenyan costs of transporting a ton per kilometre are higher. Transporting one ton per kilometre in Kenya costs US$ 0.15, compared with US$ 0.06 and 0.05 in the Western and Southern Africa regions, respectively (Teravaninthorn and Raballand, 2009). The high costs of transportation,

[2] This are the road classified by the Ministry of Transport under the first schedule of the Kenyan Roads Act into six categories (A to F) depending on cities, town , major or minor centres connected by the road
[3] Unpaved road is a dirt road made of native material of the land surface through which it passes. The highway engineers refers to it as subgrade material. Improved forms of unpaved road includes gravel, laterite and murram

coupled with local government taxes imposed on agricultural commodities traversing through several counties, contribute to higher marketing costs. Hence, prices between two markets may be related in a non-linear manner, and appropriate methodologies are required to analyse the relationship between the two markets.

In an effort to mitigate and address price instability, the Kenyan government has implemented several measures. These measures have included the importation of food by the government to replenish national stock. Other measures included the adjustment of taxes through zero rating or reducing taxes on essential food commodities, and the reduction or removal of import duty on key staples such as maize, wheat and rice. The government also introduced a cash for work programme to provide poor households with income to buy food. The government has been involved in price stabilization measures through buying maize at a lower price during harvests, and releasing the stocks during lean periods. In addition, the government has implemented subsidy programmes aimed at producers (fertilizer) and consumers (maize meal). Despite these measures, Kenya has continued to be plagued by high food prices. For policies to achieve their desired effects, their effective implementation is crucial. Highly discretionary, erratic, sudden and inconsistent have been some of the terms used to describe policy implementation in Kenya and the ESA region. Consequently, the implemented policies may not have achieved their desired goals. For example, the price stabilization policy in Kenya has resulted in market distortions as the government succumbed to pressures from producers and politicians, and then offered prices higher than the prevailing market prices. Kamau et al. (2013) found that maize prices were stable during those seasons in which the NCPB did not participate in the market, as opposed to those seasons in which they did participate.

Focusing only on the reaction of economic agents to prices does not provide information for policy makers. The response to both price and other factors that shift supply and demand provides a comprehensive picture, which is thus more useful in formulating policy recommendations. Local dynamics play a critical role in shifts in demand and supply. On the demand side, factors such as population growth rate, rapid urbanization and per capita income growth influence demand, while high input costs, climate variability and technological shift affect the supply side. Equilibrating the supply and demand sides allows for analyses to be made of changes in prices, supply and demand that are attributable to various shocks such as weather, policy and technological shifts. These analyses contribute to the question “why”, which is important for policy makers.

There are limited studies in Kenya that have addressed spatial market integration. Firstly, the available studies on spatial market integration in Kenya have predominately applied cointegration and error correction models (ECM) (Gbegbelegbe and de Groote, 2012; Nzuma, 2013; Ngare et al., 2013). The use of cointegration and ECM models has been criticized as unreliable as they do not account for transaction costs. As discussed earlier, high transportation costs, coupled with market costs, may result in the prices between two markets being related in a non-linear manner. Omitting transaction costs may result in the over- or under-estimation of variables, thus leading to erroneous policy recommendations. Secondly, studies done on market integration in Kenya did not account for the effects of policies implemented on market integration. In order to address high food prices, it important to examine whether the policies implemented to mitigate soaring food prices have achieved their intended goals. Thirdly, the available studies in Kenya on market integration have focused on domestic and world markets, and have overlooked regional markets (Gbegbelegbe and de Groote, 2012; Nzuma, 2013). Finally, the studies that have been done did not account for the local dynamics in the shift in demand and supply or their influence on markets, and neither did they factor in price formation. To the best of our knowledge, no study has been done in Kenya that has addressed non-constant transaction costs and the effects of policies on spatial market integration. Moreover, no study has complemented the spatial market integration analysis with price formation, with market equilibrium models that address local dynamics in demand and supply shifts, or with ex-ante analysis of price and markets following simulation of various shocks. This study endeavours to address this gap.

1.3 OBJECTIVE OF THE RESEARCH

The government of Kenya perceived the soaring high food prices as a failure by the markets that justified its direct intervention in the market to stabilize food prices, despite the liberalization of the maize sector. In order to discern the causes of persistent high food prices in Kenya, it important to understand the markets. The main purpose of this study is to examine whether the markets are functioning well. Additionally, the study examines the effects of government policy interventions to stabilize food prices. The specific objective of the study includes ancillary objectives:

1. To examine the degree and extent of spatial maize market integration across the domestic, regional and world markets;
2. To examine the effects of government policy interventions on spatial maize market integration across the three market clusters described above; and
3. To examine the effects of shifts in domestic commodity supply and demand dynamics on maize price formation

1.4 HYPOTHESES

For this study, we tested the hypotheses that follow.

1. Shocks emanating from the previous month's long-run disequilibrium in surplus markets were eliminated relatively quicker than in the deficit markets.
2. The previous month's long-run disequilibrium shocks emanating from the regional markets (Uganda and Tanzanian) were eliminated relatively quicker than in the domestic markets.
3. The previous month's long-run disequilibrium shocks emanating from the Tanzanian market took longer to be eliminated from the domestic markets than the shocks originating from the Uganda markets.
4. Shocks emanating from the regional to the domestic markets were eliminated faster than shocks emanating from the world markets.
5. There was no integration and long-run relationship between the domestic and world markets.
6. Policies implemented to stabilize food prices limited arbitrage and distorted the market, leading to a decline in the extent of market integration in the domestic, regional and world markets.
7. Volatile and high food prices in Kenya are driven mostly by local dynamics in commodity supply and demand, as opposed to international price shocks.

1.5 CONTRIBUTION OF THE STUDY

This study contributes to spatial market integration in Kenya by incorporating the following aspects that earlier studies have overlooked. Firstly, the study incorporates varying transaction costs when investigating spatial market integration across surplus and deficit markets. Secondly, the effects of government policies implemented to mitigate soaring high food prices are investigated across the domestic, regional and world markets. Thirdly, the effects of domestic supply and demand dynamics, and their effects on price formation, are investigated. Finally, the study investigates market integration between domestic markets, domestic and regional markets, and domestic and world markets.

None of the existing studies used data that was more recent than 2011, and spatial market integration may change over time due to changes in policy, information systems and infrastructure improvement; hence, this study provides the latest information on market integration. This study combines spatial market integration with local dynamics in demand, supply, price formation and policy changes to provide a comprehensive approach to investigating the causes of high food prices in Kenya.

1.6 ORGANIZATION OF THE THESIS

The rest of the thesis is organized as follows. Chapter 2 provides information on the maize sector in Kenya. This chapter includes discussion of the evolution of the sector and its importance to the economy, the liberalization of the grain sector, agents along the value chain, price discovery, the market information system, and policy responses to high food prices. Chapter 3 discusses the approach and method used in this study. A review of the survey of relevant literature on spatial market integration and modelling maize markets is discussed. The analytical framework, empirical models, study area and data are also discussed in this chapter. Chapter 4 presents the results and discussions regarding spatial market integration and the modelling maize markets. The summary, conclusion and policy recommendations are presented in Chapter 5.

CHAPTER 2: MAIZE SECTOR IN KENYA

2.1 INTRODUCTION

In order to discern the causes of soaring food prices in Kenya, it is important to gain an in-depth understanding of the maize sector in general. This chapter lays the foundation by providing complementary information on the maize sector required for our analysis. The chapter is organized as follows; Section 2 outlines the evolution and importance of maize in the economy. Section 3 discusses the liberation of the sector, while the mapping out of the actors along the value chain is discussed in Section 4. Section 5 outlines the maize marketing processes and sources of maize during normal and poor harvest seasons in Kenya. The price discovery mechanism in the Kenyan maize market is discussed in Section 6. The market information system, storage facilities and the road network are discussed in Section 7. Section 8 outlines government policy responses to high food prices in Kenya, while Section 8 summarizes the chapter.

2.2 EVOLUTION OF MAIZE PRODUCTION AND ITS IMPORTANCE TO THE ECONOMY

2.2.1 Evolution of maize production

The maize sector in Kenya has undergone three major phases in its evolution. Critical turning points marked the different phases and helped to shape the sector. The three phases of evolution that the maize sector has undergone are set as follows.

First Phase: Post-independence and period of strict control (1963–1980)

Maize is the most important staple food in Kenya, followed by wheat and rice, respectively. The Portuguese introduced the crop to Kenya in the 16th century (Lynam and Hassan 1998). Maize gained prominence following the First World War (WWI). The war created a demand for exports of the crop; hence, white settlers and smallholders responded to the demand. By the end of the Second World War (WWII), the role of maize as a major food and cash crop had been consolidated.

After Kenyan Independence in 1963 and during the subsequent two decades, the government singled out maize as a major staple crop. Budgetary support was established for the production and marketing of maize. In addition, the government implemented policies that focused on the input subsidy, credit, research and extension services, and the monopoly of the marketing board that set the prices, and controlled the movement and distribution, of maize (Republic of Kenya, 1974; 1981; Nyangito and Kimenye, 1995). During this phase, the majority of small- and large-scale farmers in the high-potential zones adopted the high-yielding maize varieties that were released. In the low-potential zone, about half of the small-scale farmers adopted hybrid maize seed (Karanja,1996;Lynam and Hassan, 1998; Smale and Jayne, 2010). These measures resulted in an increase in maize production, as shown in Figure 2.1 below (page 14), which consequently resulted in surplus production.

From the mid-1970s to early 1980s, a decline in production was witnessed. The decline was attributed to the rapid growth in population, the shortage of land in high- and medium-potential areas, the reforms in the late 1980s that targeted input subsidy, credit, research and extension, and the monopoly of marketing boards. The drought experienced in 1980 exacerbated the situation (Nyangito and Kimenye, 1995). The decline in production, coupled with drought, resulted in a disparity between maize demand and production, consequently resulting in the development of the first comprehensive national food policy, known as Sessional Paper No. 4 of 1981 (Republic of Kenya, 1981). The policy anticipated sustaining broad self-sufficiency in major foodstuffs and ensuring equitable distribution of nutritional food to all citizens

Second Phase: Reform Phase (1980–1995)

Reforms in the sector started in 1987/88 under the cereal sector reforms, allowing for limited numbers of unlicensed maize traders. Further reforms were later introduced, such as the relaxation of inter-district movement of maize, the deregulation of grain and maize meal prices, and the removal of subsidies for millers. The sector was fully liberalized by 1995, following the reforms in the NCPB, the abolition of import tariffs, and the elimination of import licencing and foreign exchange controls. The implementation of the structural adjustment programmes (SAPs) and subsequent liberalization of the sector by the government was meant to broaden the role of market signals through the creation of a free market, with private sector participation, to improve the terms of trade and increase maize productivity (Republic of Kenya, 1986; 1997; Nyangito and Kimenye, 1995; Nyangito and Okello, 1998).

The second national food policy was developed during this phase after the 1994 drought through Sessional Paper No. 2 of 1994. The policy mainly promoted a market-driven approach to food security. In addition, the government switched its emphasis to integrated rural development where the emphasis was placed on projects aimed at improving rural infrastructure, alleviating poverty, and ensuring food security (Republic of Kenya, 1994). Services provided by the government (research and extension) became demand driven, with beneficiaries being required to support the services through levies. Private sector participation in research and extension was introduced. This phase was characterized by a decline in production, drought, poor economic performance, the collapse of government institutions such as the Agricultural Finance Cooperation (AFC), which provided credit to farmers, and changes in research and extension policy (Smale and Jayne, 2010; Smale et al., 2013;Onono et al., 2013).

Third Phase: Post-liberalized Era (1995–2015)

During this phase, an increase in private sector participation was observed along the maize value chain. (Jayne and Jones, 1997; Nyoro et al., 1999; Jayne et al., 2008). The role of the NCPB was revised, with its core function being the establishment, maintenance and distribution of strategic grain reserves (SGR) and food relief services (FRS). The non-core functions were commercialized (sale of inputs). The implementation of agricultural activities was devolved to the relevant County government, with the National government's role being policy formulation, following promulgation of the new constitution in 2010. During this phase, Kenya continued to experience soaring food prices, despite a decline in world food prices. The price volatility of key staples was higher than those in world prices. The volatility and food prices in Kenya were higher than in other countries in the ESA region, especially with respect to the key staples of maize and wheat (Meijerink et al., 2009; ReSAKSS, 2009; Karugia et al., 2010; Nzuma, 2013; David et al., 2016).

To mitigate the effects of the high food prices, the government implemented short- and medium-term measures to address this challenge, while being cognizant of the long-term measures aimed at addressing the challenge. The short-term measures were aimed at shielding the urban and rural poor against price hikes. The short-term measures instituted included the provision of food aid and the urban consumer subsidy on maize meals. The medium-term measures included tax adjustments, and trade and marketing policies. The long-term measure programmes include increased investments in agricultural research, key agricultural services, local infrastructure, value addition and macroeconomic policies. Table 2.1 below summarizes the various measures implemented and their challenges.

Table 2.1: The measures implemented by the government to address high food prices

Range	**Policy Action**	**Challenges**
Short-term (safety nets)	Reduces tariffs and zero-rated taxes on foodstuffs	Delays in removal of the tariffs; period of removal of tariffs not adequate
	Release of stock by NCPB to the market to reduce food prices	Stock not sufficient to affect prices as the same stock used in food aid
	Subsidized maize meal for urban poor consumers	Poor targeting – not distributed to the low-income areas , costly
	Government food imports	Costly, leakage through diversion of food to non-deserving households
	Food export bans	Existence of the informal route across the border allows food exports, despite the ban
Medium-term	Increase the strategic grain reserve minimum of 720 000 metric tons by NCPB. To be held in stock or cash equivalent	Availability of funds from the Treasury
	Producer subsidy (fertilizer and seed)	Poor targeting: small-scale farmers in remote areas cannot access the fertilizer
	Cash for work programme – infrastructure work and environmental clean up	High fiscal cost – not sustainable

Long-term	Increase in food production – increase in agricultural research, strengthen agricultural extension and financial services, invest in infrastructure	Funding to actualize all the factors that will contribute to increase in food production
	Macroeconomic policy management	External shocks that may affect stability of the of domestic macroeconomic

Sources: National Food and Nutrition Security (2011); and Nzuma (2013)

Figure 2.1 illustrates the trend in production, the areas harvested, and maize yields at the critical turning points that marked the three major phases that helped shape the sector.

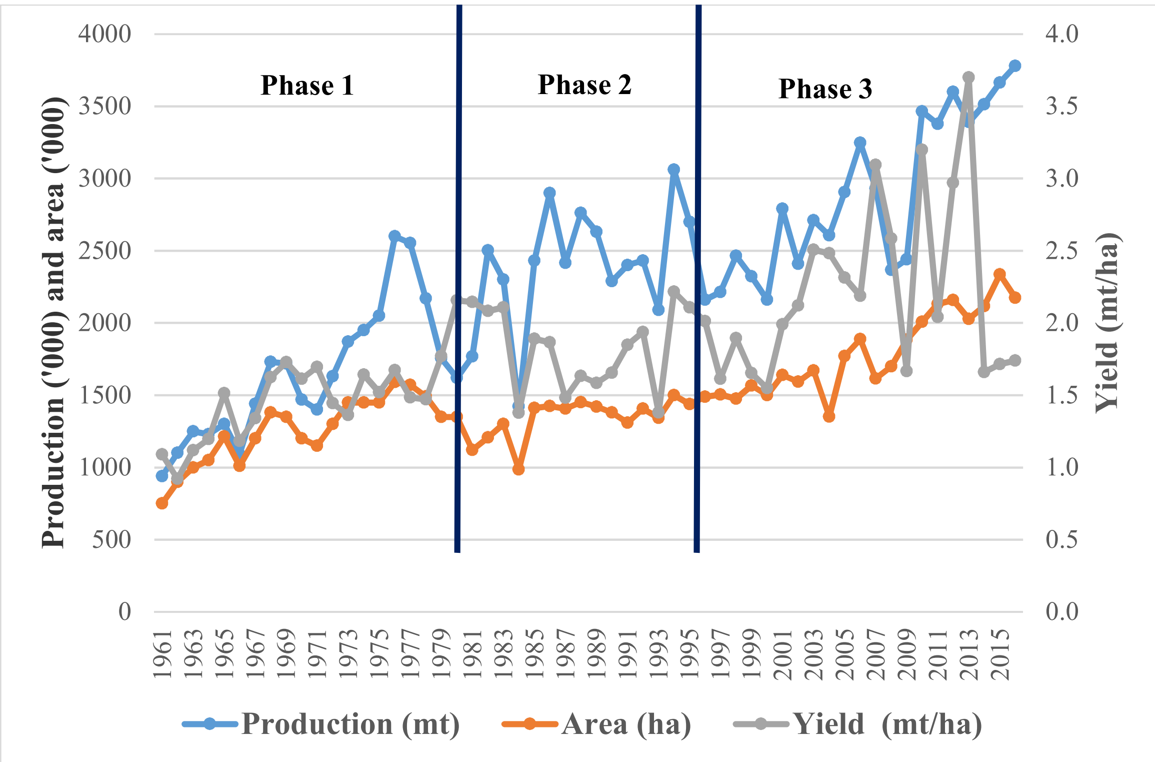

Figure 2.1: Area cultivated, production and maize yield in Kenya from 1961 to 2016

Source: FAOSTAT (1961-2015) and Economic Review of Agriculture (2000-2015)

2.2.2 Importance of maize in the Kenyan economy

Maize is the central crop in Kenyan agriculture. It takes up 56% of the total land area cultivated. Maize accounts for 51% of all staples grown and 40% of total crops grown in Kenya. The small- and medium-scale farmers[4] produce about 75% of the nation's maize crop, while large-scale farmers produce the rest. The crop is essential in the animal feed industry, where it is the primary ingredient, accounting for over 80% of feed rations (Kirimi et al., 2011; ERA, 2015; Abate et al., 2015). Maize provides roughly a quarter of the caloric intake for Kenya's population (OECD-FAO, 2016). Kenya has the highest per capita maize consumption, compared with its neighbours. The per capita consumptions of maize are 103, 31, and 72 kilograms per annum in Kenya, Uganda and Tanzania, respectively. The crop is grown across the seven major agro-ecological zones (AEZ) in Kenya. The Rift Valley region accounts for 51% of the country's total production, followed by the Nyanza and Western regions. The North Eastern region accounts for the lowest production, as it produces less than 0.1% of the national production (Abate et al., 2015).

Maize production in Kenya is dependent on rainfall. The average maize production over the past 15 years has been estimated at about 3.2 million metric tons, while consumption was 3.5 million metric tons (ERA, 2015; OECD-FAO, 2016). The deficit was covered through imports from Uganda and Tanzania during normal harvest seasons, and from the world markets during poor harvest seasons. The country has occasionally been self-sufficient during the years when it received higher rainfall. Figure 2.2 below illustrates the seasonal calendar in Kenya during a normal harvest year. The maize surplus and deficit regions have unique seasonal patterns, which complement each other. The surplus region (Western and Rift Valley) has one maize harvest season, with maize being harvested from October through to December, while the deficit region (Eastern and Northern) has two maize harvest seasons, February through to March and July through to September, with the lean maize season being from August through to November.

4 The classification of farmers in Kenya is in accordance with land owned. Small-scale farmers own less than 2 hectares, medium-scale farmers own between 2 and 10 hectares, while large-scale farmers own over 10 hectares (Nyoro et al., 1999).

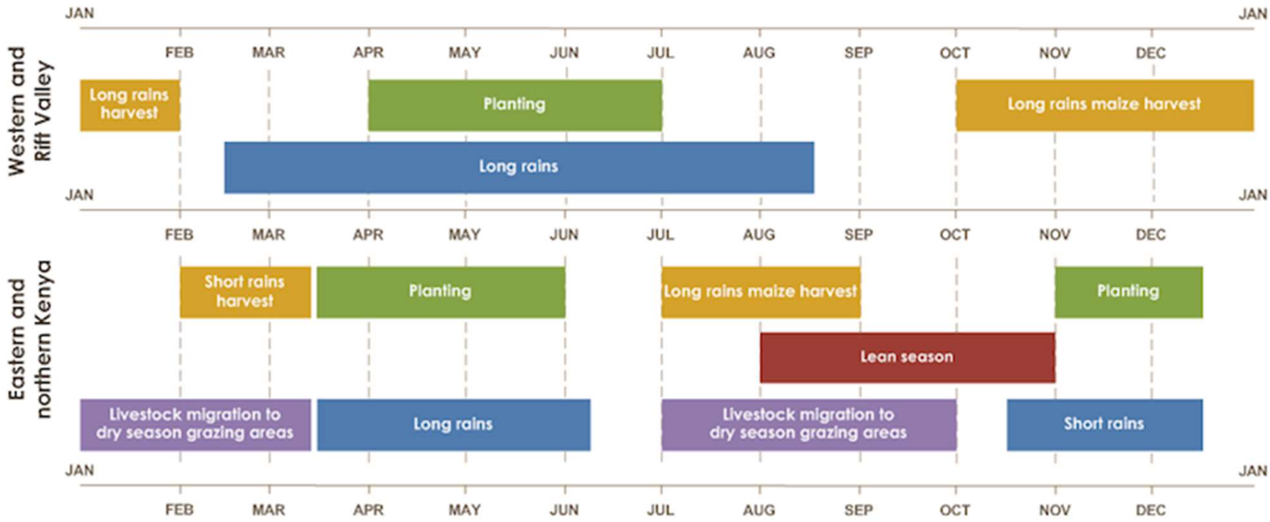

Figure 2.2: Seasonal calendar during a typical year
Source: FEWS-NET http://fews.net/east-africa/kenya

Although small-scale farmers produce 75% of the maize, that maize is consumed within the households and they only sell an estimated 20% of their production. In Kenya, 52% of small-scale farmers are net-buyers[5] of maize, while 11% are purely subsistence producers (Jayne et al., 2010; Kirimi et al., 2011; Abate et al., 2015). Table 2.2 below summarizes the Out average production and consumption of major staples in Kenya in the past two decades (between 1996-2005 and 2006-2016). On average, maize production increased by 30%, while consumption increased by 23% within the same period. Out of the three staples, rice recorded the highest growth rate with respect to production and consumption. The growth in rice may be attributed to changes in economic and social structure that affected consumption pattern and dietary preference. Increase in income and urbanization are examples of economic and social structure changes that may have resulted in changes in the household consumption pattern from coarse grain to rice, dairy and animal products (Jayne et al., 2009; Kamau et al., 2011; Onyango et al., 2016). This may explain the increase in consumption of rice by 183%.

5 Net-buyers are farmers who buy more maize than they sell.

Table 2.2: Average production and consumption of major staples in Kenya over the past two decades between 1996-2005 and 2006-2016

Staples	Avg. Production ('000)			Avg. Consumption ('000)		
	1996-2005	2006-2016	% Δ	1996-2005	2006-2016	% Δ
Maize	2,474	3,227	30	2,800	3,440	23
Wheat	295	337	14	787	1,418	80
Rice	47	88	87	155	439	183

Source: Author computation using Economic Review of Agriculture (2000–2015) and FAOSTAT (1996–2015)

In Kenya, 98% of rural households cultivate maize (Kirimi et al., 2011). Maize plays a critical role in the welfare of the rural households as it contributes about 30% to their gross value of crop income and 11% to their overall total household income (Suri et al., 2008; Kirimi et al., 2011). In Kenya, a survey of households reported the maize income contribution was 47% and 9% to gross crop income and gross total household income, respectively (Njagi et al., 2015). Figure 2.3 below illustrates the contribution of maize to gross crops and total household income across different AEZs. The lower highland zone's contribution of maize to crop income was the highest, at 86%. This zone covers the three major maize-producing counties in Kenya.

Maize plays an important role in achieving food security for poor households. Urban and rural consumption studies show a declining importance of maize in the household food basket, with an increasing consumption of Irish potatoes, rice and plantains. Although the decline was witnessed across all the income groups, the highest decline was recorded among households in the highest income group. Hence, maize still plays an important role among poor rural and urban households (Kamau et al., 2011: Onyango et al., 2016).

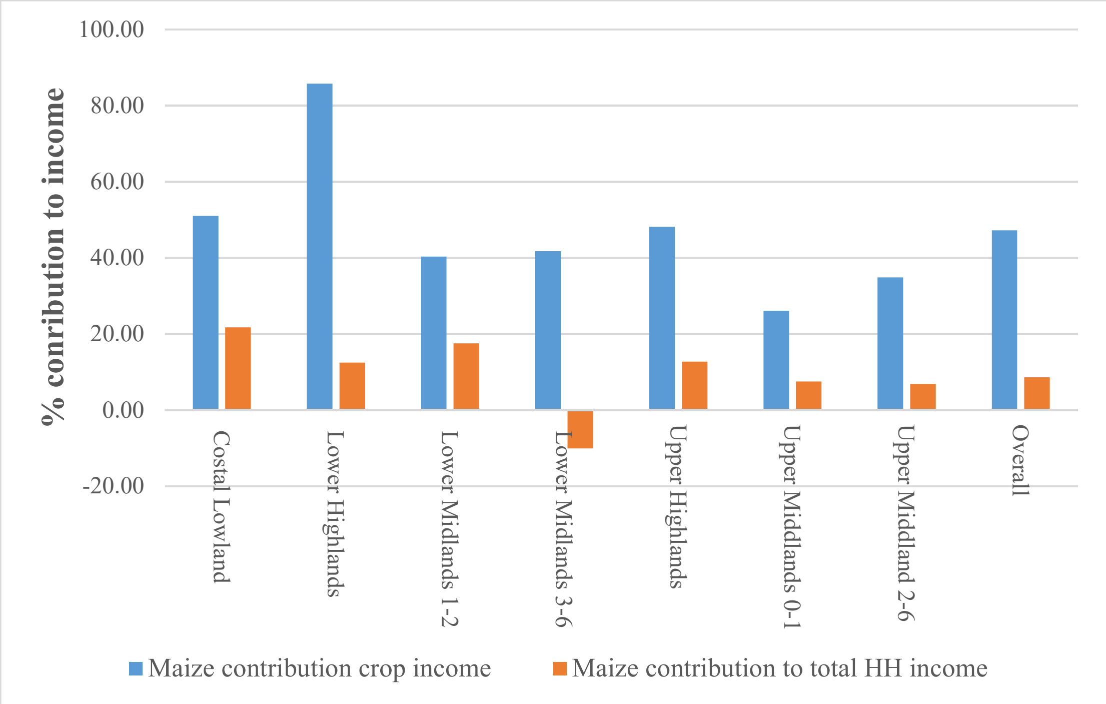

Figure 2.3: The contribution of maize to the crop and total household income by AEZ in 2014

Source: Njagi et al. (2015)

2.3 LIBERALIZATION OF THE GRAIN SECTOR

2.3.1 Market reforms in the agricultural sector

The liberalization of the grain sector was intertwined with the structural adjustment programmes (SAPs) that started in the 1980s and 1990s. The SAPs were aimed at the restructuring of the agricultural sector. The concept behind the reforms was the efficiency of market mechanisms, as opposed to the inefficiency of the state, and the elimination of distortion effects from the state (rent seeking, misallocation of resources, etc.) (Oya, 2005). However, as a result of macroeconomic instability and fiscal deficits during the 1980s and 1990s, developing economies were in a poor state; hence, the World Bank (WB), International Monetary Funds (IMF), and development partners established a development agenda that governments in developing economies were obligated to adhere to, if they were to receive assistance (Sender, 2002).

Studies have shown challenges with regard to evaluating the overall effects of the reforms with respect to their implementation, sequencing and mediation. Various authors have advanced several reasons. These include the availability of quality data, lack of consensus on appropriate timing and sequencing, varying degrees of reform implementation, partial implementation, policy reversals, political processes, and political transition costs that are yet fully understood by conventional analyses (Goletti and Babu, 1994; Gibbon et al., 1993; Kherellah et al., 2002; Dorward et al., 2004; Oya, 2007). Despite these challenges, some mixed results of reforms have been documented across the continent. An increase in output, albeit for a short period, for export crops has been noted (Kherellah et al., 2002). Furthermore, a significant decline has been noted in real producer prices of export and food crops in a country such as Kenya (Karanja et al., 2003; Jayne et al., 2010). Moreover, various authors have identified the entry of more numbers of private intermediaries along the value chain promoting competition, declining marketing margins, and improvement of market integration (Barrett, 1997; Oya, 2001; Kherellah et al., 2002; Peters, 2006; Oya, 2007).

The increase in private intermediaries along the agricultural marketing chain was concentrated downstream at the farm-gate, and secondary markets had fewer entries upstream, hence little value addition (Dorward et al., 2004). Oya (2007) observed three forms of transition following liberalization. The first form was characterized by the entry of new private traders in food crops. The second form was in respect to export crops where vertical integration with global commodity chains was established with contracted farmers upstream. The final form was in retaining the government marketing boards, but changing their role through the law to perform new duties, conforming to liberalization. Developing economies, including Kenya, have experienced the three forms in varying degrees and with varying success.

Reforms in the maize sector began around the same time as reforms began in the agricultural sector. By 1995, the maize sector was fully liberalized. Price control, restrictions on maize movement and foreign exchange controls had been eliminated (Jayne and Argwings-Kodhek, 1997). The reforms in the sector had mixed results. There were reductions in the price spread across surplus and deficit regions, and declines in maize prices, especially in deficit regions, were observed. Despite these successes, the poor state of roads, high transaction costs, lack of market information and policy uncertainty were the major challenges facing the sector and acted as a barrier to entry into the marketing chain (Nyoro et al., 1999). The highly discretionary, erratic and inconsistent price stabilization policy by NCPB, coupled with the uncertainty in the disposition of NCPB storage facilities, created uncertainty in the sector;

hence, private sector investment in the sector did not proceed as fast as was anticipated (Kirimi et al., 2011).

The government revised the NCPB Act, Chapter 338, in 2011 to move it in tandem with the liberalized grain sector. In the revised Act, the role of the NCPB was reduced to three roles. The first role was the procurement and maintenance of the SGR, on behalf of the government. NCPB was expected to have in its reserve, a minimum of 720,000 metric tons of maize in physical form or cash equivalent (ERA, 2013). In addition, NCPB was to facilitate the procurement and distribution of FRS to food deficit areas. For the FRS, NCPB either distributed the grain from SGR or purchased food from the markets. The second role was that of price stabilization. The Board was expected to purchase maize early in the season, which was then later released into the market when prices were high. The third role was acting as a commercial agent, where NCPB participated in the purchase and sale of inputs and leasing of storage facilities. The third role has been a challenge due to lack of adequate[6] finances, as NCPB relies on the Treasury for funds. NCPB has continued to face challenges operating in the liberalized grain sector, such as frequent losses, which are compounded by a weak capital base, setting maize prices that are not market driven, the uncertainty of prices for millers, political interference, and inadequate credit to farmers (NCPB, 2009).

Prior to liberalization, the NCPB used to purchase 450,000 to 720,000 metric tons of maize from the market. This constituted 30% of the marketed surplus, which was equivalent to 40% of the national maize production. After liberalization, especially during the 1990s, the NCPB market share declined to 10–20% of the marketed share. Only after 2000, when the Treasury provided more funds for the purchase of more maize, did the marketed share increase to 25% of the marketed surplus (NCPB, 2009). Figure 2.4 below summarizes the purchases and sales of maize by the NCPB prior to liberalization and after liberalization. Maize purchased by the NCPB shows a variable trend between 1988 and 2010. There was a significant decline in maize purchased from 1988 to 1990, which was a period that coincided with the beginning of reforms. Following full liberalization in 1995, there was a drastic decline in maize purchased by the NCPB, and it never went back to the same level as before or immediately after the reforms.

6 Despite the third role being a commercial one, all government institutions remit all the funds raised from their commercial activities to the Treasury. The Treasury then decides on the funds to allocate to the respective institution.

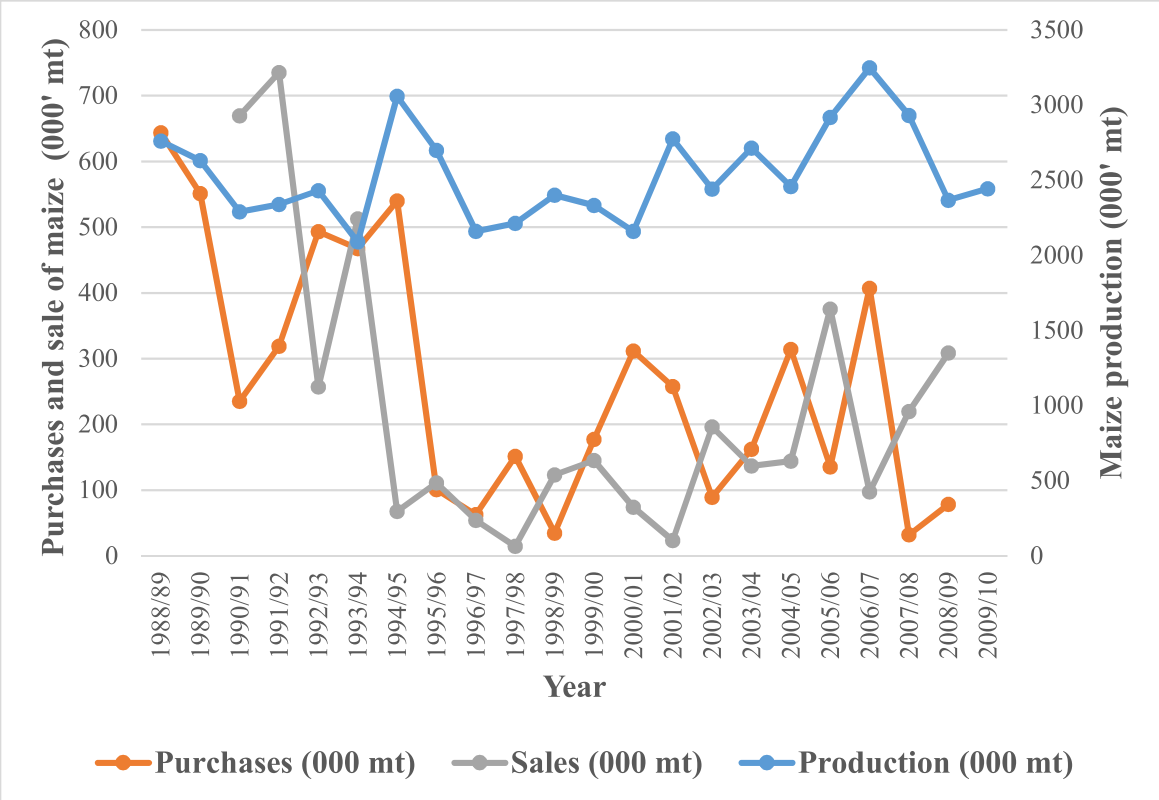

Figure 2.4: NCPB purchases and sale of maize and the total maize production from 1988-2010

Source: Market information NCPB (1989-2010) and economic review of agriculture (2000-2010)

The maize sector has undergone three major phases in its evolution. Critical turning points marked the different phases and helped to shape the sector. As the sector was undergoing evolution, so did the policy in the sector. Table 2.3 below summarizes the evolution of maize marketing policy under the three phases.

Table 2.3: Evolution of the maize marketing policy in Kenya 1963–2015

PERIOD	Maize Market Policy
Post-independent strict control period	• Strict control of maize price, movement and storage under maize marketing and produce board • Strict control of maize grain and maize meal prices and storage under NCPB • Strict control of movement of maize and maize meal across districts

Reform phase	• First reforms of the sector under the cereal sector reform programme • Limited numbers of unlicensed maize traders allowed • Further relaxation of inter-district trade restrictions • NCPB introduces ceiling price • Deregulation of maize grain and maize meal prices • Import tariffs abolished • Subsidies to millers removed • Full liberalization of the sector

Post-liberalized era	• Full liberalization of the sector
	• Increased private-sector participation
	• NCPB buyer of the last resort
	• Maize import tariff re-imposed
	• Export bans following poor harvest
	• Highly discretionary, unpredictable and unanticipated changes in trade policies and tariffs
	    o Frequent and impromptu changes in maize tariffs
	    o Import bans (GMO); export ban during drought
	    o Maize stabilization policy, NCPB buying maize at higher price than market price
	    o NCPB subsidy to millers to lower the price of maize meal during high food crisis in 2009
	• NCPB maintaining the strategic grain reserve (SGR) and food relief services (FRS)
	• NCPB imports and distributes subsidized fertilizer from 2008 with the aim to stabilize food prices.
	    o On average, imported about 15% of national requirement
	    o Challenge of lack of adequate funds from Treasury

Source: Adapted from Ariga and Jayne, 2009 and updated by the authors

2.4 MAPPING THE MAIZE VALUE CHAIN

The maize marketing and trade policy in Kenya is faced by two major challenges. The first challenge is the classic food price dilemma of keeping farm prices high enough to provide incentives for producers, while at the same time, low enough for poor consumers to access food. The second challenge has been on how to efficiently deal with high, volatile and unstable food prices. Therefore, it is important to develop an appropriate marketing and trade policy in the context of these challenges. To achieve this, it is important to understand the maize value chain in Kenya. The maize value chain consists of input suppliers, farmers, traders, processors and consumers. A comprehensive maize value chain in Kenya is illustrated in Figure 2.5 below.

2.4.1 Input suppliers

Inputs that are accessible and affordable to farmers will reduce production costs and boost supply, thus lowering consumer prices. Inputs have become more accessible to the farmers as they only have to travel an average distance of 2 kilometres to access inputs (Chamberlin and Jayne, 2009; Mathenge et al., 2012). Although inputs are easily accessible, affordability remains a major challenge. The high cost of inputs has been identified as a hindrance to the consistent use of hybrid and fertilizer combinations, leading to low productivity (Ouma et al., 2002; Wekesa et al., 2002; Suri, 2006; Suri, 2011; Gitau et al., 2012; Mathenge et al., 2012).

Fertilizer prices recorded their highest prices in the country's history during the 2007/08 cropping year. The post-election violence experienced in 2008 and high world energy prices were contributing factors (Nzuma, 2013). To reduce fertilizer prices, the government introduced a subsidy programme from 2008. The government, through the NCPB, imported and distributed subsidized fertilizer. The national fertilizer demand in Kenya is estimated at 540,000 metric tons annually. On average, 76% (410,000 metric tons) of the required fertilizer is procured by the private sector (Makau et al., 2018). Figure 2.6 below illustrates the portion of subsidized fertilizer that was included with the procured fertilizer between 2008 and 2015. On average, the subsidy fertilizer imported between 2008 and 2015 constituted 20% of the procured fertilizer. The cost of the procured subsidy increased by 116%, from US$ 17.9 million to US$ 38.8 million, under the same period (Makau et al., 2018). The fertilizer is distributed through NCPB depots, which are located only in major towns around the country, thus disadvantaging farmers who are located in remote areas (Opiyo et al., 2015).

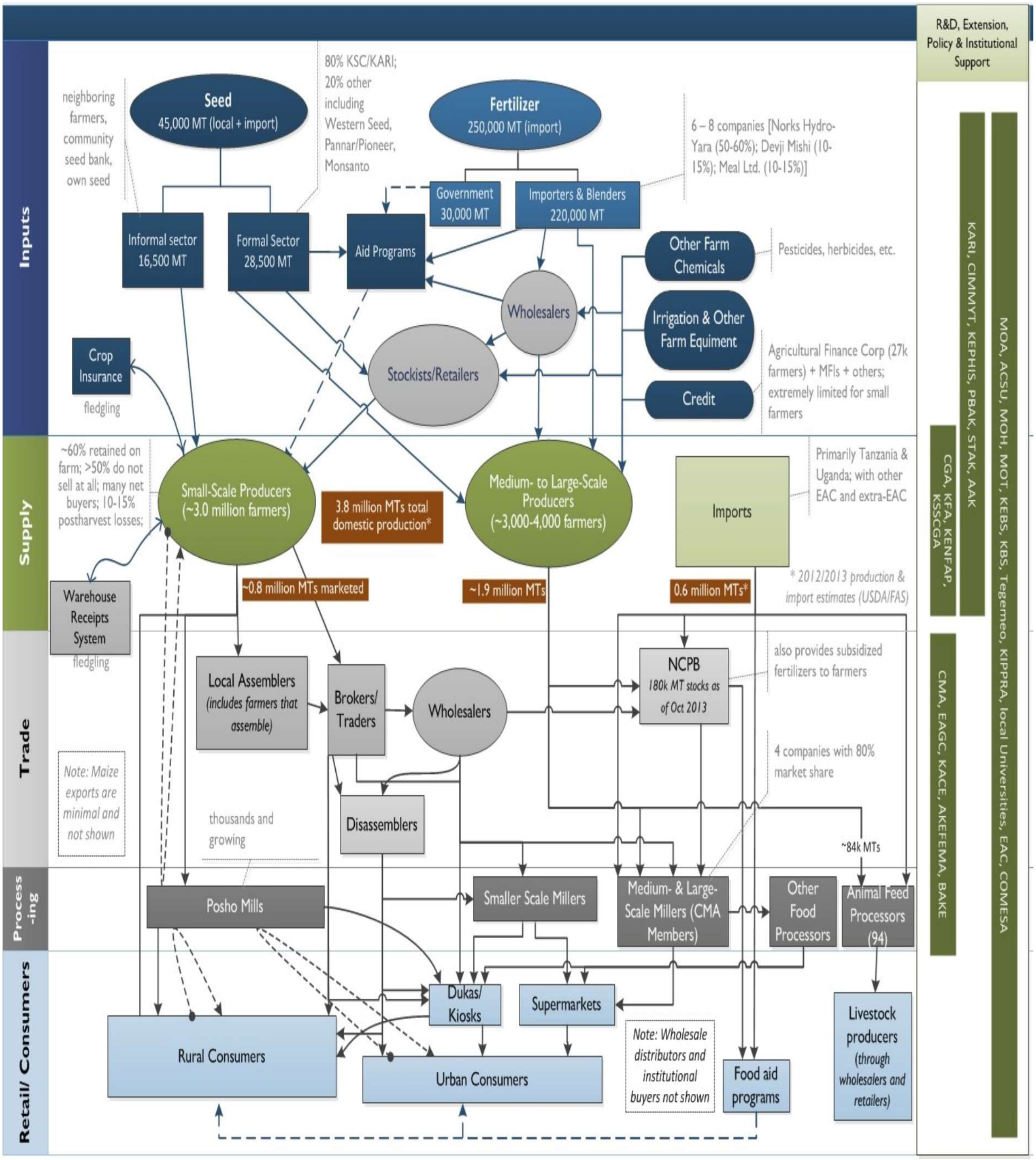

Figure 2.5: The maize value chain in Kenya

Source: USAID–KAVES Maize Value Chain Analysis (2014)

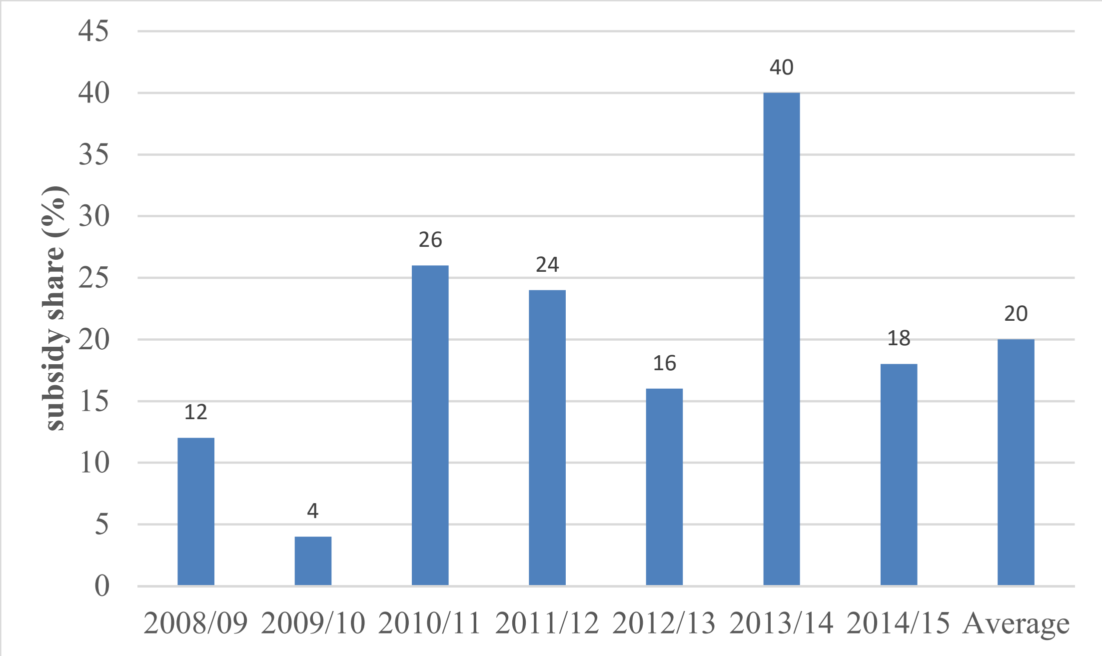

Figure 2.6: The share of subsidized fertilizer from procured fertilizer

Source: MOALF (2016)
Note: the national fertilizer demand is estimated at 540,000 metric tons annually. On average, 76% (410,000 metric tons) of the estimated demand is procured

2.4.2 Farmers

Maize accounts for 56% of the total area of cultivated land and 40% of the total crops grown. Maize is grown by small-, medium- and large-scale farmers, with small-scale farmers constituting the largest share of maize produced (Kirimi et al., 2011; ERA, 2013). Mechanization is low, with the use of hand and animal draught power at 50% and 30%, respectively, while motorized power accounts for only 30% (ERA, 2015). The three categories of farmers are discussed below

Small-scale farmers

The majority of the small-scale farmers in Kenya cultivate maize. These farmers cultivate less than 2 hectares of land, and their production is characterized by small per capita volumes that result from the low use of inputs, low yields, limited land, and lack of storage facilities, among other factors. Small-scale farmers have limited access to critical services such as finance and warehousing. They sell their maize immediately after harvest to mostly small-scale traders or consuming households (Nyoro et al., 1999; Kirimi et al., 2011). These farmers can be categorized based on their purchase and sales characteristics. Over half of the small-scale farmers usually purchase maize and never sell it. Only 18% of the small-scale farmers purchase and sell their maize, and two third of these farmers are net buyers of maize. In addition, the net buyers sell their maize at low prices during harvest and buy at a higher price during the lean season. Hence, this group is susceptible to volatile and high food prices, despite being producers. The warehouse receipt system has been mooted as a solution, where farmers store during harvest and sell when prices are high. However, the costs are prohibitive for the small-scale farmers (Coulter, 2009).

Medium-scale farmers

These farmers cultivate between 2 to 10 hectares of land and sell almost half of their production. The majority sell their maize produce to wholesalers, millers and the NCPB. Unlike the small-scale farmers, these farmers store their maize and sell it during the lean season. On average, they store their maize for 4–5 months before selling. In addition, these farmers have access to critical services such as financing and warehousing (Kirimi et al., 2011).

Large-scale farmers

Large-scale farmers cultivate over 10 hectares of land, purely for commercial purposes. Their farming is highly mechanized and input intensive. They sell their produce to large-scale traders, the NCPB and millers. It is estimated that 60% of the national marketable maize in Kenya is sourced from these farmers and they store their maize for longer than 5 months to sell when prices are at their highest. These farmers benefit from the economies of scale; hence, they are able to access cheaper inputs, critical services (finance and warehousing) and negotiate better market prices. Large-scale farmers have formed a powerful political lobby group that has been the driver of maize policies implemented in Kenya in the past decade. In addition, they have been the main advocates of subsidized fertilizer, from which they benefit the most (Kamau et al, 2013; Opiyo et al., 2015).

2.4.3 Market players

Small-scale traders

These small-scale traders accumulate maize along the value chain. They form the first commercial point in the maize value chain. The number of these traders has been on the increase, penetrating into the villages, thus creating competition along the value chain. The main characteristics of these traders are that they purchase maize within the same district, purchase low volumes, sell immediately, and operate during harvest times (Kirimi et al., 2011). The reasons why most traders do not store maize comprise liquidity constraints and uncertainty in future prices. They amass the maize in bulk and sell it to wholesalers, and they are not interested in moisture content, since they do not have to store the maize (Kirimi et al., 2011).

Wholesaler traders

Wholesale traders are important in the maize value chain as they provide working capital to the small-scale traders by paying cash for the maize they purchase. They acquire their maize from small-scale traders or directly from the farmers across a wide geographical area. The majority of these traders have permanent operation centres in major maize surplus towns. In addition, they have permanent centres in the major urban towns, which are the main deficit regions. These traders own trucks or rent trucks for transportation of their maize across districts. They mainly sell their maize to millers, to the NCPB and directly to consumers in deficit regions. Over half of the major wholesalers own storage facilities, while the rest rent storage space (Kirimi et al., 2011). The challenges in storing maize for longer periods of time are the unpredictable government policies (such as duty waivers and government releases of stock into the market) that may result in losses to the traders. Accordingly, most wholesale traders prefer to store maize for shorter periods.

NCPB

As a market player, the NCPB stabilizes prices by purchasing maize when prices are low and releasing stocks when prices are high. In addition, the Board purchases maize from the markets for SGR and FRS purposes. In the past, lobbying by large-scale farmers and politicians resulted in the NCPB offering higher prices than the prevailing market prices. This resulted in market distortion, as this resulted in upward pressure on the market prices (Kamau et al., 2013). The stringent quality measures imposed by the NCPB and the deferred mode of payment for delivered maize are the major disincentives that prompt small-scale farmers not to deliver their maize to NCPB (Nyoro et al., 1999; Kirimi et al., 2011). During poor harvests when the country relies on imports from world markets, the NCPB applies for a licence to import maize.

2.4.4 Processors

Hammer mills (posho millers)

These are mainly located in villages in rural areas. They offer milling services to the farmers for producing un-sifted maize meal. The availability of diesel-operated hammer mills ensures that their services can be made available even in areas where there is no electricity. The expansion of the rural electrification programme has boosted these local mills in rural areas, as most rural centres are connected to the national grid. The milling capacity of these millers ranges between 6 and 110 metric ton per month, but utilization is estimated at about 15% (KAVES-USAID 2014). The main challenge facing these small-scale millers is limited capital. The market niche that these millers have in the rural areas might be further expanded through assistance to invest in de-haulers. These would enable these millers to produce and package the sifted maize meal in smaller packages, which large-scale millers do not offer.

Small-scale millers

KAVES-USAID (2014) estimate that there are about 50–75 small-scale millers in the country with an installed capacity ranging from 10 to 200 metric tons per month. These millers produce sifted maize meals and maize by-products such as the composite maize meal that they provide in their own consumer brand packaging. These millers operate only in specific towns around the country.

Medium- and large-scale millers

Medium- and large-scale millers account for about 93% of the annual total installed milling capacity, estimated at 1.4 million metric tons. Most of the mills are located in Nairobi and Mombasa. Both cities account for 60% of the national installed capacity, followed by Eldoret with 15%, then Thika, Kisumu and Kitale with the remaining installed capacity (KAVES-USAID, 2014). The four main large-scale millers (Mombasa, Unga, Pembe and Eldoret) account for 70% of total milling capacity. The millers produce sifted maize meals in several packages (1 kg, 2 kg, 5 kg, 10 kg and 50 kg). Apart from sifted maize meal, these millers are also involved in animal feed production.

2.4.5 Post-processing players

These players include urban and rural consumers. Urban consumers source their maize meal from supermarkets, wholesalers and retailers. Rural consumers source their maize meal mainly from retailers (dukas/spaza shops). In the urban setting, the packaging of maize meal is usually in 1-, 2-, 5-, 10- and 50-kilogram parcels, while in the rural areas, packaging is mainly in 1-, 2- and 5-kilogram parcels. Retailers in the rural areas prefer purchasing maize meal in 50-kg bags that they parcel out and re-sell to rural consumers in smaller quantities of their choice (KAVES-USAID, 2014).

2.5 MAIZE MARKETING

Several factors determine the marketing efficiency of any agricultural commodity. These factors include marketing costs, social capital developed by the traders, marketing power wielded by different agents along the value chain, volume traded, and government policy interventions (D'hôtel et al., 2013; Kabbiri et al. 2016) These key factors influence market interactions. The disparity in maize production and supply is attributed to the geographical stratification and seasonality across Kenya (Nyoro et al., 1999). Maize markets across the Counties may be categorised into three types of markets, surplus, self-sufficient (minor surplus) and deficit markets, based on maize production.

During normal seasons, the maize deficit is sourced from Uganda and Tanzania. The maize from Uganda originates from the three main growing zones (Eastern, Western and Northern regions). The maize quality is key for determining the destination market in Kenya. The maize coming from the Northern and some parts of the Eastern Ugandan regions is of high quality and enters the Kenyan markets. Maize coming from the Western and some parts of Eastern regions is of low quality, and is mainly consumed at the local border markets in Malaba and Busia (World Bank, 2009; Nile Basin Initiative, 2012). Maize from Tanzania is mainly sourced from the Northern region and is of high quality. The maize comes into Kenya through the two border points of Isebania and Namanga. Maize passing through the Isebania border point is destined for consumer markets in the Nyanza region. Maize that comes through the Namanga border point is destined for consumer markets in Nairobi and the Eastern, North Eastern and Coastal regions (Nile Basin Initiative, 2012). During drought periods, the country imports maize from the world market, and the maize comes into the country through the port of Mombasa and is later transported inland to deficit markets. Figure 2.7 below summarizes maize flows in Kenya.

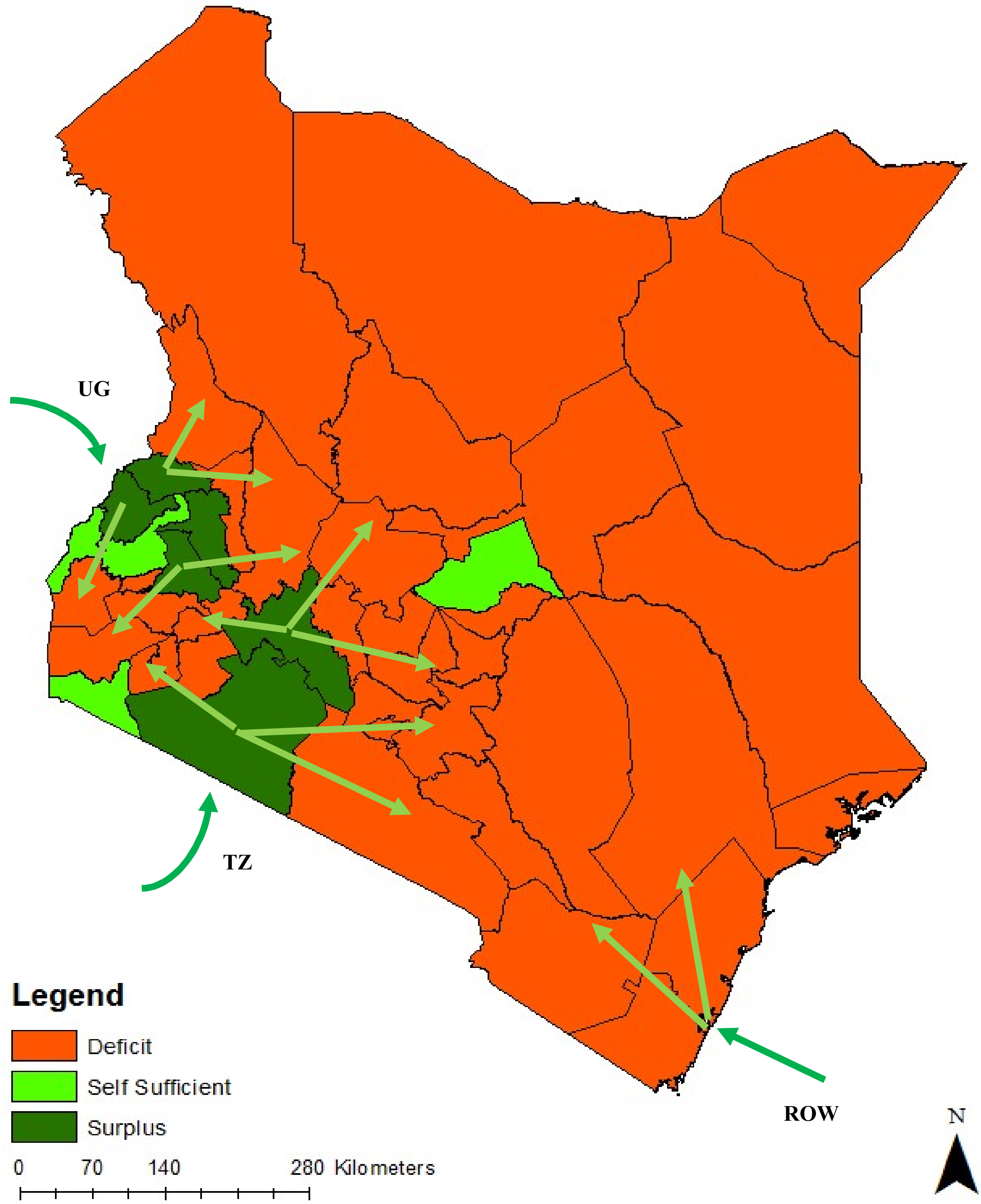

Figure 2.7: The movement of maize from the region, the world and across domestic markets

Source: Author's depiction of the three markets is based on maize production and sales.

Note: ROW=World markets

There are two distinctive marketing channels, based on maize harvests, as observed by Kirimi et al. (2011). The first occurs when the country experiences normal harvests. Small-, medium- and large-scale farmers comprise the major source of domestic supply. During this type of period, the deficit comes from Uganda and Tanzania. An import tariff of 50% on imported maize is in place. There is low concentration and the value chain is very competitive. Figure 2.8 below summarizes the sources of imported maize during this type of period. The second marketing channel occurs during times of poor harvest. Imports from the region are not adequate to meet the national demand, hence imports come from the world market. Large-scale millers, wholesalers and the NCPB are the main players, based on who receives the import tender. Small-scale assemblers, itinerant traders and small-scale millers are less active, as they depend totally on small- and medium-scale farmers for their supplies, who at these times have little or no surplus. The marketing channel is more concentrated and less competitive. The government usually waives the import duty to allow for the importation of maize. Transportation logistics and the clearance of maize at the port becomes a major challenge, given the huge volumes needed to be cleared and transported within a short period. Figure 2.9 below summarizes the sources of maize during this type of period.

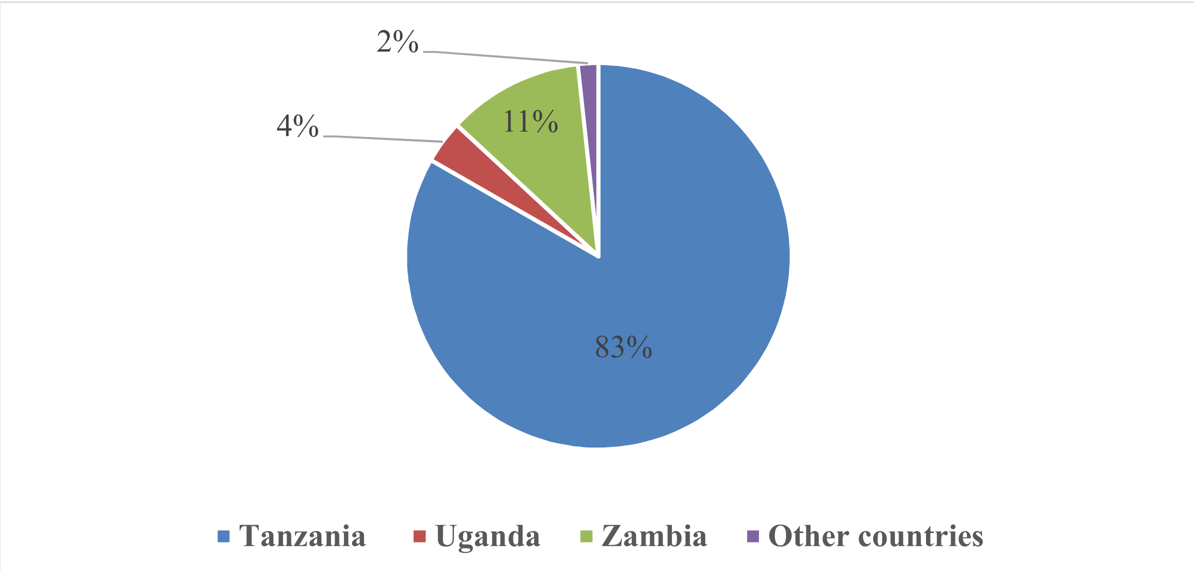

Figure 2.8: Sources of maize imports in 2012, representing a good year for imports from the region

Source: Kenya Revenue Authority (2013)
Note: other countries include South Africa, Ethiopia, Argentina, the United States of America and the United Arab Emirates

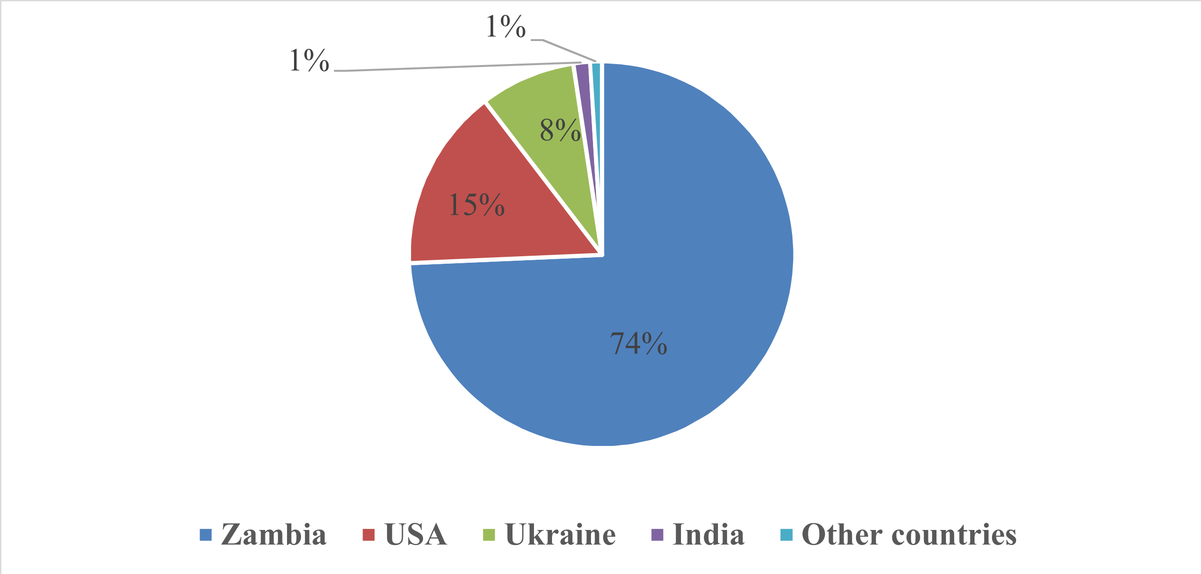

Figure 2.9: Sources of maize imports in 2009, representing poor harvest imports from outside the region

Source: Kenya Revenue Authority (2011)
Note: other countries include the United Arab Emirates, Argentina, Australia, Ethiopia, Pakistan, Saudi Arabia, Tanzania, Uganda, the United States of America and South Africa

Figure 2.10 below summarizes the trend in overall inflation, compared with food inflation, from 2009 to 2016. From February 2009 to March 2011, food inflation was lower than the overall inflation was. This trend changed from March 2011 and the food inflation was higher than the overall inflation was. The trend has persisted and the widening gap is an indication of soaring food prices.

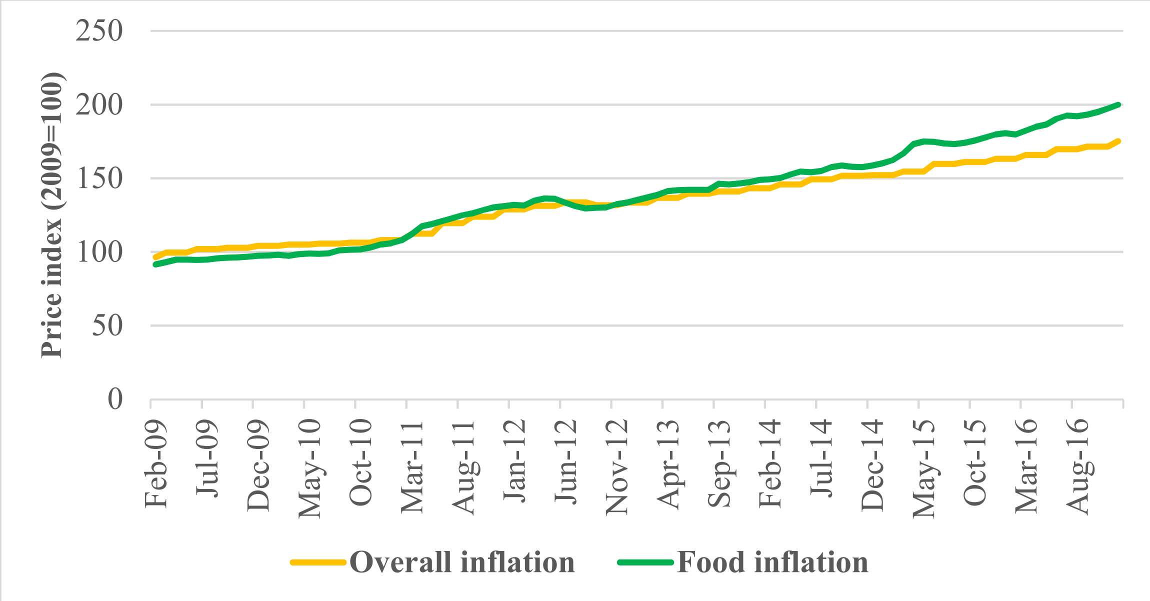

Figure 2.10: Comparison of overall inflation with food inflation from 2009 to 2016
Sources: FAOSTAT 2009-2016 and Kenya National Bureau of Statistics 2009-2016

2.6 PRICE DISCOVERY IN THE KENYAN MAIZE MARKET

In order to discern the causes of unstable food prices in Kenya, we need to understand the process of price formation in Kenya. Meyer (2006) identified three trade regimes that determine price formation. The first trade regime represents import parity, which occurs when the import parity price (IPP) and domestic prices exceed transfer costs, thus creating arbitrage opportunities and triggering imports. Domestic prices co-move with the world prices when import taxes and cost of shipping are incorporated into domestic prices. The second trade regime represents autarky. This occurs when domestic prices trade at a level where no arbitrage is triggered, and domestic demand and supply conditions determine prices. Under this regime, domestic prices are not integrated into the world prices. The final regime represents the export parity price (EPP). This occurs when domestic prices and export parity prices exceed transfer costs, hence creating arbitrage opportunities and triggering exports to the world market.

As discussed earlier, Kenya imports the maize that fill its deficit from the region (Tanzania and Uganda), and from the world market during normal and poor harvest seasons, respectively. To determine the regime under which the Kenyan maize market operates, the trend in maize exports and imports are analysed. Figure 2.11 below summarizes the trend in maize exports and imports following liberalization, and covers the period from 1990 to 2016. During the period under review, Kenya has mainly imported maize. Exports were few in number, dispersed across the year under review, and were mainly below 100,000 metric tons, except for 1994, which recorded 284,000 metric tons of exports. This is attributed to the bumper harvest received. From the maize exports and imports trend, it will be seen that Kenya operates under the first regime, which is the IPP trade regime.

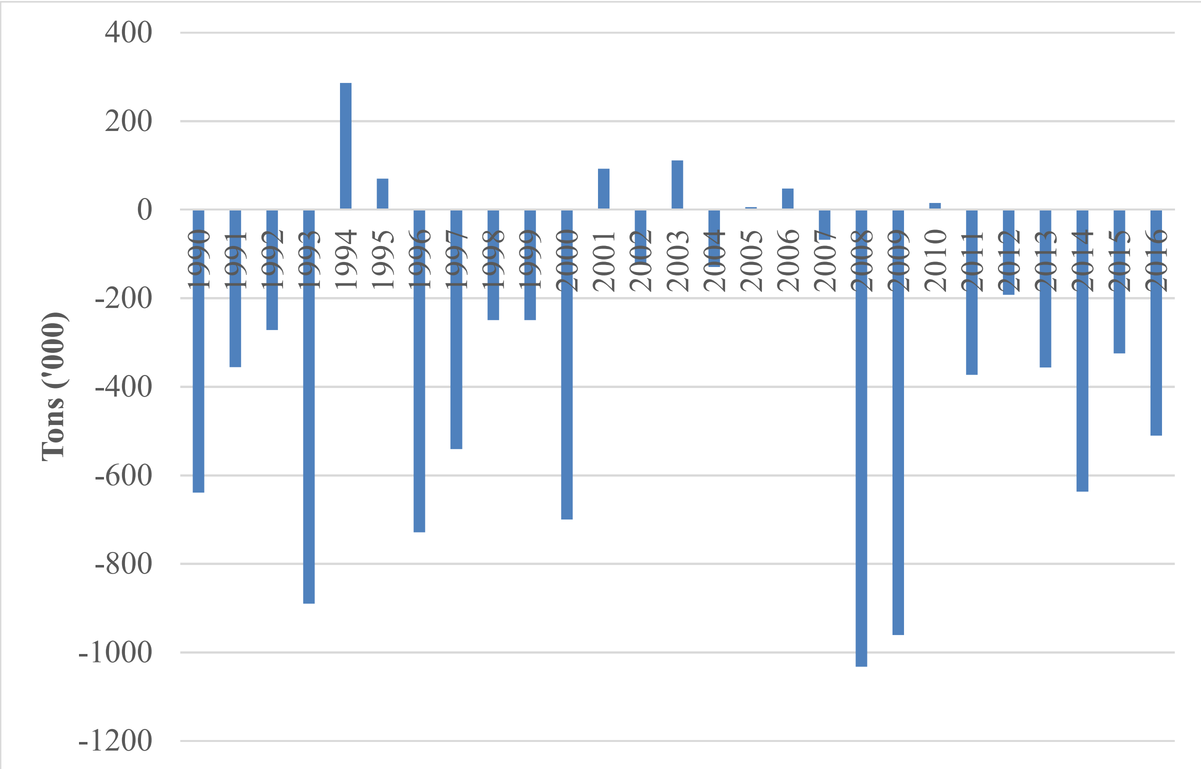

Figure 2.11: The maize exports and imports trend from 1980 to 2016

Source: Author's computation based on production and consumption data from USDA (1995-2016)

The other characteristic of an IPP trade regime is the co-movement of domestic prices with international prices. Figure 2.12 below summarizes the domestic price and IPP from three major international markets from 2008 to 2016. The visual inspection of Figure 2.12 indicates no co-movement between the IPP and domestic prices. The lack of co-movement between the two prices may be attributed to Kenya mainly relying on importing maize from the regional market, and only turning to the world market during times of poor harvest. Another reason for the lack of co-movement of IPP and domestic prices is the 50% import tariff imposed on maize coming from the world market. Meyer (2006) noted that trade flow and equilibrium differed under the three regimes, depending on other factors such as the importance of regional markets in staple foods. Given that Kenya's maize sector falls under the IPP trade regime, this study adopts model closure on imports, and domestic price is estimated through a price linkage equation (for a detailed discussion on model closure, refer to Chapter 3 on approach and methodology).

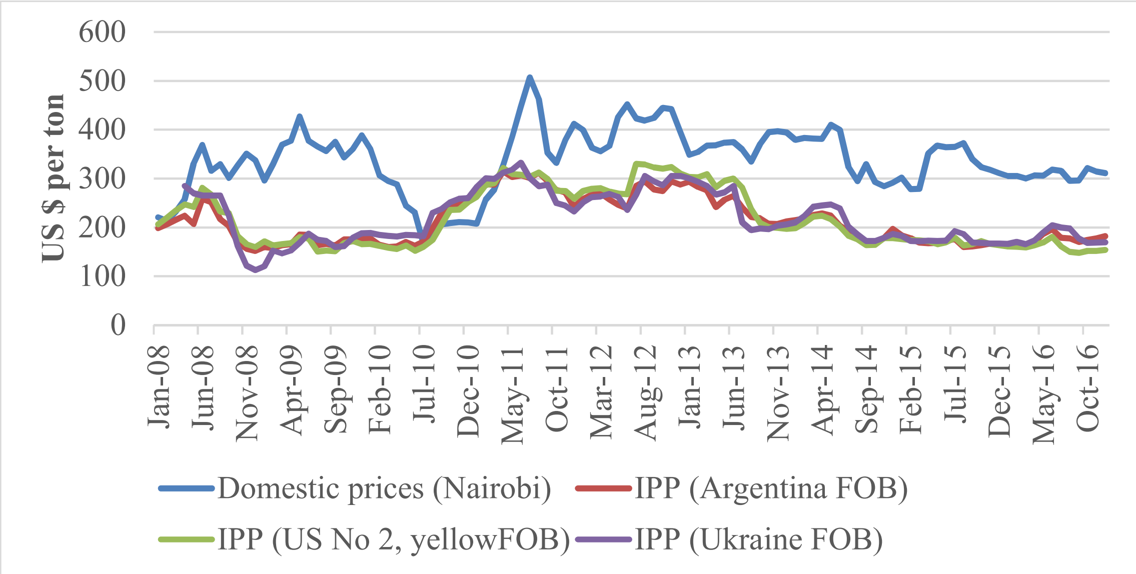

Figure 2.12: Comparison of domestic prices and import parity prices from 2008 to 2016

Sources: FAO GIEWS FPMA Tool Monitoring and analysis of food prices (2008–2016)

2.7 MARKET INFORMATION SYSTEM AND INFRASTRUCTURE DEVELOPMENT

The development of institutions, infrastructure and market information systems is crucial in the development of integrated markets in developing economies (Meijerink et al., 2009; Kabbiri et al., 2016). In Kenya, the limited market information system, poor roads and lack of storage facilities are some of the challenges that have been identified as facing the maize sector (Nyoro et al., 1999; Kirimi et al., 2011). The market information system, storage facilities and road network in Kenya are briefly discussed below.

2.7.1 Market information system

Agricultural market information systems (MIS) and infrastructure development play a critical role in market integration across spatially separate markets. Market information has an impact on the speed of adjustment of the price spread between two spatially separate markets, without having a significant effect on the transfer costs. In order to address spatial market integration, we need to understand MIS and infrastructure development. In general, the purpose of MIS includes addressing information asymmetry, facilitating decision making on selling, buying or investing, improving market transparency, improving bargaining power, especially for small-scale farmers, and reducing transaction costs (David-Benz et al., 2011; David-Benz et al., 2012: Galtier et al., 2014).

The development of agricultural MIS in SSA was expected to be an accompanying feature of liberalization, as it was meant to address the information asymmetry created by the liberalization process. MIS was intended to address the challenge of information asymmetry by creating a more open trading environment, promoting efficient markets and improving negotiating power among small-scale farmers. The development of MIS did not proceed in tandem with liberalization as it was introduced years later after liberalization of the agricultural sector (Tollens, 2006). The first-generation MIS developed was mainly based on a single model, often covered a single category of product, focused exclusively on price information, and was implemented by the public sector, through the Ministry of Agriculture (David-Benz et al., 2011; Galtier et al., 2014). The main challenges of these first-generation MIS included inaccuracies, poor quality, and data that did not account for grade or quality of commodity, and the information was not provided in real time. Hence, these first-generation MIS models could not inform on spatial arbitrage (Bowbrick, 1988; Shephard, 1997).

Rapid development in information communication technology (ICT) was witnessed in Africa in the late 1990s, which led to the diffusion of mobile phones and the internet. The rapid growth in the ICT sector was attributed to liberalization and innovation (Williams et al., 2011; Kayisire and Wei, 2016). The diffusion of mobile phones and the internet led to the development of second-generation MIS, which allowed for the dissemination of information in real time. In addition, it became possible to combine various platforms, hence providing more details of information, other than price. Real-time information on trade flows, storage facilities, credit facilities, the warehousing receipt system, commodity exchange and contacts of buyers and sellers was integrated with the system, and so was available to participants. The second-generation MIS became more beneficial to farmers and traders in developing economies (David-Benz et al., 2011; David-Benz et al., 2012: Galtier et al., 2014).

In Kenya, the ICT sector registered tremendous growth following liberalization of the sector in 1997. The mobile network by 2006/07 was over 20 times larger than the fixed line network. The number of subscribers grew from 13 to 40 million between 2008/09 and 2016/17, while the fixed network declined by 71%. Penetration of the mobile network across the country increased from 35% to 87%, and internet and data subscribers increased from 1.8 to 38 million, while penetration of these services across the country increased from 23% to 83% during the period under review (CAK, 2009-2015). The growth in mobile telephony and innovation by the private sector have led to the development of market information platforms that combine several services, such as those relating to commodity exchange, linking of farmers, traders and transporters, real-time price data, and farming advice. Table A.1 in Annex A summarizes available platforms in Kenya and the services provided.

What is of interest to researchers and policy analysts relates to the impacts of the diffusion of mobile telephony and use the MIS platforms in the agricultural sector. Studies carried out in Africa have reported mixed results. Some studies showed reduced transaction costs, promotion of market participation, and the improved prices received by farmers (Muto and Yamano, 2009; Aker, 2011; Kizito, et al., 2012; InfoDev, 2013; Courtois and Subervie, 2014;Yovo, 2015), while others reported finding no significant changes with the use of mobile phones (Molony, 2008; Staaz et al., 2014)

In Kenya, the impact of MIS is yet to be unequivocally established, as the studies done thus far have yielded mixed results. The use of MIS has been shown to promote planning on deciding when to harvest and sell, thus achieving income gains through better prices, and has also resulted in a change in cropping patterns (Karugu 2011). Other studies have found inconclusive results regarding the impact of MIS in providing better prices to farmers. The mismatch between the MIS design and farmers' perceptions of mobile use was identified as a major hindrance (Baumuller, 2015; Wyche and Steinfield, 2016). Karugu (2011) reported that positive results were indeed identified in cases where all the farmers who were participating on the MIS platform had undergone training on using the platform. The majority of the farmers in the rural areas perceived mobile phones as a tool of communication. The use of mobile phones for receiving MIS services by rural households in Kenya is low, and has been estimated at 5% (InfoDev, 2013). Rural households have relied on the traditional sources of information, such as radio, as a main source of market information. It has been reported that 35% of households acquired their market information from the radio (KAPAP, 2011). With the growth in digital streaming, the licensing of many community radios in rural areas will continue to play a significant role in the dissemination of market information.

2.7.2 Storage facilities and the road network

The provision of storage infrastructure facilitates price stabilization by allowing for purchasing and storing of food commodities during glut seasons, and then the releasing of the stocks during lean periods. Storage also facilitates the receiving of higher prices by farmers. Farmers store their maize after harvesting and sell it during lean periods when prices are higher. The majority of the storage capacity in the maize sub-sector in Kenya is held by the NCPB. Storage facilities are provided by conventional stores and silo bins that are distributed throughout the country. The storage capacity of NCPB is 1.8 million metric tons. This is available for hire by stakeholders in the sector (NCPB, 2016). Although the warehouse receipt system has been introduced in the sector, the system faces three major challenges. The first and significant challenge is the lack of institutional framework and mechanisms to operationalize the system in Kenya. The Warehouse Receipt System Bill, 2018, is pending in parliament. The second challenge is the cost of storage, which is prohibitive for small-scale farmers. The third challenge is the uncertainty. The government may require the return of facilities for storing SGR maize, especially during a bumper harvest.

The classified road network comprises 31% (61,945 kilometres) of the total road network in Kenya. The Ministry of Transport has categorized the classified road network into six categories. The first category comprises the international roads (A), which link centres of international importance, borders, and terminate at international ports. The national road system (B) is the second category. These roads link major towns and cities. The third category comprises the primary roads (C) that link important centres and higher-class roads. The fourth category, which links important centres and higher-class roads, comprises the secondary roads (D). Minor roads (E) are the fifth category, and these roads link any minor centres. The final category comprises special purpose roads (F). These are specially designated roads, and include roads in parks, settlements, and rural access roads for crops such as sugar, tea, and sisal. Figure 2.13 below summarizes the six categories of roads and the types of road in 2016. Overall, 82% of roads are covered by gravel/earth. International roads have the highest proportion covered by bitumen (89%), followed by national roads (61%), while special roads have the least bitumen cover (1%). Primary, secondary, minor and special roads are largely covered by gravel/earth.

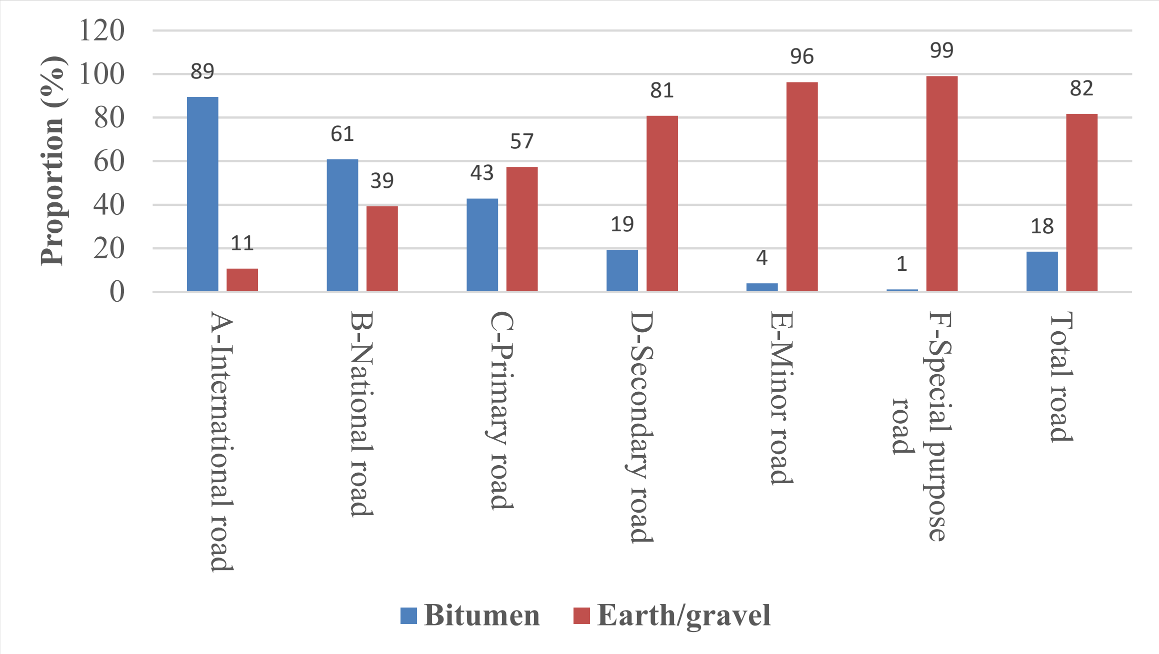

Figure 2.13: Different road categories in Kenya by type in 2016 (classified road network)

Sources: Statistical Abstract (2017)

Between 1990 and 2015, there was an overall decline in roads covered by bitumen by four percentage points. International roads recorded the highest increase (17 percentage points) of bitumen-covered roads, while special roads recorded a decline in roads covered by bitumen (Table A.2 in Annex A). Secondary, minor and special roads account for the majority of roads connecting production areas and markets, while primary roads connect the markets. The majority of the road network connecting the respective places has gravel surfaces, and this may explain the high costs of transportation. As discussed earlier, the transport costs in Kenya are high, compared with other regions. Domestically, transport costs vary depending on the destination. Transport costs across different markets are summarized in Figure A.1 in Annex A.

The categories of the classified road network in Kenya are as follows, 14% of roads are paved and 43% have gravel surfaces, while roads with earth surfaces comprise 43%. The conditions of the roads are illustrated in Figure 2.14 below. Overall, 11% of the classified road network is in good condition and 49% is, fair while 40% is in poor condition. Paved roads account for the highest proportion of good roads, and fair roads with gravel surfaces reflect the highest proportion, while earth roads have the highest poor condition proportion.

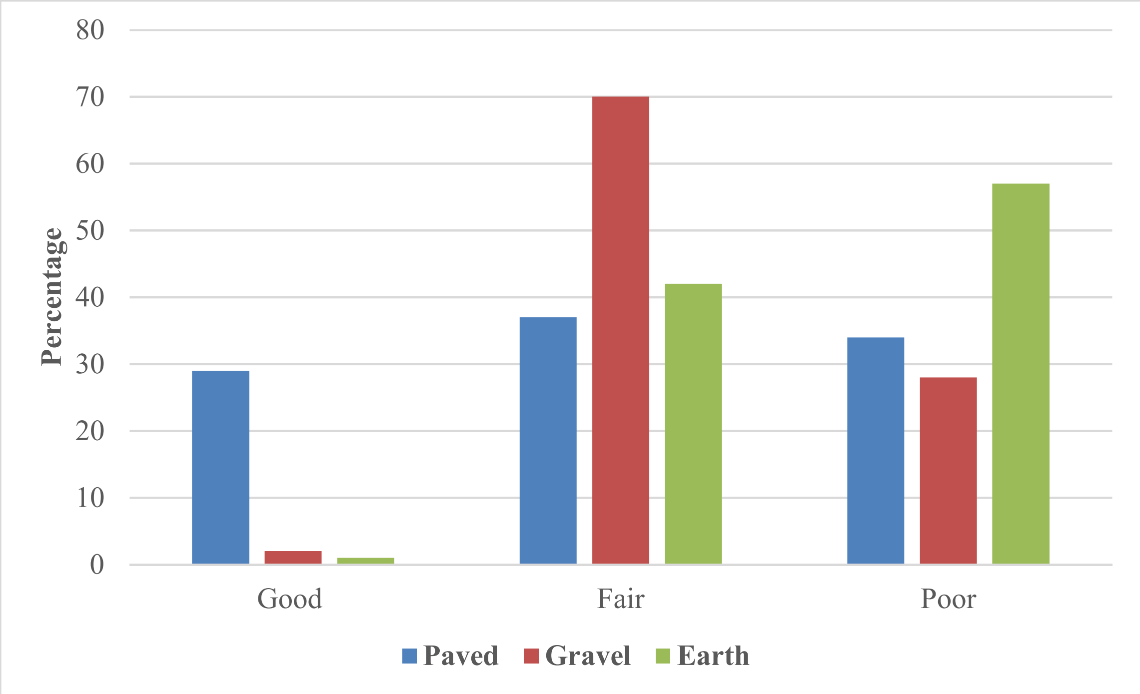

Figure 2.14: Conditions of the classified road network in Kenya, 2016
Source: Kenya Road Board (2016)

Transport prices in Kenya decline as you go down the supply chain. The cost of transporting a ton of grain per kilometre from the farm gate to the primary market is US$ 0.3. Transporting the same ton per kilometre from primary to secondary markets costs US$ 0.3. The cost drastically reduces by a third when transporting from secondary to wholesaler/miller markets to US$ 0.1 (World Bank, 2009). The reduction in costs is attributed to the road categories. A large proportion of the roads connecting the farm gate and the primary markets and between primary and secondary markets have earth surfaces (Kenya Road Board, 2015). In addition, all these roads fall into the categories of D, E or F, as illustrated on Figure 2.13 above. Furthermore, as illustrated by Figure 2.14 above, the majority of the earth roads are in poor condition. The roads connecting secondary and wholesale markets fall under category C. These roads are paved or have gravel surfaces. The majority of the gravel roads are in fair condition, while 66% of the paved roads are categorized as good and fair, as illustrated in Figure 2.14 above.

The movement of grain between the farm gate to the secondary markets (first segment) accounted for 20% of the total distance between farmers and urban consumers, while secondary and wholesaler markets (second segment) accounted for 80%. The proportion of the transport price incurred in the first segment was 40%, while 60% was incurred in the second segment (World Bank, 2009). The category and poor conditions of the roads in question provide the reason why 20% of the total distance between farmers and urban consumers accounts for 40% of the total transport prices. In Kenya, transport costs have accounted for 70% of the grain marketing costs. A breakdown of transport costs in Kenya has indicated the fixed and variable proportions of the costs of transporting a ton per kilometre at 30% and 70%, respectively. Under the variable costs, fuel and lubricants accounted for 82% of the total variable costs (World Bank, 2009). Poor roads are linked to high transportation costs in Kenya. Road conditions are an important factor in a developing economy. Investments in rural infrastructure (road categories D, E and F) have a higher internal rate of return when compared with investment in secondary and main roads, especially since these two types of roads are in fair condition, as has been evidenced in Uganda (Fan et al., 2006).

2.8 POLICY RESPONSE TO HIGH FOOD PRICES

After the liberalization of the maize sector, the market share of the government's purchases in the market declined from over 40% to between 10 and 20% (NCPB, 2009). There has been minimum government intervention in the sector. There has been investment made along the maize value chain, which led to competition and a decline in the margins across surplus and deficit regions (Nyoro et al., 1999; Jayne et al., 2005; Kirimi et al., 2011). This situation changed following the post-election violence experienced in Kenya during 2008, coupled with the high food crisis of 2008/09 that resulted in a high surge in food prices (Meijerink et al., 2009; Nzuma, 2013). The government introduced various measures aimed at taming the soaring high food prices.

The government imposed an export ban on foodstuffs in 2008 and embarked on importing maize from the world market to boost stocks for SGR. In addition, the government instructed farmers to deliver their maize to NCPB and banned millers from purchasing maize from farmers. The participation of the government in the importation of maize and the banning of direct purchases of maize from farmers was criticized as being an affront to the liberalized maize sector. The government embarked on adjusting taxes by reducing import parity prices for maize from 50% in 2007 to 25% in 2008, with the imports being zero-rated in 2009. Wheat import parity was reduced from 30% to 10% in 2009. In addition, the government zero-rated VAT on key foodstuff in 2008/09 (Nzuma, 2013).

The government has introduced subsidy programmes targeting both consumers (maize meal) and producers (fertilizer). The producer subsidy programme was aimed at reducing fertilizer costs, which accounted for 22% of the total production costs (Kirimi et al., 2018). Another aim of the subsidy was to stimulate maize production and reduce consumer price by lowering input costs. The subsidy programme is still in effect at the date of writing this thesis. The total cost of the programme between 2008 and 2016 was US$ 214 million (Makau et al., 2018). The main challenge of this programme is the dis-advantaging of small-scale farmers, as its provisions are only distributed through NCPB depots found in major towns. In 2009, a consumer subsidy programme, aimed at poor households in urban areas, was introduced. The government, through the NCPB, sold maize grain to millers at a subsidized price, and the millers were to sell a 2 kg packet of maize meal at KES 55, compared with the prevailing price of KES 72. Poor targeting and the high cost of implementation resulted in the discontinuation of the subsidy programme. By the time the programme was discontinued in late 2009, it had cost US$ 334 million. In 2009, the cash for work programme, costing US$ 214 million, was implemented under the economic stimulus programme. The aim of the programme was to increase income for poor households by providing employment, thereby ensuring food affordability. The mismanagement of programme's funds resulted in its termination (Meijerink et al., 2009; Nzuma, 2013).

The implementation of the price stabilization policy by the NCPB has resulted in market distortion. During harvest, NCPB is expected to purchase maize at a lower price and later release stocks when prices are high. In the past, lobbying by producer groups and politicians has influenced the NCPB to purchase maize at prices higher than the prevailing market prices. A study by Kamau et al. (2013) found evidence of stable maize prices when the NCPB never participated in the purchase of maize during the season, compared with the season they participated. Regarding trade policy, delays in the removal of the maize import duty by the Treasury, when the country turns to the world market to bridge the deficit, implies that the country misses the window of opportunity to import maize. The importation from world markets is plagued by time lags (a minimum of 60 days is required for imported maize to land at Mombasa port). The time lag, coupled with the delay in import tariff removal, results in consumers being exposed to high maize prices for longer than is necessary (Kamau et al., 2012;Kamau et al., 2013).

Despite the implementation of various policies, domestic food prices have continued to rise (Karugia et al., 2010; Gérard et al. 2011;Nzuma, 2013; OECD-FAO, 2016). The continued and unabated high-food prices, despite the various policies implemented to mitigate this phenomenon, indicates that the policies implemented do not meet their intended goals. Measures such as the implemented food export bans have not been effective, given the porous nature of the borders in the region. The informal border route becomes popular during times of exports bans for smuggling food across the border. Hence, export bans have resulted in increased transaction costs (smuggling costs), high consumer prices in the destination country, and low producer prices in the country of origin (Ackello-Ogutu and Echessah, 1997; Jayne et al., 2005). The reason given for why the policies have not achieved their desired effects is the nature of their implementation, which has been described as highly discretionary, erratic, sudden and inconsistent.

The private sector's willingness to invest in the maize value chain is linked to free-market policies. The government interventions in the maize sector in the effort to stabilize food prices resulted in uncertainty, leading to disincentives for private sector investment in the sector (EAGC, 2009; ATPAF-ESA, 2016). Following the promulgation of the new constitution in 2010, the implementation of projects and activities within the agriculture sector were devolved to the County governments. The National government was tasked with formulating and implementing policies for the sector. At the National level, policies relevant to the maize industry are illustrated in Table A.3 in Annex A.

2.9 SUMMARY

The maize sector has undergone three major phases that marked the critical turning point in the sector. Maize plays an important role, both at the national and household levels. The impacts of market reforms were mixed across the transition and developing economies. Understanding the overall effects of market reforms has continued to elude researchers. This is attributable to the lack of available quality data, lack of consensus on the appropriate timing and sequencing of policy, varying degrees of policy implementation, policy reversals, political transition costs, and the political process. All these factors are yet to be comprehended, notwithstanding fully using conventional analyses.

Maize production in Kenya is dependent on the weather, which affects marketing channels, with the country having to source stocks to make up its deficit from the regional market during normal harvest seasons, and to turn to the world market during poor harvest seasons. Consequently, Kenya operates under the IPP trade regime, as it is a net importer of maize. MIS is important as it facilitates a faster speed of adjustment between two markets, without having a significant effect on transfer costs. The impact of MIS in Kenya is inconclusive as a result of the mismatch between the MIS design and farmers' perceptions on mobile telephony use. To mitigate the soaring food prices, government intervened in the market. The heavy government intervention distorted the market and did not achieve the intended goals. This was mainly due to the nature of implementation that was highly discretionary, erratic, sudden and inconsistent.

CHAPTER 3: APPROACH AND METHOD OF STUDY

3.1 INTRODUCTION

Economic theory is central in the development of quantitative methodology, which ensures that policies formulated are anchored on sound economic tenets. Researchers have identified key aspects and interaction of variables to analyse and solve problems in the agricultural sector. Spatial market integration analysis provides information on price transmission and the speed of adjustment. It mainly relies on prices for analysis and thus overlooks the effects of local dynamics such as policies, demand and supply. Stand-alone market integration studies have been criticized for excluding the local dynamics that play a major role in commodity price formation. Partial equilibrium models examine the specific sub-sector in isolation by providing in-depth analysis on the supply, demand, price formation, the relationship between agricultural input and output of different products, and the impact of policy on supply and demand.

The main objective of this chapter is to develop a framework that combines spatial market integration and partial equilibrium model analysis to gain an in-depth understanding of the continued high food prices in Kenya. A framework combining these two approaches addresses our objectives in three ways. Firstly, the criticism of the exclusion of local dynamics by stand-alone spatial market integration is addressed. Secondly, the approach provides information on changes in local dynamics, projections and simulation analysis of various shocks on demand, supply and prices. Finally, the approach provides a holistic approach in addressing the causes of high food prices in Kenya, which to the best of our knowledge, has not been attempted before.

The rest of the chapter is organized as follows: Section 2 outlines the causes of high food prices and the conceptual framework to address high food prices. Section 3 discusses a survey of the relevant literature for spatial market integration and modelling the Kenyan maize market. Section 4 outlines the analytical framework and empirical models for both spatial market integration and modelling the Kenyan maize market. Section 5 discusses the study area and data used in analysis, while section 6 summarizes the chapter.

3.2 CAUSES OF HIGH FOOD PRICES IN KENYA

As demonstrated in Chapter 2, Kenya has continued to be plagued by high and volatile food prices, compared with the world and the surrounding region. Two market-related factors are the cause of high food prices. The first factor is price transmission from the world market and the second one comprises domestic supply and demand dynamics. Price transmission from the world market occurs when there is market integration between the domestic and the world markets. Free trade between the two markets facilitates international arbitrage and deepens market integration. Three factors may slow or obstruct price transmission from the world to the domestic markets. The first factor comprises trade policies. The government may implement trade policies aimed at blocking or slowing down the transmission of shocks from the world to domestic markets. In the case of the maize sector, during normal seasons, Kenya relies mainly on imports from the region to bridge its deficit, and only turns to the world market during poor harvests. During normal seasons, a 50% import duty is in effect. Hence, there is no arbitrage opportunity for traders to import maize from the world market. During a poor season, the import duty is reduced or zero-rated to facilitate the importation of maize from the world market. The import duty blocks transmission from the world market to the domestic market during a normal season.

The second factor that may slow or hinder price transmission is the applicable trade regime. The interaction between production and consumption patterns determine the trade regime, which determines price formation. As discussed earlier in Chapter 2, there are three types of trade regimes – IPP, autarky, and EPP. Kenya operates under the IPP trade regime. Under the IPP regime, domestic prices are a function of transport costs, exchange rates and import taxes, as price formation is dependent on IPP (Meyer, 2006). In addition, a high price transmission from the world to the domestic market is expected. In the case of Kenya, regional markets play an important role in the domestic price formation of maize. The world price transmission shocks only come into play during poor harvest seasons when the country imports from the world market.

Finally, the tradability of a commodity is another factor that may hinder or slow down the price transmission from the world to domestic markets. Commodities traded in the international markets will have price transmission from the world market to the domestic market. Non-tradable commodity prices are only affected by the local demand and supply dynamics, and have no link to international prices. For our study, maize is an internationally traded commodity; hence, price transmission is expected from the world market to the domestic market. Despite maize being an internationally traded commodity, Kenya mainly depends on the regional market to offset its deficit. An import tariff of 50% is in effect. Consequently, there may be no transmission from the world market to the domestic market. The country only turns to the world market during poor harvest seasons and the import tariff is removed to allow for the importation of maize.

The second market-related factor that causes high food prices comprises the local supply and demand dynamics. Local dynamics may be categorized into the demand block, the supply block, and policies. Policies are cross-cutting and influence both supply and demand. The interaction of these dynamics determines price formation. The demand block includes incomes, substitution, and population growth. Policies implemented that focus on the demand block are subsidies, e.g. urban maize meal subsidies to poor households and tax adjustments such as the reduction or zero rating of taxes on foodstuffs. The supply block includes input costs, productivity, and climate variability. The fertilizer subsidy programme and price stabilization are two policies which have been implemented that are geared toward the supply block.

In order to understand the causes of high food prices, we need to look at the regional and world markets. Thus, domestic prices are a function of transport costs, the exchange rate and import taxes (from the world market). The interaction between demand and supply also affects domestic price formation. Policies cut across these factors, which also influence domestic price formation. Figure 3.1 below illustrates the interaction of all these factors which are to be acknowledged in understanding the causes of high food prices in Kenya.

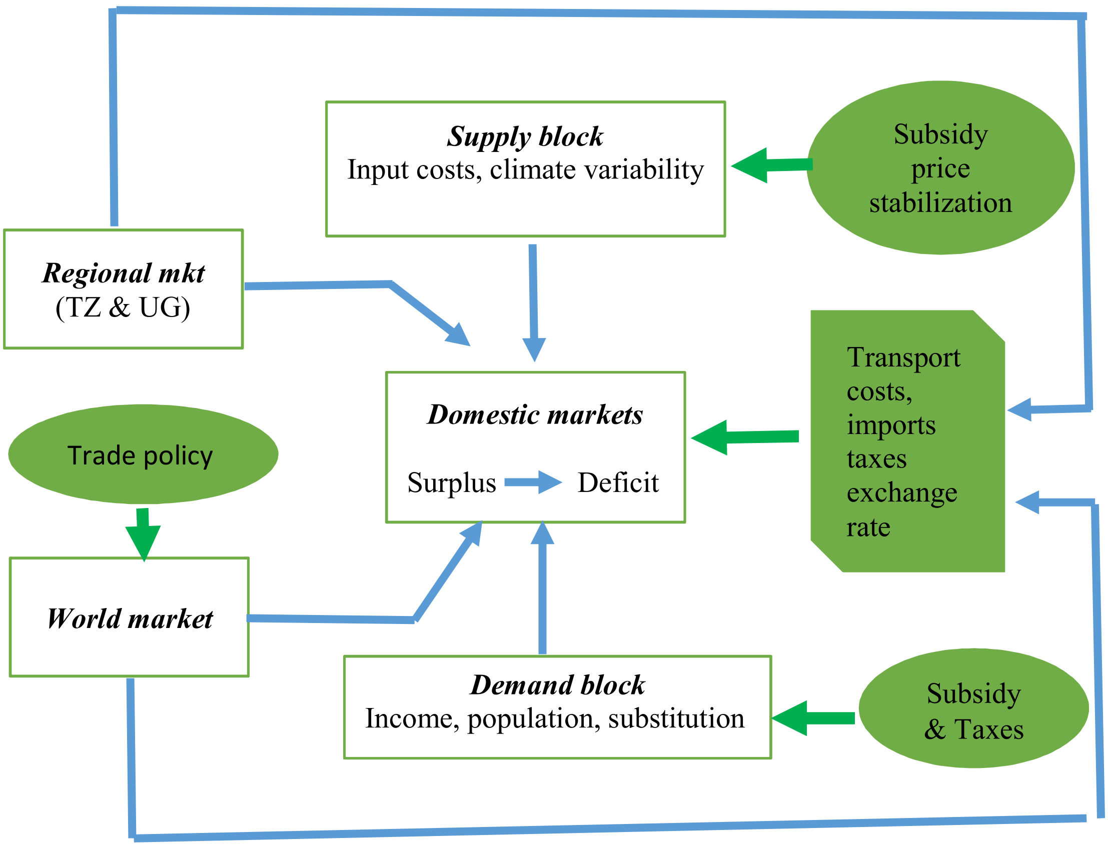

Figure 3.1: Conceptual framework for understanding high food prices in Kenya
Source: Author's depiction

3.3 SURVEY OF RELEVANT LITERATURE

3.3.1 Spatial market integration

Market integration is defined as the transfer of the Walrasian excess demand from one market to another. The transfer may be either of physical commodities or the transmission of price shocks or both (Barrett, 1996). Although the physical flow of goods between the two markets is sufficient, it does not necessarily demonstrate tradability. Market efficiency is a price-based concept, which refers to the speed at which the system is restored back to equilibrium after the transmission of shocks (Barrett, 2001). The measurement of how well markets are integrated across space is price transmission (Fackler and Goodwin, 2001). Spatial price analysis studies have been used to indicate the extent to which markets are integrated. The importance of understanding the functional structure of markets for the appropriate design and assessment of market policies cannot be overstated. The underlying objective of market integration analysis is to provide a better understanding of the implementation of such short- and long-term policy interventions.

The literature on spatial market integration identifies three techniques – pre-cointegration, cointegration and post-cointegration (von Cramon-Taubadel, 2017). Pre-cointegration techniques were early market integration techniques, which focused on the simple bivariate price correlation of a product in different markets to infer to market integration (Blyn, 1973; Timmer, 1974). These studies overlooked the dynamic nature of agricultural commodity markets, non-stationarity in time series data, and the distinction between efficiency and integration.

To overcome the challenges of pre-cointegration techniques, Ravallion (1986) formulated a dynamic model that allowed for differentiation between short-run and long-run market integration and segmentation. This led to the development of cointegration techniques as a measure of market integration. Cointegration techniques accounted for non-stationarity in time series data, thus avoiding spurious regressions. This technique became popular in the measurement of the extent and degree of market integration, as demonstrated by various studies (Ardeni, 1989; Goodwin and Schroeder, 1991; Palaskas and Harriss-White, 1993; Alexander and Wyeth, 1994; Dercon, 1995; Asche et al., 1999; Gonzalez-Rivera and Helfand 2001; Balcombe and Morrison, 2002;Rashid, 2004; Lutz et al., 2006).

However, cointegration techniques were criticised for overlooking transaction costs. The presence of transaction costs may result in a non-linear relationship of prices between two markets. Consequently, cointegration techniques resulted in bias and erroneous policy conclusions, especially where trade is discontinuous and bidirectional, and where transaction costs are high and non-stationary (Dahlgran and Blank, 1992; Barrett, 1996; Baulch, 1997a and 1997b; McNew and Fackler, 1997; Li and Barrett, 1999; Barrett et al., 2000; Barrett, 2001; Fackler and Goodwin, 2001: Fackler and Goodwin, 2002; Barrett and Li, 2002;Fackler,2004).

As researchers gained an in-depth understanding of the complexity of agricultural commodity markets, post-cointegration techniques were developed. These sophisticated methodological approaches addressed the complexities in agricultural commodity markets. Post-cointegration methodologies have included non-linear, asymmetric adjustment, regime switching, time-varying copulas, band spectrum regression, and non-parametric ECM techniques (von Cramon-Taubadel, 2017).

Market integration studies follow the market equilibrium theory of Enke (1951), Samuelson (1952) and Takayama and Judge (1971), commonly referred to as the ESTJ theory of spatial equilibrium. This theory assessed the interconnection between markets within the concept of tradability, market equilibrium and efficiency. The concept implies multiple equilibria systems that are defined by prevailing arbitrage conditions and corresponding tradability structure (Baulch, 1997b; Sexton et al., 1991; Spiller and Wood, 1988; Abunyuwah, 2008). The importance of market integration was underpinned by market reform and the continued strong argument for a free market economy (Baulch, 1997b, Barrett and Li, 2002, Minot, 2011).

Sexton et al. (1991) summarized the lack of market integration into three factors. The first factor is the lack of market links through arbitrage (autarchic). This may be due to prohibitive transaction costs, public market protection or local dynamics influencing price formation. The second factor includes impediments to efficient arbitrage, e.g. trading barriers or risk aversion. The third factor is imperfect competition in one or more of the markets.

Using a dynamic framework, time series tools of varying levels of non-linear complexity have been applied in market integration analysis. Brorsen et al. (1985) used a theoretical model for price determination. Wohlgenant (1999) determined the relationship between the price of aggregate output and raw material prices. The asymmetric adjustment was used to estimate price transmission (Kinnucan and Forker, 1987; von Cramon-Taubadel, 1998; Meyer, 2004). Abdulai (2000) used a threshold cointegration approach to determine the asymmetric adjustment in the market. Goodwin and Piggott (2001) used a threshold autoregression (TAR) and cointegration approach to determine market integration. Fackler and Tastan (2008) used indirect inference on a conditional density function to estimate market integration. In addition, the extended parity bound model (PBM) was used to determine spatial market integration (Moser et al., 2009; Butler and Moser, 2010). The extent to which price signals are transmitted across spatial markets determines the attainment of efficient market performance. The level of tradability, as might be dictated by trade restrictions, market competition and the cost of arbitrage, determines the level of efficiency and integration of the markets under consideration.

The past decade has seen improvements in the approaches and methodologies employed with respect to measuring market integration. Studies by Negassa and Myers (2007), Tostao and Brorsen (2005), Moser et al. (2009), and Van Campenhout (2007) incorporated non-linearity of transaction costs. The authors argued that although the advantages of the TAR models are now widely known, few studies had applied this approach. The use of threshold models has become popular with researchers, especially in the modelling of non-linear and dynamic behaviour in market integration. The threshold methods commonly used include the threshold error correction model (TECM), PBM, and a variation of TAR. The variation of the TAR model overcomes the assumption of constant transaction cost by including a time trend.

The PBM approach was first introduced by Spiller and Huang (1986) and was then developed by Sexton et al. (1991), Baulch (1997b), Park et al. (2002), Barrett and Li (2002), and Negassa and Myers (2007). This model estimates the probability of being in a spatial regime, which is consistent with the equilibrium notion that all spatial arbitrage opportunities are exploited. There are several criticisms with regard to this approach. The first criticism is that the results are sensitive to the underlying assumptions. The application method is based on one market at a time in order to manage a large number of trade regimes that may occur in a multi-market context. The second criticism is the assumption that shocks are independent and hence provide no path for adjustments. A third criticism is the assumption of a constant extent of spatial efficiency (inefficiency) between pairwise markets over time (time-invariant), despite policy regime changes and investment within the markets. The fourth criticism is the assumption that half-normality and normality are inherently arbitrary (Fackler, 1996; Barrett and Li, 2002; Fackler and Goodwin, 2001; Van Campenhout, 2007). The final criticism is the assumption of constant unobserved transfer costs across time and space. To address these weaknesses, later market integration studies used an extended version of PBM that relaxed some of the assumptions (Barrett and Li 2002; Negassa and Myers, 2007; Moser et al., 2009).

Tong and Lim (1980) introduced the TAR model. Tong (1990) later exhaustively discussed the model. The model assumes a regime that is determined by a variable c_t relative to a threshold value. In market integration studies, the threshold values used are either transaction costs or trade volumes, which play a role in the mechanism leading to spatial equilibrium. Hence, threshold values constrain price transmission and exhaustion of arbitrage opportunities. Balke and Fomby (1997) introduced two forms of the TAR model, the equilibrium-TAR and band-TAR. The equilibrium-TAR follows conventional practice and assumes that equilibrium is the centre of the threshold interval that forms the point of attraction from both outside and inside the interval. The band-TAR allows the outer boundary of the threshold band to be that point of attraction from without. This distinction is important for inference and for subsequent analysis. Studies such as that of Balcombe et al. (2007) have utilized both equilibrium- and band-TAR in the measurement of the extent and degree of market integration.

The TAR model has two shortcomings. The first is the assumption of constant transaction costs over time and the second is with respect to the thresholds of the parameters where asymptotic distribution of the threshold parameter is neither normal nor nuisance parameter free. Hence, it is not possible to obtain standard errors and confidence intervals, as shown by Chan (1993). Hansen (1996) and Li and Ling (2012) developed a mathematical methodology to mimic the limiting distribution of the estimated threshold through an associated compound Poisson process. Based on the mathematical results, one would then construct a confidence interval, thereby solving the problem highlighted by Chan (1993).

Studies carried out in ESA using pre-cointegration and cointegration techniques on various agricultural commodities are summarized in Table A.4 in Annex A. The use of cointegration techniques has been criticized as restrictive as it overlooks the transaction costs, which are a prohibitive factor in market integration. With the development in methodological approaches to market integration, later studies incorporated non-linearity and regime switching methods to carry out studies on market integration.

Studies that use the TAR approach in the ESA region include the following studies. Van Campenhout (2007) compared the two divergent empirical methods for measuring market integration that had been developed (PBM and TAR). The author argued that the TAR models were better able to capture the dynamics of the arbitrage process between two inter-connected markets, as compared with their counterparts. According to the author, the TAR model allows for the differentiation between transaction costs on one hand and the speed of adjustment on the other. These two components are critical to inter-market arbitrage. The author used an extended TAR on seven selected markets in Tanzania that include a time trend in both the threshold and adjustment parameters to account for non-constant transaction costs. The author concluded that relaxing the constant transaction resulted in a lower speed of adjustment and reasonably lower half-life.

Myers (2013) evaluated whether the spatial and temporal price patterns observed in the Malawian retail maize markets were consistent with conditions required for effective inter-regional trade and storage by using TAR. Spatial efficiency conditions were found to hold in the long run for all trade routes investigated, and short-run deviations from these conditions dissipated quickly. The author concluded that these results indicated that the private sector in Malawi was transporting maize from surplus to deficit regions and smoothing maize consumption between harvests.

Abidoye and Labuschagne (2014) used TAR in their investigation of price transmission from the world market to the domestic market in South Africa. The authors compared nested and non-nested models that capture forms of non-linearity in the price spread and used a Bayesian approach. The results showed the presence of non-linearity in price transmission from the world market to the South African market, and identified three regimes that were triggered by the price spread in the previous period.

There a few cross-border studies that have focused on market integration. A study by the World Bank (2009) focused on regional maize markets and marketing costs. The study used cointegration and ECM to establish the extent of market integration across the borders, production and consumption markets within borders, and major markets across the border with world markets. The results from the study showed that the major markets, Mombasa, Nairobi, Kampala and Dar es Salaam, were integrated. Within the three countries, the major production areas were relatively integrated with consumer markets and across the borders. Market pairs that at least had one Tanzanian market reported weaker and slower integration than the other market pairs in the rest of the region. The authors attributed this fact to the size of Tanzania, poorer infrastructure, and distortive policy interventions such as export bans.

Ihle et al. (2009), using a Markov-switching estimation model, estimated the spatial price transmission between Kenya and Tanzania. The authors found poor price transmission between Kenya and Tanzania during maize export bans, and that the situation improved with the removal of the ban. In their study on heterogeneous infrastructure and cross-border trade in the East Africa Community (EAC), Ihle et al. (2011) used cointegration and the semi-parametric partial linear model. The authors found that distance had a significant non-linear impact on the transmission of information. Strong negative effects for the market pair located in Tanzania or across the country borders were observed. The transaction costs within Tanzania or crossing borders were higher, compared with the rest of the region. Market pairs with at least one Tanzania market were less integrated. The weaker market integration was attributed to poor infrastructure, size of the country, and distortive policy interventions. The gap with respect to the cross-border studies was the lack of a comprehensive analysis of the cross-border markets integration, domestic spatial integration, domestic and world market integration, and the effects of policy across all the markets. One study attempted such a comprehensive analysis (World Bank, 2009) but overlooked the effects of policy across the three market clusters. These issues are addressed by this study.

Studies carried out on market integration in Kenya include Gbegbelegbe and de Groote's (2012) study on the spatial and temporal maize price analysis. The authors used cointegration and an error correction method to establish the extent and degree of market integration in five major markets in Kenya. The authors found that all the markets were integrated. Ngare et al. (2013) used an asymmetric approach to determine retail price transmission across maize and beans markets in Mbeere and Meru South. The authors determined that retail price transmission was asymmetric, thus supporting the hypothesis of sticky[7] prices. Market pairs that were further apart had a higher speed of price response, compared with market pairs closer to each other. The maize and beans markets were all integrated. Nzuma (2013) conducted a study on the political economy of food price policy. He tested for market integration in five major markets by using correlation coefficients. The author concluded that all the markets were highly integrated. Studies carried out on market integration in Kenya have predominately applied

7 Food prices show a greater response to rising prices than to falling prices (Peltzman,2000).

cointegration and ECM techniques. However, these studies overlooked transaction costs, the effects of policies on market integration, and the effects of local demand and supply dynamics. In addition, none of the existing studies used data that was more recent than 2011. It needs to be noted, however, that spatial market integration may change over time due to changes in policy, information systems, and infrastructure improvement (Negassa and Myers, 2007).

3.3.2 Modelling the Kenyan maize market

3.3.2.1 Modelling approaches

Researchers have used quantitative models to analyse and solve problems through the identification of key aspects and interaction of variables that are a representation of our realities. In addition, models are used to explain certain discernible events and the improvement of economic theory (Howitt, 2005; Garforth and Rehman, 2006; Lee and Olson, 2006). The tools developed for the models have been utilized for the building of projections, simulations and the assessment of changes in the domestic and international markets. The tools have been used to assess the influence of market price on the agricultural market (Buckwell, 1989; Erjavec and Kavcic, 2005). Quantitative models have been extensively applied in agriculture policy analysis. This is due to their ability for quantifying welfare effects as a result of policy implementation (Calcaterra, 2002). A range of quantitative models has been developed and applied in examining the impacts of policies on the agricultural sector over the past decade.

Researchers have classified the models used into several categories. The first category is subject related. These include classifying the analysis carried out into subjects such as food security, environment, rural development, and trade. Geographical coverage is another category used to classify models. An analysis is conducted based on geographical coverage, whether at the national, regional or global levels. Subject-related and geographical-coverage models may be combined for analysis, for example, food security challenges in the ESA region. Another category is the single model equation. The single model equation was the traditional approach to modelling the commodity market. These models are static in nature and investigate the direction of causality between various variables within the agricultural sector. The main challenge of these models was the over-simplification of the agricultural sector to represent the complexity in the sector. Another category comprises market equilibrium models. These models incorporate the responses of economic agents to changes in price, and supply and demand shifts. These models capture the dynamic nature of the agricultural sector. Partial equilibrium and general equilibrium are the two common market equilibrium models used. Partial equilibrium focuses on a single sector in the economy, while general equilibrium accounts for the whole economy (Poonyth et al., 2000; Binfield et al., 2001; Lehtonen, 2001; Salvatici et al., 2001; Jensen et al., 2002; Calcaterra 2002; Erjavec and Kavcic, 2005; Bellu and Pansini, 2009). Notwithstanding the different classifications made by the different researchers, the one underlying theme is the static or dynamic nature of the models. Consequently, we may categorize commodity market models into single equation, and partial and general equilibrium models.

Single equation models

These models assume that the agricultural sector is statistic and that products are perfectly homogenous. Single equation models explain the causality that could result in market variation. These models have been used to capture the impacts of policies on the supply side of the sector (Conforti, 2001). The models have also been used in the estimation and forecasting of net income (Nivens et al., 2000). However, due to the over-simplification of the sector, the stochastic components of the key variables are overlooked. In addition, the models cannot capture the intricacy in the agricultural sector. Only a few of these models have managed to capture the demand for inputs, albeit not comprehensively. Hence, the net impact of economic policies cannot be exhaustively determined (Conforti, 2001). The major weakness of these models is the assumption that the agricultural sector is static; hence, dynamics changes within the sector are not accounted for. In addition, the impacts of the policies implemented on various components across the sector, such as on production, supply, consumption and demand, are difficult to analyse using a single equation. When modelling the agricultural sector, the underlying assumptions used in simplifying the structure of the model are critical, as they anchor the model mirroring reality (Soregaroli and Sckokai, 2011).

General equilibrium models

These models analyse the interrelation and interdependencies of economic agents to gain an understanding of the working of the economic system as a whole. The changes in prices and quantities of commodities and services are observed in relation to the entire economy. An economy is in equilibrium when all economic variables are simultaneously in equilibrium and linked by factor and commodity prices. These models have been used in the analysis of aggregate welfare distribution attributable to policy implementation. Simulation analysis has been used to assess the impacts of shocks on economic agent interventions (Rumler, 1999; Mitra-Khan, 2008; Soregaroli et al., 2011). General equilibrium models are based on the neo-classical economics theory of utility maximization by households and profit maximization by the firms. Decisions made by the firms and households are based on a set of signals that they observe. The social accounting matrix (SAM) is a form of general equilibrium that is used. It is a comprehensive, economy-wide data framework that is based on the principle of double entry in accounting that requires the total income to equal the total expenditure (Pyatt, 1988).

The assumptions made under the general equilibrium approach include perfect market competition in commodity and factor markets; homogenous productive services; that tastes, habits and incomes of households are given and constant factors of production that are perfectly mobile between different occupations and places; homogenous productive services; constant returns to scale, and that all firms operate under identical cost conditions (Pyatt, 1988; Kuenne, 1992). The general equilibrium models have several uses. They have been used in endeavours to understand whether the economic system is working efficiently, and if not, what the factors were that resulted in disequilibrium. General equilibrium models have been used in understanding the multifaceted problems facing markets, as they can predict the consequences of an autonomous economic event on the complex chains of interactions of the markets on a systematic basis. The models have been used in analysing the decisions of the different economic agents that result from changes in prices. General equilibrium has been used to understand the input–output analysis of an entire economy.

The strength of the general equilibrium model is in the solid microeconomic foundation that allows for integrating the behaviour of all economic agents systematically, which dictates how the market operates in equilibrium (Borges, undated). The internal consistency of the model allows the analyst to integrate all the components of a problem into the single structure equation.

This consequently allows the simulation of complex interrelations with many ramifications, overall, for the economy. The general equilibrium models have developed highly disaggregated models, which are useful in analysing the structure of the economy. Policy actions or exogenous shocks that impact on the overall economy are much smaller than their effect on the structure of the economy (Pyatt, 1988). Disaggregation allows for analysis of the impact on the structure of the economy. Moreover, disaggregating allows for the identification of structural aspects that lead to distortion or failure of the market. General equilibrium models provide a better measurement of welfare loss or gain linked to new policies. Weaknesses of the model include the lack of empirical validation, and the model's assumptions that may not explain when an economy is in a persistent disequilibrium state. The model may not address macroeconomic issues related to stabilization policies. In addition, the model requires a rich dataset in order for it to be implemented.

Partial equilibrium models

Unlike the general equilibrium models that deal with the entire economy, the partial equilibrium models examine specific sub-sectors. The partial model analyses the supply, demand, price formation and the impact of the policy. Furthermore, the relationship between agricultural inputs and outputs of different products is investigated. The model is suitable for the analysis of policy impacts on a specific sector (Garforth and Rehman, 2006; Kotevska et al., 2013). The key assumptions in the partial equilibrium model are the maximization of profit and utility by producers and consumers, respectively, to reach equilibrium. Moreover, the models are based on historical data, thus model projection and simulation relies on the assumptions that the structure of the markets is correctly specified and remains unchanged (Garforth and Rehman, 2006; Kotevska et al., 2013).

Two approaches are used for partial equilibrium models. The first and commonly used method is the econometric approach. This method entails the estimation of coefficients by using different econometric techniques. The second method is the synthetic approach. Coefficients are obtained by using elasticities values from earlier similar studies that are calibrated and used in the estimation of the initial equilibrium equation. This approach has commonly been used when there is limited data on the explanatory variables or when the econometric approach yields undesirable coefficients. The lack of statistical assessment of the coefficients is the major weakness of the synthetic approach (Conforti, 2001). An example of a partial equilibrium model that applies econometric approaches is the Global Agricultural Perspective System (GAPS) used by the Food Agriculture Organization (FAO). This partial equilibrium model studies the growth of global food markets in the long term and analyses how socio-economic variations, investment pay-offs, and climate change may affect the future of global demand. The Common Agricultural Policy Regionalized Impact analysis (CAPRI) is an example of a synthetic model, which was developed for the European Union (EU). Other than assessing the impact of the EU's common agricultural policies, the model has been used on trade and environmental policies within the EU (Adenauer, 2008; Kavallari et al., 2016).

The neo-classical theory of maximization of profit and utility for attaining equilibrium by producers and consumers, respectively, is the foundation of partial equilibrium models (Garforth and Rehman, 2006). The partial equilibrium model equates the supply and demand sides and uses a recursive procedure to solve for prices based on the country's trade regime (autarky, import or export parity regime). Typically, agricultural partial equilibrium models consist of the following components: supply, demand, trade, price linkage and model closure (Meyer, 2002;Meyer, 2006). These components are discussed in detail in Section 3.4. Devadoss et al. (1993) noted that partial equilibrium models that use econometric techniques did not recursively link the input and output sides, and hence missed the influence on input costs. The lack of recursively linking input and output was addressed through the treatment of input costs as exogenous variables and capturing their influence via an input cost index. Another approach used was the estimation of inputs cost through adjusting previous input expenditure with an index derived from output models and input price index forecasts (Westhoff et al., 2004: McGath et al., 2009).

Studying a sector in isolation allows for gaining a comprehensive understanding of the sector. Partial equilibrium models are best suited for these analyses and they add significant value, especially when analysing the impact of risks. The advantages associated with the partial equilibrium models include the fact that minimal data is required to undertake an analysis of a sector, they allow the analysis of the impacts of policy and shifts in local dynamics at a disaggregated level, and facilitate an in-depth understanding of a sector. Criticism of the partial equilibrium models is that their trade-off of comprehensively studying a sector overlooks the interlinkage between different sectors in an economy. In reality, the whole economy is interlinked and different sectors depend on each other to contribute to the overall economy (Conforti, 2002; Binfield et al., 2002; Piermartini & Teh, 2005; Meyer, 2006; Strauss, 2009; De Beer, 2009; Soregaroli and Sckokai, 2011). Moreover, a comprehensive knowledge of the sector, strong underlying assumptions based on sound economic theory, and quality data lay the foundation for better projection and simulation of analysis that is closer to reality (Soregaroli and Sckokai, 2011).

3.4 ANALYTICAL FRAMEWORK AND EMPIRICAL MODELS

3.4.1 Analytical framework

3.4.1.1 Spatial market integration

The market equilibrium theory is at the core of various spatial market integration studies. This theory refers to price dispersion between two markets for a homogenous good that is restricted from above by the cost of arbitrage between the two markets, with no trade volume constraints, and is restricted from below when trade volumes reach a ceiling (Barrett, 2001). Under this concept, several equilibria systems, defined by prevailing arbitrage conditions and matching tradability arrangements, are inferred. The interconnection between markets is assessed with respect to tradability, market equilibrium and efficiency concepts. Prices, transaction costs and trade volumes are used in the analysis of spatial market integration. The market equilibrium theory is summarized as follows:

$$p_t^b < p_t^a + \tau_t^{ab} \quad \text{if} \quad q_t^{ab} = 0 \tag{3.1}$$

$$p_t^b = p_t^a + \tau_t^{ab} \quad \text{if} \quad q_t^{ab} \in (0, q_t^z) \tag{3.2}$$

$$p_t^b > p_t^a + \tau_t^{ab} \quad \text{if} \; q_t^{ab} = q_t^z \tag{3.3}$$

where p_t^b and p_t^a are the prices in markets b and a in time t, respectively. $\tau_t^{ab}$is the transfer cost from market a to b at time t, while q_t^{ab} represents the physical flow of trade between markets a and b in time t. q_t^z represents the maximum trade allowed between these two markets. The spatial price dispersions between the two markets in Equation 3.1 are less than the transfer costs are. Under Equation 3.1, no arbitrage opportunities exist between the two markets for traders to engage in trade. The two markets are spatially efficient if no trade occurs, and inefficient if trade occurs. The spatial price dispersion in Equation 3.2 equals transfer costs. This is consistent with spatial market efficiency, irrespective of trade occurring. When trade occurs, we expect that p_t^b and p_t^a will differ from the autarky price; thus, demand and supply shocks will shift between the markets. Competitive equilibrium also holds under these conditions (Barrett and Li, 2002; Negassa and Myers, 2007). The spatial price dispersions in Equation 3.3 are greater than the transfer costs are. There are unexploited arbitrage opportunities; hence, these markets are spatially inefficient, irrespective of the occurrence of trade (Fackler and Goodwin, 2001). These markets are characterized by imperfect competitive equilibrium. Several factors have been attributed to this phenomenon, including the restriction on trade flows across regions, non-competitive practices, and government policies and price supports activities (Tomek and Robinson, 1990; Baulch, 1997b; Barrett and Li, 2002).

Three regimes are established, with transaction costs acting as the threshold. Regime 1 is where price dispersions are less than transaction costs (Equation 3.1), Regime 2 occurs when price spread equals transaction costs, while under Regime 3, the price spread is greater than the transaction cost is. Accordingly, the regime switching model alternates between the three states, depending on price dispersion and its relationship with the threshold, which in this case, is transaction costs (Barrett, 2001). Trade volumes have been used as a threshold to depict market integration. The regime switching in this scenario is dependent on the magnitude of trade flow between regions. Barrett (1996) observed that the main challenge facing spatial market integration studies was limited observable time series data on transaction costs and trade flows, which challenges are still experienced, to date.

The issues with having limited observable time series data on transaction costs have been addressed via estimation within the model. The standard assumption of most studies that have estimated a transaction cost was that it was constant (Goodwin and Piggott, 2001; Sarno et. al., 2004). In reality, transactions costs for an agricultural commodity vary according to different scenarios. In Kenya, transaction costs may vary according to the quality of the road, distance travelled, season, marketing costs, number of municipalities crossed, among other factors (Kirimi and Swinton, 2004;World Bank, 2009; Kirimi et al., 2011; Gitau and Meyer, 2018). To overcome the challenge of constant transaction costs, studies have extended the model to incorporate a time trend (Van Campenhout, 2007; Amikuzono, 2012). For this study, we also incorporated a time trend to overcome the standard assumption in literature of constant transaction costs.

As discussed earlier, the availability of time series data for trade volumes is a challenge. In instances where trade volume data is available, it is aggregated and commonly compiled in monthly, quarterly, semi-annual or annual series (Barrett and Li, 2002). The aggregation of data (on price or trade volumes) may affect price transmission and market integration, as demonstrated by Von Cramon-Taubadel et al. (2006). Despite these challenges, where trade volume data was available, studies combined transaction costs and trade volumes to establish multiple thresholds, which allowed for price transmission to differ, not only based on transaction costs but also on the magnitude of trade flow between regions (Traub et al., 2010: Meyer and Jayne, 2012).

To analyse the effects of policies on price transmission and market integration, dummy variables, time trend, splitting the data into sub-samples, parity bound models, and threshold techniques have been applied in literature (Negassa et al., 2004; Van Campenhout, 2007; Ihle et al., 2009; Yang et al., 2015; Gitau and Meyer, 2018). Marketing and trade policies implemented by the government play a crucial role in market integration. Studies have shown that the policy insulation of domestic markets has resulted in little or no relationship being identified between the international and domestic prices, or the two being related in a non-linear manner (Martin and Kym, 2012; Baltzer, 2013; Yang et al., 2015).

For this study, we split the data into sub-samples to correspond to the identified policy regimes. We classify the policy regime in Kenya according to the method shown in Gitau and Meyer (2018). The first policy regime covered the liberalization of the maize sector. Under this regime, the NCPB was restructured, investments along the maize value chain were witnessed, and low concentration along the value chain, competition, and low maize prices were experienced. In addition, the regime was characterized by minimal or no policy intervention and the existence of a free market (Nyoro et al., 2004; Kirimi et al., 2011). The second regime covered the period of soaring food prices and was characterized by heavy government interventions through several policies. Table 3.1 below summarizes the two regimes and specific policy interventions experienced during each regime.

Table 3.1: Regime type and specific policy interventions 2000–2016

Regime type	**Specific policy intervention**
Regime 1 (Jan 2000–Dec 2007)	Market liberalization – NCPB restructured EAC customs union formed 2005 – zero rating of imports between member states No government participation in the market
Regime 2 (Jan 2008–Dec 2016)	Fertilizer subsidy, November 2008 to date Ban on millers buying maize directly from farmers, 2008 Zero-rated value-added taxes (VAT) on foodstuffs, 2008 Maize meal subsidy programme for urban poor households, 2009 Maize imports 2008, 2008/09, 2011 Cash for work programme, 2009 Import ban on GMO foodstuffs, November 2012 to date Reduction or removal of duty on imported maize, November 08-December 09, June-December 2011 NCPB purchases of maize in the market – price stabilization

Sources: Adapted from Nzuma et al. (2013) and as updated by the authors

As illustrated on Table 3.1 above, under Regime 2, several policies were implemented to mitigate high food prices. The TAR model was used to analyse the effects of aggregated policies implemented under Regime 2, as compared with Regime 1. We complemented the TAR approach by attempting to disaggregate the policies under Regime 2. The fertilizer subsidy programme, an import ban on GMO foodstuffs, and the reduction/removal of duty on imported maize were selected. A new sample, encompassing four regimes, was reconstituted. Regime 1 remained the same (market liberalization) and Regime 2 represented the fertilizer subsidy programme. The import ban on GMO foodstuffs and the reduction/removal of duty on imported maize were set for Regimes 3 and 4, respectively. A vector error correction model (VECM) was used to investigate price transmission across the four policy regimes.

We were cognizant of the overlapping periods of policy interventions. In our analysis of each policy intervention, other policies implemented during the same periods might have been overlooked. The challenges associated with evaluating policy include the implementation, timing and sequencing, partial implementation, and policy reversals (Gibbon et al., 1993; Dorward et al., 2004; Oya, 2007). For this study, we focus on policies that targeted markets, trade, and food security in the maize sector.

3.4.1.2 Modelling the Kenya maize market

The fundamental assumption of the partial equilibrium models is the neo-classical theory of profit and utility maximization by producers and consumers to respectively achieve equilibrium (Garforth and Rehman, 2006; Kotevska et al., 2013). A typical partial equilibrium framework consists of supply, demand, trade, price linkage and model closure features. The supply side consists of area harvested, yields, production and beginning stock. The demand side consists of human consumption, feed utilization, and seed use. Trade consists of exports and imports, depending on the country's trade regime. The price linkage connects the demand and supply sides under equilibrium conditions. The trade regime under which the country is operating determines the model closure. Kenya is a deficit maize producing country, and thus operates under the IPP regime. Consequently, the Kenyan maize model will be closed on imports.

Figure 3.2 below summarizes a typical grain market, operating under net import or export parity. The broken line indicates a lagged relationship between variables. The lagged prices of the crops being planted and the lagged prices of the substitute affect farmers' decisions on the acreage to be cultivated. The ending stocks of the production year become the beginning stock for the subsequent year. On the supply side, the weather plays a crucial role as it affects the area harvested and yields. Kenya, like most countries in the ESA region, depends on rainfall for crop production. On the demand side, the population and incomes drive human use. The livestock sector is the main driver of feed utilization. The increase in incomes by households has an impact on feed utilization, as increases in incomes operate to increase demand for animal products and by-products, consequently driving up the demand for feed utilization. Kenya, being a net importer of maize, operates on net import parity; therefore, trade would consist of net import from the regional trade, and occasionally the world market during times of poor harvest. Domestic maize prices will consist of import parity price, exchange rate, import taxes, transport from source, clearance at the port of entry, and inland transportation. Kenya relies mainly on imports from the region (Tanzania and Uganda) and, being members of EAC customs union, no import duty is paid on imported maize. During poor harvests when Kenya imports maize from the world market, the Treasury usually reduces the 50% import duty imposed on imported maize or zero rates it.

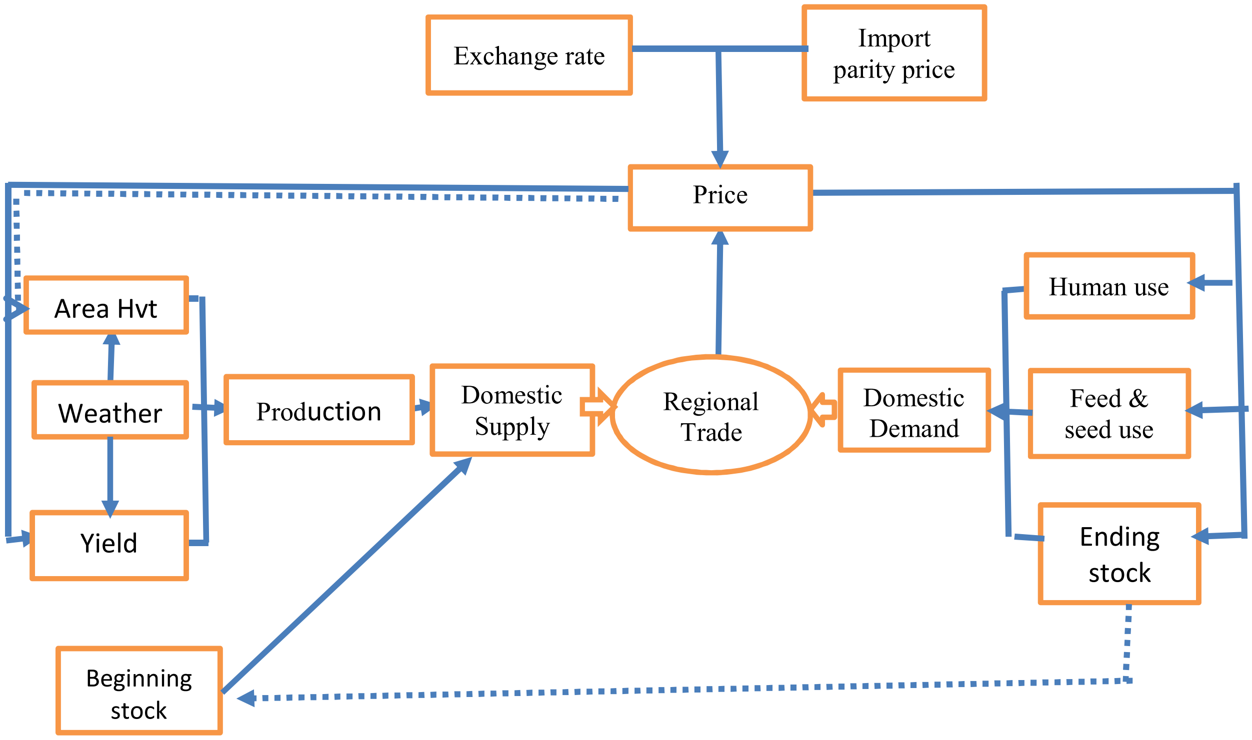

Figure 3.2: Flow diagram of the typical grain market in net export or net import parity

Source: Meyer (2006)

Supply elasticities represent the speed and magnitude of output changes that are attributable to changes in product price. These elasticities are important for policy as they measure the ability of the farm to adjust production to changes in economic conditions. Single commodity or aggregate supply response models are an improvement of the Nerlovian adoptive and partial adjustment models that hypothesize production decisions made by farmers, which are postulated to be based on future prices, as opposed to previous season prices. A later development in supply response studies addressed the challenges of the Nerlovian approach. These challenges included overlooking the dynamic nature of agriculture and the aggregate supply response to prices, distinguishing between short- and long-run elasticities, and not being cognizant of the lack of or limited market information system in developing economies (McKay et al., 1998; Thiele, 2000; Ball et al., 2003).

Time series data suffers from non-stationarity. Regressing non-stationary variables violates the classical assumption of mean reverting and constant variance, thus resulting in spurious regression (Granger and Newbold, 1974). Supply response studies have adapted cointegration techniques to overcome the problem of running spurious regressions (Alemu et al., 2003: Mose et al., 2007). Conte et al. (2014) identified constraints in finances, irrigation, infrastructure and inconsistent agricultural policies as being among the issues that have contributed in a less elastic supply response to prices in developing economies. Mixed results with respect to supply responses to prices have been reported in developing economies. Binswanger (1989) found evidence of persistent adjustment of resource allocation due to changes in price in developing economies. A study done in Uganda by Kassie et al. (2011) found instances of poor management of several input factors that arose through the reallocation of certain resources.

The supply response in our case for the area planted under maize will be influenced by the price of maize, price of a substitute, cost of inputs, and the weather conditions. In a typical agricultural production year, farmers observe prices after harvests. Consequently, the area to be planted in the next season is informed by the prices of maize and substitute crops received in the current season, and by the cost of inputs and weather in the next season. Therefore, the area planted under maize in the current season is influenced by previous season's prices of maize and substitute crops (lagged prices), and the current cost of inputs and weather conditions. A cointegration and error correction technique was used in this study to estimate the supply response to the price of maize in Kenya. Once the area planted has been determined, it is influenced by yields and weather conditions, resulting in the total maize production. The total maize production is derived by multiplying maize yield and area harvested. Adding a calculation of the beginning stocks results in the figure for the domestic demand.

On the demand side, human consumption is influenced by population, household income, the price of maize, the price of substitute crops, and changing consumption patterns. The increase in population results in an increased demand for food. On the other hand, an increase in incomes affects households' spending patterns. With increased income, households opt out of consuming staples that they consider to be "inferior", and switch to consuming animal products, animal by-products, and staples such as wheat (Jayne et al., 2009; Onyango et al., 2016). Urban and rural consumption studies in Kenya have shown a decline in the importance of maize in the food basket, with a decline in per capita maize consumption over time. The highest decline was recorded among the wealthiest households (Kamau et al., 2011; Onyango et al., 2016). This implies that maize still plays a significant role among rural and urban poor households. When maize prices are high, households are expected to substitute maize. Urbanization has been identified as a reason for the change in consumption patterns, such as the increased of importance of rice, Irish potatoes and plantains in urban centres (Onyango et al., 2016). The particular maize stocks at any one time influence maize ending stocks, reflect the maize produced during the season, and accordingly affect the prevailing maize prices. High maize prices will deplete ending stocks, as producers would want to take advantage of the high prices and hence would sell their maize. The reverse is also true. Adding human use, feed and seed utilization, and the ending stock will equal domestic demand. Since Kenya is a net importer of maize and operates under the IPP regime, we close the model on imports. Closing the model on imports allows for the estimation of the price linkage equation, rather than relying on equilibrium price formation. This is more realistic, as price formation in Kenya and the IPP trade regime implies that the domestic prices are influenced by the import parity price, the exchange rate, import taxes and transfer cost rather than relying on equilibrium price formation (Meyer, 2006). The price linkage equation is a factor of import parity consumption and production ratio.

The area harvested, yield, human use, ending stock and price linkage equations may be estimated using either an econometric or a synthetic technique. The common econometric technique used to estimate the supply and demand block equation is the ordinary least square (OLS) method. OLS assesses the relationships between the dependent and independent variables in the supply and demand block equations. The sign of coefficient and goodness of fit are used to evaluate the robustness of the OLS model. Time series data suffer from non-stationarity, and running OLS on non-stationary variables will result in variable misspecification that is carried over into the baseline, projection and simulation analyses. Researchers have used both OLS and ECM. The ECM is used where the variable is non-stationary and cointegrated. For this study, we use both OLS and ECM to overcome non-stationarity in our supply and demand block variables.

3.4.2 Empirical models

Time series data suffers from non-stationarity, and therefore violates the classical assumptions of mean reverting and constant variance. Running an OLS using non-stationary variables will lead to spurious regressions (Granger and Newbold, 1974). Cointegration methods are used to estimate the long-run relationship among variables that are non-stationary. The variables are required to have the same order of integration. The Augmented Dickey-Fuller (ADF) tests are commonly used to test for the order of integration (Dickey and Fuller, 1979). The Phillips-Perron (PP) and Kwiatkowski-Phillips-Schmidt-Shin (KPSS) unit root tests are commonly used to check for robustness of the ADF tests. The null hypothesis for ADF and PP test is the presence of unit root, while for KPSS test, the reverse is true (no unit root).

3.4.2.1 Spatial market integration

The popularity of the TAR models is based on their capability of producing and modelling many non-linear phenomena, which are observed in many empirical studies and cannot be explained by linear time series models. Moreover, the regime changing the autoregressive structure of the TAR model offers a simple and convenient means for interpretation. The model has been widely used by biological sciences, econometrics, environmental sciences, finance, hydrology, physics and population dynamics (Chang et al., 2015). The reasons why TAR models have not enjoyed the same popularity as their linear counterparts are given as time consumption and requirements for higher computing processing capacity when dealing with higher regimes (Li and Ling, 2012; Chang et al., 2015). A multi-parameter grid-based search over all possible values for all threshold parameters is required for a global minimum of the least square criterion when we have more than two regimes. Some approaches have been suggested to solve this problem, such as the graphical approach to determine the number and location of the threshold (Tsay, 1989), sequential estimation procedure (Gonzalez and Pitarakis, 2002), and factorization matrices (Coakley et al., 2003). Despite these approaches, there is a lack of a computationally efficient procedure that can be applied in general situations and on large sample sizes; hence, the computational burden is still growing exponentially with sample size.

Chang et al. (2015) focused on tackling the computational challenge inherent with multiple thresholds. The authors were motivated by the efficient least angle regression, developed by Efron et al., (2004), and by a modified procedure of the least absolute shrinkage and selection operator of Tibshirani (1996) for the framework of threshold models. The authors tackled the problem in estimating multiple regimes as a model selection problem and therefore developed an efficient algorithm that gives a computationally feasible solution. As discussed earlier, based on the market equilibrium theory, we have three regimes based on tradability restrictions and arbitrage conditions. The TAR model is a statistical model that is consistent with spatial efficiency, but allows for deviation from the efficiency condition, as well as a dynamic adjustment over time. The TAR model will take the following forms in the three regimes:

$$\Delta A_t = \lambda + \sum_{k=1}^{k} \gamma_k \Delta A_{t-k} + \varepsilon_t \qquad if\ A_t \leq \tau_t \qquad (3.4)$$

$$\Delta(A_t - \tau_t) = \lambda\,(A_{t-1} - \tau_{t-1}) + \sum_{k=1}^{k} \gamma_k \Delta(A_{t-1} - \tau_{t-1}) + \varepsilon_t \quad if\ \mathrm{A}_t > \tau_t \qquad (3.5)$$

$$\Delta(A_t + \tau_t) = \lambda\,(A_{t-1} + \tau_{t-1}) + \sum_{k=1}^{k} \gamma_k \Delta(A_{t-1} + \tau_{t-1}) + \varepsilon_t \quad if\ \mathrm{A}_t < \tau_t \qquad (3.6)$$

A_t represents the price spread in our deficit (P^d) and surplus (P^s) market ($P^d - P^s$) in the period t. Δ is the first difference operator ($\Delta A_t = A_t - A_{t-1}$). λ represents the speed of adjustment. τ_t is the transfer costs and represents the threshold variable which defines a boundary for when the price spread is too small to encourage trade, as represented by Equation 3.4 (Regime 1). The price spread may be positive and large enough to encourage trade from market B to A, as represented by Equation 3.5 (Regime 2), or negative and large enough in absolute value to encourage trade reversal from market A to B, as represented by Equation 3.6 (Regime 3).

These thresholds create nonlinearity, which results in the price difference behaving differently, inside versus outside a parity bound, represented by the transfer costs (Goodwin and Piggott, 2001; Sarno et al., 2004). Under Regime 1, the price differential is sufficiently small, and hence is no incentive for trade. There is no link between prices in different locations. Under Regime 2, the price spread is large enough to encourage trade from B to A, which causes the price spread to adjust back to the transfer cost boundary τ_t. Under Regime 3, the price spread is large enough in absolute value and negative to encourage trade reversal from B to A. This will lead to the price spread adjusting back to the transfer cost boundary -τ_t. The speed of adjustments in Regimes 2 and 3 back to their respective transfer cost boundaries is determined by the speed of adjustment parameter λ. One of the challenges in time series analysis is that there is little or no transfer data available. Where it is available, it does not incorporate all the transfer costs. The three regimes can be summarized in the following form, derived from Equation 3.5.

$$\Delta A_t = \begin{pmatrix} \lambda^{out} + \sum_{k=1}^{k} \gamma_k \Delta A_{t-k} + \varepsilon_t & if\ A_{t-1} > \tau_t \\ \lambda^{in} + \sum_{k=1}^{k} \gamma_k \Delta A_{t-k} + \varepsilon_t & if - \tau_t \leq A_{t-1} \leq \tau_t \\ \lambda^{out} + \sum_{k=1}^{k} \gamma_k \Delta A_{t-k} + \varepsilon_t & if\ A_{t-1} < -\tau_t \end{pmatrix} \qquad (3.7)$$

λ^{in} is the adjustment parameter when the price margin is below the threshold τ_t whereas λ^{out} represents the adjustment parameter when the absolute value of the price margin surpasses τ_t. The lower $(-\tau_t)$ and upper (τ_t) threshold values demarcate trade into three regimes. Profitable arbitrage opportunities exist in the two outer regimes, signified by $A_{t-1} > \tau_t$ or when $A_{t-1} < \tau_t$, thus the need for full exploitation by traders. It is generally assumed that the adjustment within the band formed by the threshold values is a purely stochastic process, thus no adjustment within the band ($\lambda^{in} = 0$). Hence, Equation 3.7 can be reduced to the following equation:

$$\Delta A_t = \begin{pmatrix} \lambda^{out} + \sum_{k=1}^{k} \gamma_k \Delta A_{t-k} + \varepsilon_t & if\ A_{t-1} > \tau_t \\ \varepsilon_t & if - \tau_t \leq A_{t-1} \leq \tau_t \\ \lambda^{out} + \sum_{k=1}^{k} \gamma_k \Delta A_{t-k} + \varepsilon_t & if\ A_{t-1} < -\tau_t \end{pmatrix} \qquad (3.8)$$

One of the weaknesses of the TAR model is the assumption of constant transaction cost, as noted by Goodwin and Piggott (2001) and Sarno et al. (2004). In Kenya, transaction costs are not constant and they may vary according to the season, the price of fuel, quality of the road, and distance travelled, amongst other factors. To overcome the assumption of constant transaction costs, we adopt Van Campenhout's (2007) approach that introduces a time trend on the transaction cost, allowing the data to identify systematic changes in transfer costs over time.

$$\tau_t = \tau_0 + (\tau_1 - \tau_0)\frac{t}{T-1} \qquad (3.9)$$

where t represents time t=0,1,2…………T-1, and T is the total number of observations, τ_0 is the threshold at the beginning of the sample, and τ_1 is the threshold at the end of the sample, after allowing for linear time trend. We introduced the time trend in Equation 3.8 to account for varying transaction costs where the time trend is represented as:

$$\Delta A_t = \begin{pmatrix} \lambda^{out} + \lambda' + \sum_{k=1}^{k} \gamma_k \Delta A_{t-k} + \varepsilon_t & if\ A_{t-1} > \tau_t \\ \varepsilon_t & if - \tau_t \leq A_{t-1} \leq \tau_t \\ \lambda^{out} + \lambda' + \sum_{k=1}^{k} \gamma_k \Delta A_{t-k} + \varepsilon_t & if\ A_{t-1} < -\tau_t \end{pmatrix} \quad (3.10)$$

λ' and τ_t represent the speed of the price adjustment parameter and threshold variables, respectively, which vary with time. Time is represented by t which ranges from 0 to T. When $t = 0$, then the threshold will be τ_0 and at time T it will be τ_T. Equation 3.10 is estimated via a grid search. Equation 3.11 was estimated to allow for comparison between constant and varying transaction costs. The properties of the speed of adjustment were noted. If the speed of adjustment is between -2 < λ < 0, there exists a long-run equilibrium relationship and the spatial price spread reverts to the transfer cost boundary. If the speed of adjustment is between -1 < λ < 0, the price spread adjusts smoothly back to the transfer cost boundary. When the speed of adjustment is between -2 < λ < -1, the adjustment back to the boundary is oscillatory. Where a long-run equilibrium relationship exists, the price spread may deviate outside the bound in the short run, but will revert to the bound in the long run. The speed of adjustment back to the bound becomes very important, as a faster adjustment is a characteristic of better-integrated markets.

To complement the analysis of policy effects using the TAR model, a VECM was used to analyse spatial price transmission across four different policy regimes. This was an attempt to disaggregate policies implemented under Regime 2 (see Table 3.1 above). We can derive VECM as follows:

$$P_t = A_0 + A_1 P_{t-1} + A_2 P_{t-2} + \quad \dots \dots + A_k P_{t-k} + \varepsilon_t \quad (3.11)$$

P_t represents a vector of endogenous prices for deficit and surplus market prices, $P_t = \begin{pmatrix} P_t^d \\ P_t^s \end{pmatrix}$, A_t are matrices of unknown parameters, while ε_t are error terms. Taking the first difference of Equation 3.11, it can be rewritten as:

$$\Delta P_t = \pi_0 + \pi_1 \Delta P_{t-1} + \cdots + \pi_{k-1} \Delta P_{k-1} + \pi P_k + \varepsilon_t \tag{3.12}$$

where $\pi_0 = A_0, \pi_i = -\left(1 - \sum_{j=1}^{k=1} A_j\right)$ and $\pi = -\left(1 - \sum_{j=1}^{k} A_j\right)$

The rank of π provides the basis for establishing the presence of cointegration. When the rank (π)=0, the prices are not co-integrated and the model is equivalent to a VAR in first difference, and if the (π)=2, the prices are stationary and the model is equivalent to a VAR in level, while if (π)=1, the prices are co-integrated. The vector π can be decomposed as π=αβ', where α is the matrix of the speed of adjustment coefficient and β is the cointegration vectors. The long-run disequilibrium term for VECM for one lag is expressed as follows

$$\Delta P_t = \alpha \beta' P_{t-1} + \sum_{i=1}^{k-1} \pi_i \, \Delta P_{t-1} + \varepsilon_t \tag{3.13}$$

We can express the long-run spatial price relationship as:

$$P_t^d = \lambda + \beta P_t^s + \nu_t \tag{3.14}$$

Where $\lambda = \beta_0/\beta_1$ *and* $\beta = \beta_2/\beta_1$. Therefore, β measures the long-run equilibrium relationship. Since our market prices are expressed in logarithms, then β in our case represents long-run price transmission elasticity to the deficit market from the surplus markets. When β is close to 1, then markets are well co-integrated and price fluctuation from the surplus market is completely transmitted to the deficit markets. The VECM is expressed as follows:

$$\Delta P_t^d = \alpha \nu_{t-1} + \sum_{j=1}^{k} \vartheta_{ij} \Delta P_{t-j}^d + \sum_{j=1}^{k} \vartheta_{ij} \Delta P_{t-j}^s + \varepsilon_i \tag{3.15}$$

VECM takes into account the point that the change in price in the deficit market P_t^d is a factor of changes in P_t^d, P_t^s and disequilibrium in the previous period of the two prices, represented by ν_{t-1} in our Equation 3.16. Typically, -1< α < 0, the negative value of α usually helps to revert the price to the long-run equilibrium. If α is close to -1, we can imply that short-term disturbances can quickly return to equilibrium and the two markets are closely interlinked. The coefficient change in the surplus market ϑ_{ij} is the short-run elasticity of deficit price relative to surplus price. The half-life represents the time required for a given shock to return to half its initial value. Half-life is computed as follows,

$$Half\ life = \frac{\log(0.50)}{\log(1+\alpha)} \tag{3.16}$$

where α represents the speed of adjustment.

3.4.2.2 Modelling the Kenyan maize market

To develop a model for the maize sector in Kenya, the following assumptions were made. Producers and consumers maximize profit and utility to achieve their respective equilibria. There is perfect competition in the maize market. Maize is a homogenous product and there is a constant return to scale. Kenya is a small country with respect to maize trade. Consequently, Kenya's maize demand and supply have no impact on the world market. These assumptions guided the modelling of the partial equilibrium model for the maize sector.

Kenya is a net importer of maize, hence it operates under the IPP regime trade regime. Adopting Meyer's (2006) IPP trade regime for maize sector in Kenya, we have a supply block under which three equations were estimated, the maize supply response (area harvested), yield equation, and total maize produced. Adding beginning stock resulted in the total domestic supply block. Under the demand block, three equations were estimated for per capita consumption, ending stocks, and total food use. Tallying food use and feed and seed utilization with ending stock resulted in the total domestic demand block. Price linkage and model closure block, each with one equation, completed the eight single individual behavioural equations required for a partial equilibrium model. We closed the model on imports as Kenya is a net importer of maize and operates under the IPP trade regime. To close the model, imports were equated to total domestic demand plus exports plus ending stock, minus beginning stock minus maize production.

The maize price formation of the Kenyan maize sector under the IPP regime is illustrated in Figure 3.3 below. The arrows represent the direction of influence and the broken line represents the lagged relationship. Own and substitute prices have a lagged relationship with maize area harvested. This is due to farmers observing prices after harvest. The reason for the lagged relationship between ending and beginning stocks is that it closes one season and opens for a new season. The partial equilibrium model incorporated eight individual equations under supply, demand, price linkage and model closure blocks. Three equations, for maize area harvested, maize yields and total domestic production, were estimated under the supply block. The demand block had three equations, for per capita consumption, ending stocks and total domestic consumption, while the price linkage and model closure blocks each had one individual equation.

Regarding the supply block, maize price was positively correlated to area planted, and the higher maize prices implied higher returns and that farmers dedicated greater areas for maize, and the reverse was true. The price of the maize substitute was negatively correlated to the area planted. Both prices had a lagged effect on area planted. Input costs were directly linked to the area planted. When inputs costs are high, farmers either reduce area planted or maintain the same acreage and apply less than the recommended rate of inputs. Both these options result in a decline in maize production (Kibaara et al., 2008). Inflation affects the costs of inputs and the purchasing power of households. High inflation will result in higher costs of inputs and lower purchasing power of the households, consequently reducing the maize area harvested. The breeding of high yielding maize seed will increase maize production. For Kenya which has land constraints, this is a better alternative for increasing production without necessarily expanding land cultivation areas. Weather plays an important role in maize production and yield, as Kenyan agricultural production is rain-fed. Adding the beginning stock to maize production results in the total domestic supply block.

The domestic demand block included imports, human consumption, feed and seed utilization, and ending stocks. Population and income influenced human consumption, while the livestock sector influenced feed utilization. Human consumption may also indirectly influence feed utilization through an increase in demand for the consumption of animal protein and animal by-products. Kenya is a net importer of maize and consequently the price linkage equation plays a critical role in the recursive model, as domestic prices are influenced by IPP. The trade regime and net import status of the maize sector imply that we have to close the model on imports.

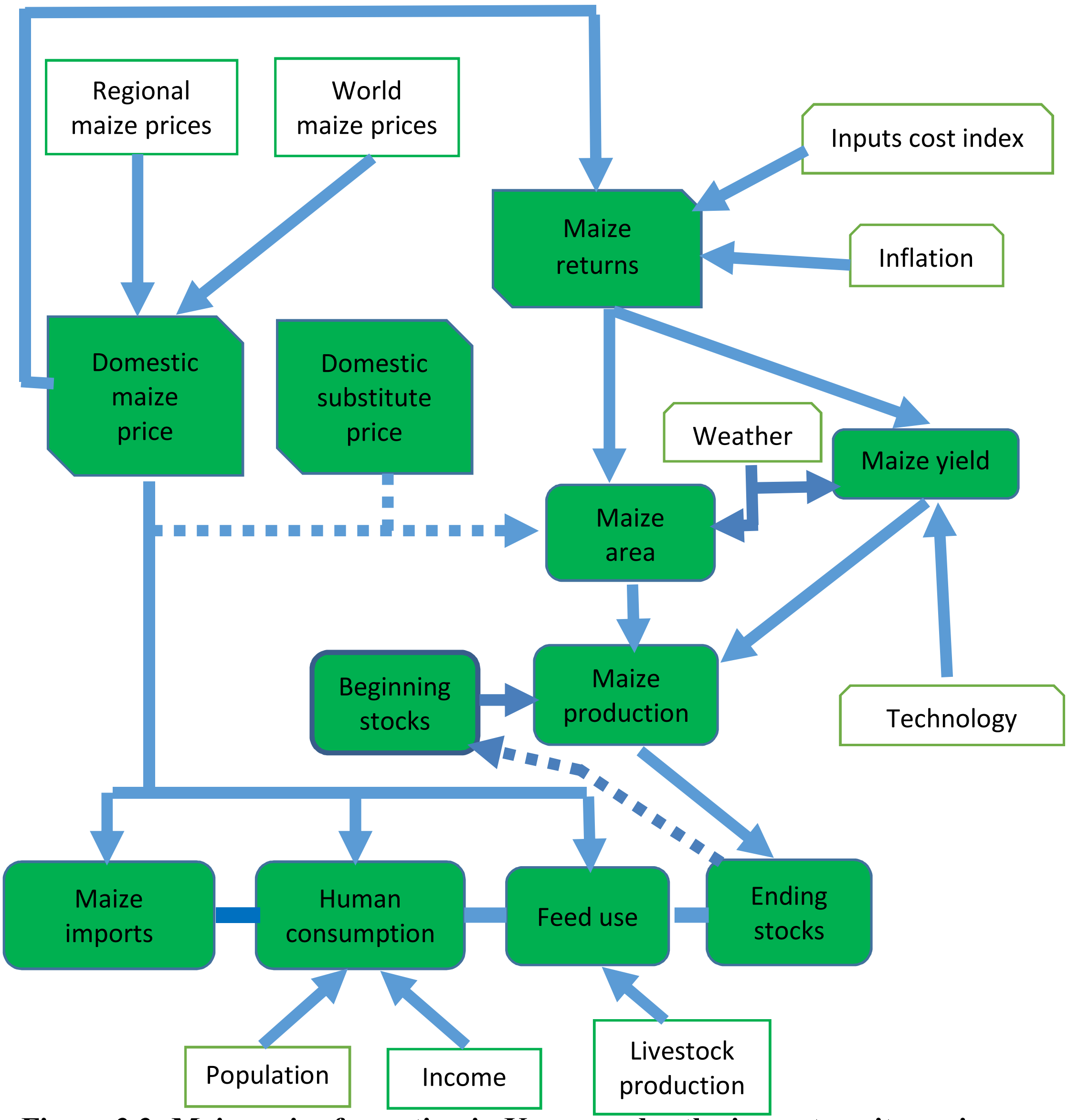

Figure 3.3: Maize price formation in Kenya under the import parity regime
Source: Author's compilation

Model specification for the partial equilibrium model for the Kenyan maize market is based on assumption discussed earlier combined with the knowledge of the maize sector. There are four blocks, supply, demand, price linkage and model closure, which forms the partial equilibrium model. Each block has its own individual single equations as discussed earlier. The model specification of each individual equation under the four blocks is discussed below.

3.4.2.2.1 Domestic supply block

The supply block had three equations, consisting of maize area harvested, maize yield and domestic maize production. The model specifications for the three equations are described below.

Maize Area harvested

The maize area harvested represents the maize supply responses to prices. This analyses a farmer's decision on allocating area under maize, based on producer price expectations. In agricultural decision-making, the area harvested has been commonly used as a proxy for the decision on acreage due to the lack of data on area planted. Moreover, farmers have control over area planted, as opposed to the output that may be affected by other factors such as weather, diseases, and damage (Meyer and Kirsten, 2010). Access to infrastructure (roads, markets and irrigation), finances (credit), extension services, improved technology (seed and fertilizer), farm size, human capital and weather are among the factors that affect agricultural productivity in Kenya (Karanja et al., 1998). The maize area harvested in our model is a factor of own price, the price of the substitute crop, the cost of inputs captured by input index, technology (time trend) and rainfall. Irish potatoes were picked as the substitute for maize as household studies have shown that this crop competes with maize (Njagi et al., 2015). The maize area harvested equation is specified as follows:

$$\mathrm{MZAREA_t} = f\ (\mathrm{RMZPRIC}_t, \mathrm{RPTSPRIC}_t, \mathrm{INPTINDEX_t}, \mathrm{RAINYS_t}, \mathrm{LNTREND_t}) \quad (3.17)$$

where –

$\mathrm{MZAREA_t}$ The maize area harvested, measured in hectares ('000).

$\mathrm{RMZPRIC}_t$ The lagged real maize prices in Kenyan shillings (KES). The nominal maize wholesale maize prices were deflated using CPI (2009=100) to account for inflation. We expect a positive correlation between maize prices and area harvested.

$\mathrm{RPTSPRIC}_t$ The lagged real wholesale prices of Irish potatoes in KES. The nominal wholesale Irish potato prices are deflated using CPI (2009=100) to account for inflation. We expect a negative correlation between maize prices and area harvested.

$\mathrm{INPTINDEX_t}$ Input cost index is a ratio that equals ((yield*wholesale price)/fertilizer prices), and the input index is adapted from Meyer (2006). We used fertilizer costs as the denominator instead of gasoline prices. In Kenya, the use of motorized mechanization for agricultural production is low, accounting for only 30%. It is mostly used by large-scale farmers who consist of a small proportion of farmers in Kenya. The use of hand and animal draught power still dominates agricultural production in Kenya, accounting for 50% and 20%, respectively (ERA, 2015). We expect the input index to be negatively correlated with maize harvested area.
RAINYS_t The rainfall received in millimetres. In Kenya, there are two main seasons based on the rainfall. The 'long rains' cover the period from March to May, while the 'short rains' cover the period from October to November. The Western and Rift valley regions plant their maize during the long rains and harvest in November–December, while the Eastern and Coastal regions plant their maize during the short rains and harvest in February–March. The rainfall information captures both the long and short rains. We expect a positive correlation between rainfall and area harvested.
$\mathrm{LNTREND_t}$ Captures the effects of maize technological improvement in time. A positive correlation is expected between yield and technological improvement.

Maize Yield

The maize yield equation is estimated as a function of the proportion of area planted with improved maize seed, input cost index, rainfall received and technological development carried out in seed maize production. Yields are specified as:

$$\mathrm{MZYIELD_t = f(IMPRVSEED_t, RAINYS_t, INPTINDEX_t, LNTREND_t)} \qquad (3.18)$$

where –
$\mathrm{MZYIELD_t}$ The maize yields, measured in tons per hectare.
$\mathrm{IMPRVSEED}_t$ The share of the area planted with improved maize seed, measured in hectares ('000). The use of hybrid maize by households in Kenya varies according to the agro-ecological zones. In high potential zones, the proportion of households using hybrid maize seed is very high and ranges between 89 and 94%, while in low potential zones, only 28% of the households use hybrid maize seeds. Nationally, the proportion of households using hybrid maize seed has

been estimated to be 77% (Joynes et al., 2011;Njagi et al., 2015). We expect a positive correlation between improved hybrid seed and maize yields.

RAINYS_t The rainfall received, measured in millimetres. We expect a positive correlation between rainfall and maize yields.

INPTINDEX_t The input cost index is the ratio represented by ((yield*wholesale price)/fertilizer prices). A negative correlation is expected between the input index and yields.

LNTREND_t Captures the effects of maize technological improvement in time. A positive correlation is expected between yield and technological improvement.

Beginning stock

The beginning maize stock for every production year is the ending stock of the previous season. Hence, lagged ending stock equates to the beginning stocks. This is represented by the following equation:

$$\text{BEGSTOCK}_t = \text{ENDSTOCK}_{t-1} \tag{3.19}$$

where:

BEGSTOCK_t Beginning stock at the start of the production year, measured in tons ('000).

ENDSTOCK_{t-1} Ending stock at the close of previous production year, measured in tons ('000).

Domestic maize production

Domestic maize produced in Kenya was computed using maize area harvested and maize yields, as follows:

$$\text{DOMPRO}_t = \text{MZAREA}_t * \text{MZYIELD}_t \tag{3.20}$$

where:

DOMPRO_t Total maize production, measured in tons ('000).

MZAREA_t Maize area harvested, measured in hectares ('000).

MZYIELD_t Maize yields, measured in tons per hectare.

Domestic supply block

The total maize supply (domestic supply block) was computed as follows

$$\mathrm{DOMSUPLY_t = BEGSTOCK_t + DOMPROD_t} \qquad (3.21)$$

where:

$\mathrm{DOMSUPLY_t}$ Total domestic maize supply, measured in tons ('000).

$\mathrm{BEGSTOCK_t}$ Beginning stock at the start of the production year, measured in tons ('000).

$\mathrm{DOMPROD_t}$ Total maize production, measured in tons ('000).

3.4.2.2.2 Domestic demand block

The domestic demand block has three single equations, consisting of per capita consumption, ending stocks, and total domestic demand. The model specifications for the three equations are discussed below.

Per Capita Consumption

Maize is the most important staple food in Kenya. The country has the highest per capita consumption, at 103 kilograms per annum, when compared with its neighbours (Abate et al., 2015). The per capita consumption of maize is influenced by its own price, the price of a substitute (in this case Irish potatoes), the income of the household, and shifts in consumption patterns. The per capita consumption of maze is modelled as follows:

$$\mathrm{PCONS_t = f(RPCGDP_t, RMZPRIC_t, RPTSPRIC_t, TRCONS_t, SHIFT2009)} \qquad (3.22)$$

where:

$\mathrm{PCONS_t}$ Per capita consumption, measured in kilograms per person.

$\mathrm{RPCGDP_t}$ Real per capita Gross Domestic Product (GDP), in US$ per person.

$\mathrm{RMZPRIC_t}$ Real maize price, in KES/ton.

$\mathrm{RPTSPRIC_t}$ Real Irish potato price, in KES/ton.

$TRCONS_t$ Change in consumption patterns over time by households.
SHIFT2009 Dummy variable representing the period of high food prices since 2009.

Ending stock

The ending stock equation is a function of beginning stocks at the start of the season, the prevailing maize price within the season, and the amount of maize produced during the season. The ending stock equation is modelled as follows:

$$ENDSTOCK_t = f(BEGSTOCK_t, MZPRDN_t, WMZPRIC_t) \quad (3.23)$$

where:
$ENDSTOCK_t$ Ending stock at the close of the season, measured in tons ('000).
$BEGSTOCK_t$ Maize stock at the beginning of the season, measured in tons ('000).
$MZPRDN_t$ Maize produced during the season, measured in tons ('000).
$WMZPRIC_t$ Nominal wholesale maize prices prevailing during the season, in KES/ton.

Domestic maize consumption

The maize consumed as food in Kenya was computed using per capita consumption and the population figure, as follows:

$$FOODUSE_t = PCONS_t * POPL_t \quad (3.24)$$

where:
$FOODUSE_t$ Maize consumed as food, measured in tons ('000).
$PCONS_t$ Per capita consumption, measured in kilograms per person.
$POPL_t$ Kenyan population (million).

Domestic demand block

This represents the total maize consumed within Kenya. Other than food use, maize is used for animal feed and other uses. Data for animal feed and other uses was sourced from secondary sources, such as MOALF, FAO, and United States Department of Agriculture (USDA). The domestic demand block is computed as follows:

$$\mathrm{TDOMCON_t} = \mathrm{FOODUSE_t} + \mathrm{FEEDUSE_t} + \mathrm{OTHUSE_t} + \mathrm{ENDSTOCK_t} \qquad (3.25)$$

where:

$\mathrm{TDOMCON_t}$ Total maize used within the economy, measured in tons ('000).

$\mathrm{FOODUSE_t}$ Total maize used for food consumption, measured in tons ('000).

$\mathrm{FEEDUSE_t}$ Total maize use for feed utilization, measured in tons ('000)

$\mathrm{OTHUSE_t}$ Other uses of maize and losses, measured in tons ('000).

$\mathrm{ENDSTOCK_t}$ Ending stock at the close of the season, measured in tons ('000).

3.4.2.2.3 Price linkage

In economic theory, prices connect the demand and supply sides under equilibrium conditions. As discussed earlier, Kenya is a net importer of maize and therefore operates under the IPP trade regime. Kenya commonly imports maize from the region (Uganda and Tanzania) and occasionally imports from the world market during poor harvest seasons. In reality, domestic maize prices will consist of the import parity prices, exchange rate, import taxes, and transfer costs from point of origin. As noted by Meyer (2006), closing the model at import under the IPP regime allows for the estimation of the price linkage equation, rather than relying on equilibrium price formation. This is more realistic as it captures domestic price formation under the IPP regime. The governments in developing economies have used policies to shield domestic markets from high international food prices (Minot, 2011; Minot, 2014; Chapoto and Sitko, 2014; Bryan, 2015; Gitau and Meyer, 2018). We use a policy shift dummy to capture policies implemented following the high food prices. The wholesale maize prices linkage equation can be estimated through the import parity price, the ratio of consumption versus production, and policy shift dummy, and is computed as follows:

$$\mathrm{WMPRIC_t} = \mathrm{f(IMPRIC_t, CONPDNR_t, SHIFT08_t)} \qquad (3.26)$$

where:

$\mathrm{WMPRIC_t}$ Domestic wholesale prices, measured in KES/ton.

$\mathrm{IMPRIC_t}$ Maize import parity prices, in KES/ton.

$\mathrm{CONPDNR_t}$ Consumption/production self-sufficiency ratio.
$\mathrm{SHIFT08_t}$ Policy shift variable capturing policies implemented to mitigate high food prices, 1 for 2008 and subsequent years.

3.4.2.2.4 Model closure

As noted by Meyer (2006), the trade regime determines model closure of a system in a partial equilibrium model. Kenya is a net importer of maize and operates under an IPP trade regime; therefore, the model was closed on imports. The closure of the model is computed as follows:

$$\mathrm{IMPRT_t} = \mathrm{TDOMCON_t} + \mathrm{EXPRT_t} + \mathrm{ENDSTOCK_t} - \mathrm{BEGSTOCK_t} - \mathrm{MZPRDN_t} \quad (3.27)$$

where:
$\mathrm{IMPRT_t}$ Imported maize, measured in tons ('000).
$\mathrm{TDOMCON_t}$ Total maize used within the economy, measured in tons ('000).
$\mathrm{EXPRT_t}$ Exported maize, measured in tons ('000).
$\mathrm{ENDSTOCK_t}$ Ending stock at the close of the season, measured in tons ('000).
$\mathrm{BEGSTOCK_t}$ Maize stock at the beginning of the season, measured in tons ('000).
$\mathrm{MZPRDN_t}$ Maize produced during the season, measured in tons ('000).
The amount of maize exported officially to the neighbouring countries is negligible and sporadic, and between 2008 and 2016, 5000 tons, on average, were recorded as exports from Kenya. The biggest challenge is the porous nature of the border and the existence of informal maize routes (FSNWG, 2018).

3.4.2.2.5 Model performance

Models have been used in forecasting and in policy analysis. Before models are used for these purposes, the models need to be evaluated and tested to ascertain the extent to which they mirror or replicate the current phenomena. Graphical and statistical methods are the two techniques commonly used to evaluate the models. Once researchers validate and establish that the model is adequate for tracking actual values, they can use the model for simulation analysis.

Graphical evaluation

Graphical evaluation relies on using dynamic forecasting which takes the estimated value of lagged dependent variable to forecast a current value. The actual and forecasted values are plotted graphically side by side for visual inspection. Consequently, the closer the predicted graph is to actual graph, the better the forecasting ability of the model is.

Statistical evaluation

The assessment of the forecasted error value is the basis for evaluating a model statistically. The error values are computed as the deviation of the forecast value from the actual value. Hence, if the model error values were low, the forecasting ability of the model was good (Gebrehiwet, 2010). Based on a forecasted error term, Pindyck and Rubinfeld (1998) established four statistical techniques to evaluate the forecasting abilities of the models.

$$MAE = \frac{1}{T}\sum_{t=1}^{T}\left|y_t^{\wedge} - Y_t\right| \tag{3.28}$$

The mean average error (MAE) represented in Equation 3.28 is computed as the average value of the absolute value of the error term occurring in each period. The second statistical technique is the mean average percentage error (MAPE) term. This technique measures the error term in the form of a percentage of the actual value. The formula for MAPE is illustrated in Equation 3.29.

$$MAPE = \frac{1}{T}\sum_{t=1}^{T}\left|\frac{y_t^{\wedge} - Y_t}{Y_t}\right| \tag{3.29}$$

The third technique measures the square root of the square error term. In this technique, unlike the MAE, large errors are given higher weights, thus penalizing large deviations. The square root of the mean square root error (RMSE) formula is illustrated in Equation 3.30.

$$RMSE = \sqrt{\frac{1}{T}\sum_{t=1}^{T}\left(y_t^{\wedge} - Y_t\right)^2} \tag{3.30}$$

The final technique is the Theil inequality coefficient (U), developed by Theil (1967). Like MAPE, U is a scale-invariant forecast error measurement. The numerator of U is the RMSE. The denominator forces the value of U to fall between 0 and 1. When the U coefficient is closer to 0, it implies that the model is relatively good, while a value closer to 1 indicates that the model is inadequate for forecasting. The formula for U is illustrated in Equation 3.31.

$$U = \frac{\sqrt{\frac{1}{T}\sum_{t=1}^{T}\left(\hat{y_t} - Y_t\right)^2}}{\sqrt{\frac{1}{T}\sum_{t=1}^{T}\left(\hat{y_t}\right)^2}\ \sqrt{\frac{1}{T}\sum_{t=1}^{T}(Y_t)^2}} \qquad (3.31)$$

3.5 STUDY AREA AND DATA

With respect to maize marketing, Kenya can be divided into three distinctive regions, namely surplus, self-sufficient (minor surplus), and deficit markets, based on maize production. The three regions each have distinctive seasonality for maize, which makes it possible for trade across the three regions (see Kirimi et al., 2011 and Gitau and Meyer, 2018, for detailed characteristics of the three regimes). This study focused on surplus and deficit markets. Surplus maize markets are located in the North and South Rift valley regions. These regions are considered as constituting the grain basket of the country, and account for 57% of the national production and over 60% of the national marketed surplus (Karanja et al., 1998; Kirimi et al., 2011). The deficit markets are located in the regions characterized by high population density and net[8] maize consumers. These include the lower parts of the Eastern, Nyanza and Western regions, and the Coastal and North Eastern regions. The three major cities of Kisumu, Mombasa and Nairobi also form part of the deficit markets.

For domestic spatial market integration, this study utilized monthly data obtained from the Agricultural Commodity and Market Information Division of the MOALF. The division collects maize prices on a daily basis from the major market across the country. The prices available for public use are aggregated on a monthly basis. Data available for surplus markets included that for Eldoret, Kitale, Bungoma, Busia and Narok. We dropped the Bugoma, Busia and Narok markets due to high proportions of missing data. The Kitale market had a few

8 Households that consume more maize than they produce and have to depend on the market to bridge the deficit.

missing wholesale prices that we interpolated. For deficit markets, the three major city markets of Nairobi, Mombasa and Kisumu were selected. Other than being the major consumption markets in Kenya, these three markets play an important role in connecting the rest of the country with the grain trade corridor. The cities of Kisumu and Nairobi connect the rest of the country with maize coming from the exporting region (Tanzania and Uganda), while maize imported from the world market enters through Mombasa port (Nile Basin Initiative, 2012). The Nakuru market was selected for its close proximity to the surplus markets and its central location; hence, it is well connected to other deficit markets by road. The Machakos, Garissa and Kisii markets were selected because of their importance in the lower Eastern, North Eastern and lower Nyanza regions, respectively. In addition, these markets had lower proportions of missing price data, which were interpolated. Data from nine markets, two surplus markets (Eldoret and Kitale) and seven deficit markets (Kisumu, Mombasa, Nakuru, Garissa, Machakos, Kisii and Nairobi) was used to analyse domestic spatial market integration. The data covered the period from January 2000 to December 2016 (204 months).

For the analysis of integration between domestic, regional and international markets, the data used was sourced from the FAO's Global Information and Early Warning System (GIEWS) food prices. The domestic markets used in this analysis were the three major consumption markets of Nairobi, Mombasa and Kisumu. For the regional markets, Arusha, Iringa and Dar es Salaam from Tanzania were selected, while the Busia and Kampala markets were selected from Uganda. For the international markets, the Argentina and Ukraine markets were selected. Although the import ban on GMO foodstuffs is still in effect, the US and South African markets were also picked for comparison purposes. The data covered the period from January 2000 to December 2016 (204 months).

For the modelling of the Kenyan maize markets, data was collated from different sources that included IMF, FAO, Global Insight, the United States Department of Agriculture (USDA), the Kenya National Bureau of Statistics (KNBS), Kenya Metrological Department (KMD) and MOALF. Time series data on wholesale prices were sourced from MOALF and deflated to take care for inflation by using CPI details sourced from KNBS. Monthly rainfall data was obtained from KMD. Time series data on endogenous variables, such as areas harvested, production, and yield, was sourced from MOALF. Details on the utilization of maize (food, animal feed and other) were sourced from USDA. Details of macroeconomic variables, such as population, real GDP, inflation, and economic growth, were sourced from several sources – Global Insight, IMF and KNBS. The historical data covered the period from 1995 to 2016. Table B.1 in Annex B summarizes the entire array of exogenous and endogenous variables used and their sources.

3.6 SUMMARY

This chapter discusses price transmission and dynamics in local supply and demand. These two factors are the market-related causes of high food prices. The chapter developed a framework that combined spatial market integration and modelling of the Kenyan maize market to investigate the causes of high food prices. The relevant survey of these two approaches was discussed. For spatial market integration, three market clusters were investigated to determine if they were integrated. The clusters comprised domestic, regional and world markets. The methodology used to investigate market integration and the effects of policy included the Johansen cointegration test, TAR and VECM. For the modelling of the Kenyan maize markets, OLS and ECM techniques was used to estimate single equations on the demand, supply and price linkage blocks. This chapter also described the data used for the analysis in this study.

CHAPTER 4: RESULTS AND DISCUSSIONS

4.1 INTRODUCTION

This chapter presents the results and discussions of spatial market integration and the modelling of the Kenyan maize market. The rest of the chapter is organized as follows: Section 2 discusses the result of the spatial market integration in three different market clusters. These clusters comprise the domestic, regional and world markets. In each cluster, the results are discussed under the headings of descriptive statistics, unit root testing, pairwise cointegration and long-run relationship. Section 3 discusses the modelling of the Kenyan maize market under several headings. These include descriptive statistics, supply, demand, price linkage, model closure, model performance, maize outlook and simulation analysis. Section 4 summarizes the chapter.

4.2 SPATIAL MARKET INTEGRATION

Integrated markets guarantee smooth trade flow and exchange of food products between surplus and deficit regions, mitigate famine, facilitate the design of successful price stabilization policies, provide opportunities for welfare improvement and ensure a well-functioning economy. In addition, they have acted as a driver for escaping poverty by households (Ravallion, 1986; Dercon, 1995; Baulch, 1997b; Fackler and Goodwin, 2001; Krishna, 2004; Krishna et al., 2004; Abunyuwah, 2008; Ihle et al., 2009). In this study, spatial market integration was addressed in three aspects.

Firstly, we addressed domestic market integration by analysing the surplus and deficit market integration. To demonstrate the effects of policy on domestic market integration, we compared integration between surplus and deficit markets under the two policy regimes. The first regime was characterized by the liberalization of the maize sector, while heavy policy intervention following the soaring food prices characterized the second regime (refer to Table 3.1 above). Secondly, we analysed the integration between domestic and regional markets. The effects of the policy were also analysed by comparing integration between domestic and regional markets under the two policy regimes. Finally, we analysed integration between domestic and world markets and the effect of the two policy regimes.

4.2.1 Domestic market integration

We used monthly wholesale maize price data for this analysis. The data covered nine markets, two surplus markets (Eldoret and Kitale) and seven deficit markets (Kisumu, Mombasa, Nakuru, Garissa, Machakos, Kisii and Nairobi). The data covered the period from January 2000 to December 2016 (204 months). The data was sourced from the Agricultural Commodity and Market Information Division of the MOALF.

4.2.1.1 Descriptive statistics

A summary of the real monthly maize prices, in KES per bag, is set out in Table 4.1 below. The unit of measurement for a bag is 90 kilograms. We deflated the monthly maize prices using the CPI (2009=100). The motivation behind deflating our nominal prices is to ensure that we remove fluctuation in the time series brought about by inflation. In addition, it stabilizes the variance of seasonal fluctuation by ensuring no other fluctuations are captured in our time series data. It was seen from the full sample that, as expected, deficit market prices were higher, compared with the surplus markets. The deficit market maize prices ranged from KES 1,896 to 2,805, while maize prices ranged from KES 1,721 to 1,828 in surplus markets. The Garissa market recorded the highest price differences, while Nakuru recorded the lowest, when compared to the surplus markets. The price differences in Garissa were 53% and 64% higher, while in Nakuru they were 4% and 10% higher than the prices in the Eldoret and Kitale markets, respectively. The reason for the high market prices in the Garissa market is its location. The market is located at least 700 kilometres away from the surplus markets. In addition, some sections of the road network connecting Garissa to the surplus market are in poor condition. The poor road network, coupled with distance traversed, contributes to high transport costs. Traders also incur high marketing costs when traversing several municipalities, where they have to pay local taxes in each municipality. This may also explain the high maize prices in Garissa.

The results for Regime 1 indicate that maize prices ranged from KES 1,930 to 2,919 in deficit markets, while the range was from KES 1,766 to 1,811 in the surplus markets. The Garissa and

Nakuru markets recorded the highest and the lowest price differences with the surplus markets, respectively. The price differences in Garissa were 65% and 61% higher, while in Nakuru, they were 9% and 7% higher than the prices in the Eldoret and Kitale markets, respectively. Under Regime 2, the prices ranged from KES 1,867 to 2,667 in the deficit markets, while the range was from KES 1,678 to 1,884 in surplus markets. The Garissa and Nakuru markets recorded the highest and the lowest price differences with the surplus markets, respectively. The price differences in Garissa were 41% and 58% higher, while in Nakuru, they were 0.3% and 12% higher than the prices in the Eldoret and Kitale markets, respectively. When we compare maize prices across the two regimes, overall, the maize prices in Regime 2 appear lower, as compared with the maize prices under Regime 1. Further investigations comparing individual market reveal mixed results when comparing Regimes 1 and 2. The Eldoret, Kisii, Kisumu and Machakos markets recorded increases of 7%, 3%,6% and 3%, respectively, while the Kitale, Mombasa, Nairobi Nakuru and Garissa markets recorded declines of 7%, 3%, 2%, 2%, and 9%, respectively. Lower prices were expected under Regime 1, compared to Regime 2, as this regime was characterized by the liberation of the maize sector, low maize prices, and minimal policy interventions. The reasons for these results may be the short span of the data used to represent Regime 1. The liberalization of the maize sector started in 1990; hence, the Regime 1 period should have covered the period from January 1990 to December 2007, but due to data limitations, this period was limited to the period from January 2000 to December 20007 (96 months). This short period may have influenced prices in Regime 1, resulting in higher mean prices.

Table 4.1: Descriptive results of real monthly maize prices 2000–2016

Sample	Markets	Obs	Mean	Max	Min	Std. Dev.	CV
Full	Eldoret	204	1,828	3,411	918	477	0.26
	Garissa	170	2,805	4,020	1,170	728	0.26
	Kisii	153	2,214	4,015	1,285	506	0.23
	Kisumu	204	2,176	3,875	1,316	489	0.22
	Kitale	108	1,721	3,269	829	514	0.30
	Machakos	162	2,144	3,367	1,099	503	0.23
	Mombasa	204	2,018	3,573	1,115	453	0.22
	Nairobi	204	2,106	3,439	1,293	453	0.22
	Nakuru	204	1,896	3,277	925	474	0.25
Regime 1	Eldoret	96	1,766	2,955	918	500	0.28
	Garissa	96	2,919	4,020	1,300	814	0.28
	Kisii	48	2,144	3,143	1,285	481	0.28
	Kisumu	96	2,038	3,453	1,316	488	0.28
	Kitale	35	1,811	2,905	829	682	0.28
	Machakos	69	2,127	3,367	1,099	555	0.28
	Mombasa	96	2,045	3,573	1,312	504	0.28
	Nairobi	96	2,123	3,439	1,293	487	0.28
	Nakuru	96	1,930	3,224	1,022	494	0.28
Regime 2	Eldoret	108	1,884	3,411	1,110	451	0.24
	Garissa	74	2,657	3,882	1,170	571	0.24
	Kisii	105	2,246	4,015	1,430	516	0.24
	Kisumu	108	2,300	3,875	1,411	457	0.24
	Kitale	73	1,678	3,269	943	410	0.24
	Machakos	93	2,157	3,204	1,178	464	0.24
	Mombasa	108	1,993	3,253	1,115	403	0.24
	Nairobi	108	2,091	3,411	1,463	422	0.24
	Nakuru	108	1,890	3,277	925	457	0.24

Figure 4.1 below illustrates the real maize prices across the surplus and deficit markets, from January 2000 to December 2016. A visual inspection of the graph indicates that maize prices across all the markets were volatile during the period under review. All the price series appear to co-move across the different markets, over time. Under Regime 2, prices were higher and appeared more volatile, when compared with Regime 1. This is consistent with the soaring high food prices and heavy government interventions experienced under Regime 2. The highest prices kinks across the markets coincide with weather shocks (drought) experienced in 2009 and 2011. Kenya imported maize from outside the region during this period.

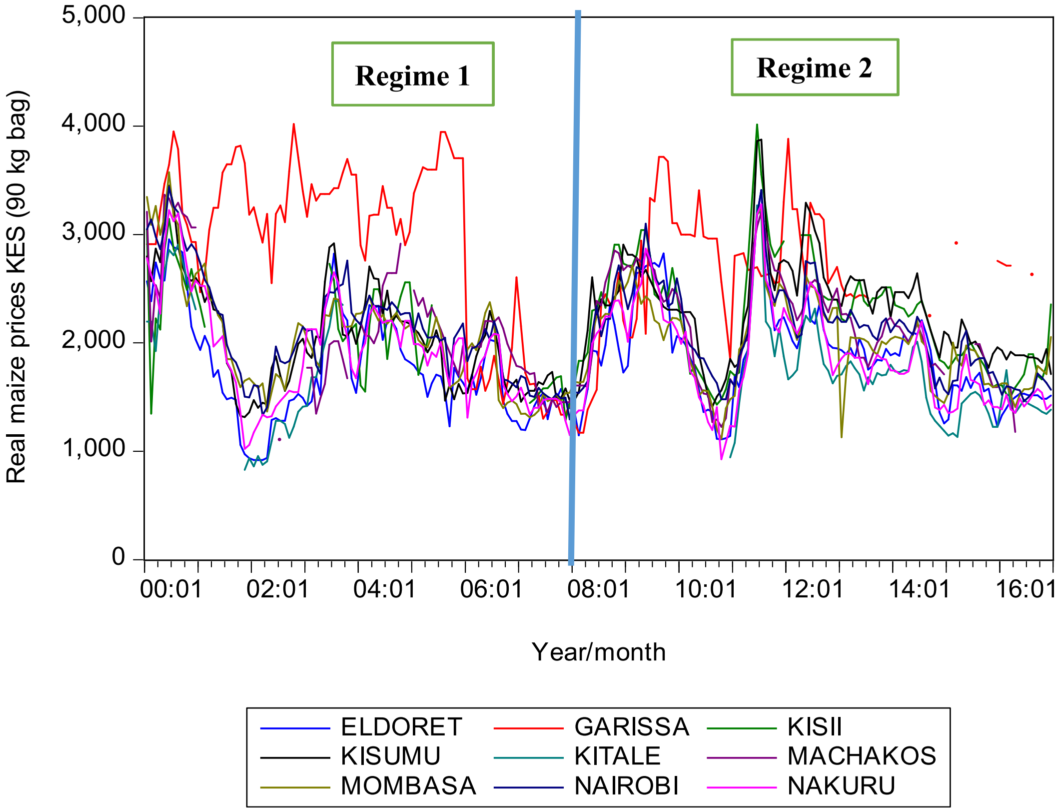

Figure 4.1: Real monthly maize prices across the deficit and surplus markets in Kenya 2000–2016

The geographical stratification and seasonality is the main determinant of the disparity in the production and supply of maize in Kenya. The surplus region has one maize harvest season, from October to December, while the deficit region has two harvest seasons. The first harvest season runs from July to September, while the second harvest season is from February to March. Hence, using a maize production calendar, a production year can be classified into harvest and lean periods, based on maize availability. Harvest periods coincide with the periods of maize harvests across the surplus and deficit regions, while lean periods coincide with periods of little maize being available, both in the households and in the markets. Harvest periods include the months of July to September and October to March, while the lean periods include April to June and September and October. There is an overlap in the September and October months, as the harvest in the surplus region may start in late October and the harvest may end in early September in deficit regions.

The average unconditional price volatility for the harvest and the lean periods between 2000 and 2016 for all the markets was computed by dividing the mean and standard deviations for the harvest and lean periods during the period under review. Figure 4.2 below summarizes the average unconditional price volatility between 2000 and 2016. The volatility of maize prices was higher during the lean periods, compared with the harvest periods. The deficit market exhibits lower price volatility, during both lean and harvest periods, compared with the two surplus regions. Harvest prices in the surplus region are generally low, compared with harvest prices in the deficit region. Consequently, the price swings in the harvest and lean periods are higher in the surplus region, compared with the deficit region, thus explaining the lower price volatility in the deficit region. Figure B.1 and Figure B.2 in Annex B summarize the yearly price volatility for harvest and lean periods, respectively.

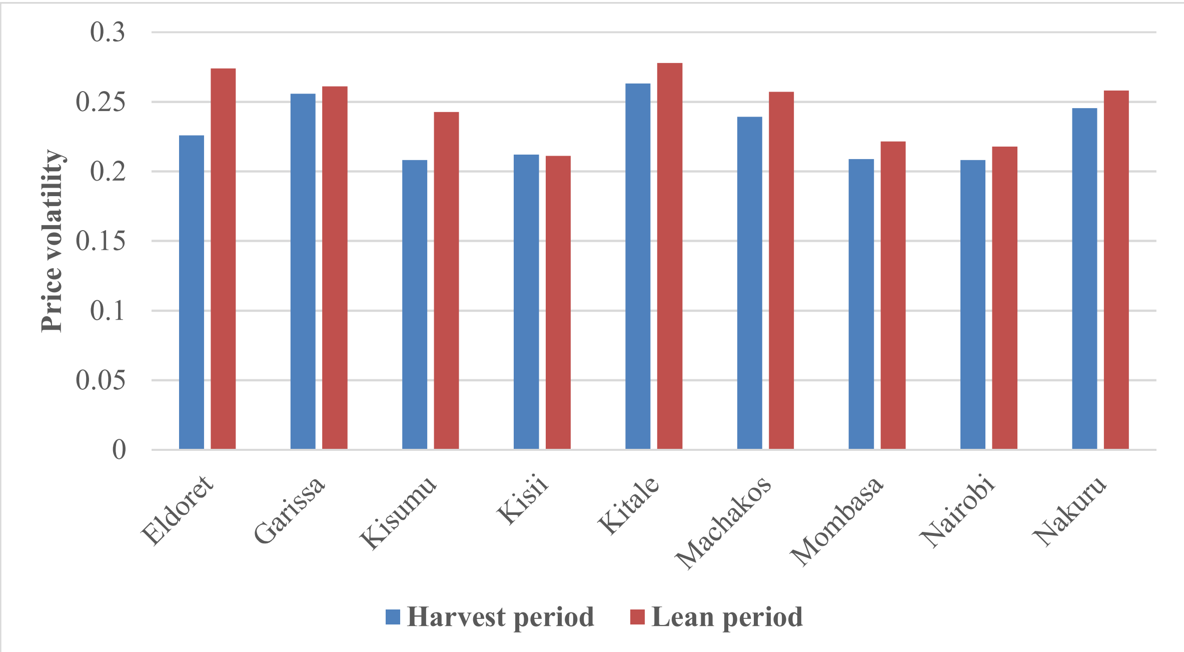

Figure 4.2: Average unconditional price volatility during harvest and lean periods across the markets between 2000 and 2016

4.2.1.2 Unit root testing

A visual examination of Figure 4.1 above indicates that prices are volatile across all the markets, and therefore the time series data may not be stationary. We tested for unit root without intercept and deterministic trend, as our price series data followed a random walk process, with value rarely reverting to the mean. We conducted the ADF and PP unit root tests on the price series. The null hypothesis for both the ADF and PP tests is the presence of unit root on the variables. The ADF is an adjustment test that accounts for possible serial correlation in the error term by adding the lagged difference term. On the other hand, the PP test uses a non-parametric statistical method to take care of serial correlation, without the addition of the lagged difference term (Gujarat and Porter, 2009). A summary of the results of the ADF and PP tests is set out in Table 4.2 below. The prices across all the markets were non-stationary at the level, as the null hypothesis of unit root was not rejected. The prices became stationary on first differencing, as the null hypothesis of unit root was rejected at the 1% significant level. All our market prices were integrated in the order of one I (1).

Table 4.2: Results of the ADF and PP unit root tests on real monthly prices

Markets	**ADF test**		**PP test**	
	level	**first diff**	**level**	**first diff**
Eldoret	-1.169	-12.498***	-1.176	-12.399***
Garissa	-0.857	-13.880***	-0.758	-14.130***
Kisumu	-1.024	-11.120***	-1.003	-10.809***
Kisii	-0.248	-13.174***	-0.856	-13.108***
Kitale	-0.248	-7.611***	0.070	-7.350***
Machakos	-0.074	-13.228***	-0.899	-13.020***
Mombasa	-1.282	-13.153***	-1.285	-13.229***
Nairobi	-1.214	-12.834***	-1.217	-12.809***
Nakuru	-1.212	-11.560***	-1.238	-11.322***

ADF and PP critical value are -1.62, -1.94, and 2.58 for 10%, 5% and 1 % significant levels, respectively. Asterisks ***, ** and * signify rejection of the null hypothesis of a unit root at 1%, 5% and 10% significant levels, respectively.

4.2.1.3 Pairwise market cointegration

We carried out a pairwise cointegration test to establish whether our deficit and surplus markets were integrated. The Johansen maximum likelihood VAR approach was used (Johansen and Juselius, 1990). The wholesale maize price series for the markets were converted into logarithmic values. To determine the lag order for the Johansen cointegration test, we first estimated the unrestricted VAR model by using a market pair with one surplus and one deficit market. From the result, we used the lag structure to get the lag order selected by using the Akaike Information Criterion (AIC).

The results for the full sample and the Regime 1 and Regime 2 samples are summarized in Table 4.3 below. The results of the full sample indicated that all the markets were integrated, as the null hypothesis (absence of cointegration relation) was rejected. The test confirms the presence of one cointegrating vector (r=1) across the surplus and deficit markets. Under Regime 1, for the Eldoret and its respective pairwise cluster, all the markets were cointegrated, except for the Garissa and Nairobi markets. For Kitale and its respective pairwise cluster, all the markets were integrated, except for Kisii and Machakos. Under Regime 2, the presence of one cointegrating vector (r=1) was present across all the markets. We had expected to have all our markets cointegrated under Regime 1. As discussed earlier, the short time span of the data used to represent Regime 1 may explain why some markets were not cointegrated under Regime 1. The results of all the markets being integrated under Regime 2 were not surprising. A cointegration test just provides the information of whether markets are integrated or not. Although all the markets were integrated under the Regime 2, the assessment of the extent of integration, or how long the shocks take to dissipate, is beyond cointegration tests. Consequently, it is difficult to determine under which regime the markets were better. Another possible explanation of the market being integrated under Regime 2 is that cointegration tests overlook transaction costs, which constitute an inhibiting factor in market integration.

Table 4.3: Johansen's cointegration test statistics for surplus and deficit markets

	Full sample		Regime 1		Regime 2	
Market pair	**# of Obs.**	**Trace test**	**# of Obs.**	**Trace test**	**# of Obs.**	**Trace test**
Eldoret-Nakuru	204	49***	96	16**	108	41***
Eldoret-Kisii	153	52***	57	31***	96	36***
Eldoret-Kisumu	204	47***	96	21***	108	25***
Eldoret-Machakos	167	39***	82	23***	85	27***
Eldoret-Garissa	170	19**	96	8	74	17**
Eldoret-Nairobi	204	42**	96	11	108	32***
Eldoret-Mombasa	204	47***	96	18**	108	34***
Kitale-Nakuru	108	32***	35	19*	73	24***
Kitale-Kisii	89	23***	19	7	70	19**
Kitale-Kisumu	108	18**	35	25*	73	16**
Kitale-Machakos	80	23***	22	7	58	21***
Kitale-Garissa	74	17**	35	18*	49	16**
Kitale-Nairobi	108	36***	35	23*	73	23***
Kitale-Mombasa	108	33***	35	19*	73	24***

Asterisks *** and ** signify rejection of the null hypothesis (no cointegration vector) at 1% and 5% significant levels, respectively

4.2.1.4 Spatial market integration in the presence of varying transaction costs

Cointegration techniques have been criticized because they do not provide information on the extent or level of market integration. In addition, the technique ignores transaction costs. Transaction costs may introduce a non-linear relationship of prices between two markets. Cointegration techniques may result in bias and erroneous policy conclusion, especially when transaction costs are high and non-stationary (Fackler and Goodwin, 2001: Fackler and Goodwin, 2002; Barrett and Li 2002). We estimated two TAR models for this study. The first model was the standard-TAR model (refer to Equation 3.8). This model assumes constant transaction costs. One of the weaknesses of the TAR model in literature is the assumption of constant transaction costs (Goodwin and Piggott, 2001; Sarno et al., 2004). Transaction costs in Kenya may vary depending on different scenarios, such as seasons, the price of fuel, quality of the roads, and distance travelled. The second model estimated was the extended-TAR (refer to Equation 3.10) adapted from Van Campenhout (2007). This model relaxes the assumption of constant transaction costs by introducing a time trend.

The results of the standard-TAR model for the full sample are summarized in Table 4.4 below. The results from the Johansen cointegration test on the full sample, set out in Table 4.3 above, show that all the surplus and deficit markets were cointegrated. The full sample results when transaction costs are included (Table 4.4 below) indicate that all surplus and deficit markets were integrated, except for the Garissa and Machakos markets under Eldoret and its respective pairwise cluster. Overlooking transaction costs may result in integration between markets being shown, even where there is none.

In the results of the standard-TAR shown in Table 4.4 below, τ^{ds} represents the transaction costs threshold and measures the proportion amount that the inter-market price differential must exceed before provoking price adjustments. The half-life measures the time taken to eliminate a shock to half of its original value, represented by λ^{s}, and is measured in months. Overall, the transaction costs threshold was 0.24, implying that the price differential between surplus and deficit markets must be 24% above the transaction costs to prompt price adjustments. Increases or decreases in prices in the surplus markets were transmitted faster to the deficit markets, with a speed of adjustment of 1.5 months. This implies that it took 1.5 months to eliminate half of the shocks coming from the surplus markets.

A comparison between the two surplus pairwise clusters showed that Eldoret and its respective pairwise cluster had a lower transaction cost threshold of 0.16 and faster transmission, with a speed of adjustment of 1 month, compared with Kitale and its respective pairwise cluster with a transaction cost threshold of 0.31 and speed of adjustment of 2 months. Market pairs that were farther apart displayed higher transaction thresholds, compared with markets pairs that were closer together. Under Eldoret and its respective pairwise cluster, the Garissa and Machakos markets were not integrated. Under Kitale and its respective pairwise cluster, all the markets were integrated. The Garissa market reported the highest transaction cost threshold of 0.85, implying that the price differential between the Kitale and Garissa markets must be 85% above transaction costs to prompt price adjustments. The reason behind the high transaction thresholds in Garissa is that the market is over 700 kilometres away from the surplus markets. In addition, a section of the road network to Garissa is classified as very poor, thus contributing to high transportation costs (Kenya Road Board, 2015).

However, the Mombasa market is located farther away from the surplus market, compared with the Garissa market. Despite the distance, the road network connecting the surplus markets to Mombasa is classified as category A (international road), which is tarmacked and in very good condition (KNBS, 2017). Consequently, the costs of transportation for Mombasa are far lower than those for Garissa are.

Table 4.4: Standard-TAR model results for the full sample 2000–2016

Markets pair	Dist. (Km)	τ^{ds}	ρ^{out}	λ^{s}
Eldoret-Nakuru	156	0.138	-0.733*** (-10.99)	0.5
Eldoret-Kisii	195	0.174	-0.760*** (-10.47)	0.5
Eldoret-Kisumu	118	0.205	-0.364*** (-6.143)	1.5
Eldoret-Nairobi	311	0.17	-0.400*** (-7.110)	1.4
Eldoret-Mombasa	796	0.11	-0.345*** (-4.809)	1.6
Kitale-Nakuru	227	0.134	-0.247*** (-3.672)	2.4
Kitale-Kisii	265	0.147	-0.284*** (-3.209)	2.1
Kitale-Kisumu	158	0.387	-0.480*** (-7.643)	1.1
Kitale-Machakos	447	0.425	-0.366*** (-3.471)	1.5
Kitale-Garissa	711	0.849	-0.480*** (-7.643)	1.1
Kitale-Nairobi	382	0.296	-0.348*** (-6.876)	1.6
Kitale-Mombasa	867	0.219	-0.233*** (-3.725)	2.6

*** denote the significance of the adjustment parameters at 1% levels. ρ^{out} represents the speed of adjustment in the outer regime, the t-values of the speeds of adjustment given in the brackets. λ^{s} represents the half-life measured in months, which is computed as ln(0.5)/ln(1+α), where α is the speed of adjustment. Dist. is the distance in kilometres between markets. τ^{ds} represents the transaction costs threshold.

The extended-TAR results for the full sample are summarized in Table 4.5 below. As we expected, there was an increase with respect to the speed of adjustment and reduction in the half-life. Using constant transaction costs for analysis will under-estimate the threshold parameters, leading to a high and unrealistic half-life (Van Campenhout, 2007). These results of constant transaction costs under-estimating threshold parameters are consistent with other studies (Van Campenhout, 2007; Van Campenhout, 2012). Overall, the transaction costs threshold was 0.26, implying that the price differential between surplus and deficit markets must be 26% above transaction costs in order to prompt price adjustments. Increases or decreases in prices in the surplus markets were transmitted faster to the deficit markets, with a speed of adjustment of 1.3 months. This implies that it took 1.3 months to eliminate half of the shocks coming from the surplus markets. This parameter took 1.5 months to eliminate under the standard-TAR test.

A comparison between the two surplus pairwise clusters showed that Eldoret and its respective pairwise cluster had a lower transaction cost threshold of 0.17 and faster transmission, with speed of adjustment of 0.95 months, compared with Kitale and its respective pairwise cluster with a transaction cost threshold of 0.34 and speed of adjustment of 1.69 months. Market pairs farther apart displayed higher transaction thresholds, compared with market pairs that were closer together. The results from the standard-TAR and extended-TAR tests both indicated that Eldoret and its respective pairwise cluster had a lower transaction threshold and speed of adjustment than Kitale and its respective pairwise cluster did. Eldoret town is ranked third in milling capacity in the country. Major large- and medium-scale maize traders are located within Eldoret, and these traders have satellite premises in deficit regions. The town is a major assembly point for maize coming from the surplus region and Uganda. The flow of information among traders who use mobile phones and other forms of MIS may contribute to the high speed of adjustment. In addition, a 73-kilometre stretch of road to Kitale is in very poor condition and this may contribute to higher transportation costs.

Table 4.5: Extended TAR model results for the full sample 2000-2016

Markets pair	Dist. (Km)	τ^{ds}	ρ^{out}	ρ'	λ^{s}
Eldoret-Nakuru	156	0.127	-0.903*** (-6.198)	0.0016 (1.241)	0.3
Eldoret-Kisii	195	0.174	-0.869*** (-6.843)	0.001271 (1.0456)	0.3
Eldoret-Kisumu	118	0.205	-0.293** (-2.547)	-0.000595 (0.7947)	2.0
Eldoret -Machakos	376	0.227	-0.740*** (-6.091)	0.001033 (0.875)	0.5
Eldoret -Nairobi	311	0.17	-0.435*** (-5.192)	0.000918 (1.0195)	1.2
Eldoret -Mombasa	796	0.09	-0.396*** (-3.82)	0.000723 (0.706)	1.4
Kitale-Nakuru	227	0.106	-0.277*** (-3.092)	-0.00032 (-0.401)	2.1
Kitale-Kisii	265	0.270	-0.309** (-2.349)	0.005798 (1.905)	1.9
Kitale-Kisumu	158	0.279	-0.543*** (-5.80)	0.000139 (0.279)	0.9
Kitale-Machakos	447	0.38	-0.841*** (-4.728)	0.002689** (2.143)	0.4
Kitale-Garissa	711	0.849	-0.260*** (-3.285)	0.003371** (2.128)	2.3
Kitale-Nairobi	382	0.280	-0.322*** (-5.488)	-0.000556 (-1.066)	1.8
Kitale-Mombasa	867	0.219	-0.253*** (-3.176)	-0.00094 (0.126)	2.4

** and *** denote significance of the adjustment parameters at the 5% and 1% levels, respectively, ρ^{out} represents the speed of adjustment in the outer regime, and the t-values of the speeds of adjustment are given in the brackets. λ^{s} represents the half-life measured in months, which is computed as ln(0.5)/ln(1+α), where α is the speed of adjustment. Dist. is the distance in kilometres between markets. τ^{ds} represents transaction costs threshold.

4.2.1.5 Effects of policies on spatial market integrations in the presence of varying transaction costs

To investigate the effects of policy on market integration, we split the extended-TAR into two policy regimes. Regime 1 represents the liberalization of the maize sector, while Regime 2 represents the heavy government interventions and soaring food prices, as discussed earlier.

The results of the extended-TAR models under the two regimes are summarized in Table 4.6 below. Under Regime 1, the Machakos market dropped out from the markets that were integrated with Eldoret in the full sample, while Nakuru, Kisii and Machakos dropped out from markets that were integrated with Kitale.

Overall, under Regime 1, the transaction costs threshold was 0.27, implying that the price differential between surplus and deficit markets must be 27% above transaction costs to prompt price adjustments. Increases or decreases in prices in the surplus markets were transmitted faster to deficit markets, with a speed of adjustment of 1.6 months. This implies that it took 1.6 months to eliminate half of the shocks coming from the surplus markets. A comparison between the two surplus pairwise clusters under Regime 1 showed that Eldoret and its respective pairwise cluster had a lower transaction cost threshold of 0.26 and faster transmission, with speed of adjustment of 0.96 months, compared with Kitale and its respective pairwise cluster with a transactions cost threshold of 0.30 and speed of adjustment of 2.5 months. Under Regime 2, markets were not integrated and the shocks from the surplus markets were never corrected, except for the Eldoret and Nakuru markets. The heavy policy intervention to mitigate soaring food prices may have led to the distortion in the markets, resulting in the lack of market integration under Regime 2. The integration of the Nakuru market with Eldoret under Regime 2 may be attributed to its close proximity to Eldoret market.

Table 4.6: Extended-TAR model results for Regime 1 and Regime 2

Market pairs	Regime 1-Liberalized maize sector, minimal policy interventions (January2000 to December 2007)				Regime 2-Heavy policy interventions and soaring high food prices (January 2008 to December 2016)			
	τ^{ds}	ρ^{out}	ρ'	λ^{s}	τ^{ds}	ρ^{out}	ρ'	λ^{s}
Eldoret-Nakuru	0.13	-0.881***	-0.002	0.3	0.12	-0.648***	-0.000	0.7
		(-4.67)	(-0.56)			(-4.39)	(-0.10)	
Eldoret-Kisii	0.30	-0.848***	0.008	0.4	0.28	0.044	-0.001	16.1
		(-3.26)	(1.32)			(0.144)	(-0.27)	
Eldoret-Kisumu	0.27	-0.448***	0.013***	1.2	0.24	-0.068	-0.001	9.8
		(-6.14)	(5.59)			(-0.62)	(-0.72)	
Eldoret-Nairobi	0.36	-0.672***	0.021***	0.6	0.17	-0.187	0.001	3.3
		(-5.26)	(4.65)			(-1.58)	(0.27)	
Eldoret-Mombasa	0.26	-0.264***	0.009***	2.3	0.08	-0.269	0.002	2.3
		(-3.38)	(3.68)			(-1.65)	(0.85)	
Kitale-Kisumu	0.20	-0.254***	-0.020	3.1	0.44	-0.557	0.002	0.2
		(-3.27)	(-1.74)			(-1.230)	(1.21)	
Kitale-Garissa	0.44	-0.987**	0.015	0.1	0.54	-0.600	0.002	0.8
		(-2.45)	(0.94)			(-1.37)	(0.72)	
Kitale-Nairobi	0.22	-0.145***	-0.007	4.4	0.21	-0.529	0.003	0.4
		(-3.76)	(-1.10)			(-1.200)	(1.64)	
Kitale-Mombasa	0.32	-0.273**	0.003	2.2	0.25	-0.45	0.005	0.1
		(-2.34)	(0.39)			(-1.07)	(1.82)	

The asterisks ** and *** denote the significance of the adjustment parameters at the 5% and 1% levels, respectively. ρ^{out} represents the speed of adjustment in the outer regime, the t-values of the speeds of adjustment given in the brackets. λ^{s} represents the half-life measured in months which is computed as ln(0.5)/ln(1+α), where α is the speed of adjustment. τ^{ds} represents transaction costs threshold.

To complement the TAR approach on the effects of policy on domestic market integration, we used an ECM that followed the approach of Yang et al. (2015). We reconstitute the regimes into four policy regimes by further disaggregating the policies under Regime 2 in the extended-TAR model. The first regime represents the liberalization era in the maize sector and covers the period from January 2000 to December 2007. The second regime represented the subsidized fertilizer programme that was aimed at stimulating production and reducing consumer maize prices, which covered the period from October 2008 to December 2016. The third regime represents the ban on GMO foodstuffs. With the ban in effect, Kenya being a net importer of maize, had to source maize from a non-GMO producing country, which comes with a premium. The period covered under this regime is from November 2012 to December 2016. The fourth regime comprised of the duty waiver period when the Treasury has to reduce or zero rate import duty to allow for the importation of maize from the world market, which attracts a 50% import duty. This regime covered the periods from November 2008 to December 2009 and June to December 2011.

In analysing the policies, we were cognizant of the fact of the overlapping periods of policy interventions, and since we are evaluating each of the policies individually, the effects of the other overlapping policy interventions might be overlooked. Figure 4.3 below illustrates maize prices across the four policy regimes. A visual inspection shows that under Regime 1, prices and volatility were lower, compared with the rest of the regime. The effects of removing import duty (Regime 4) can be observed by the decline in maize prices across all the markets.

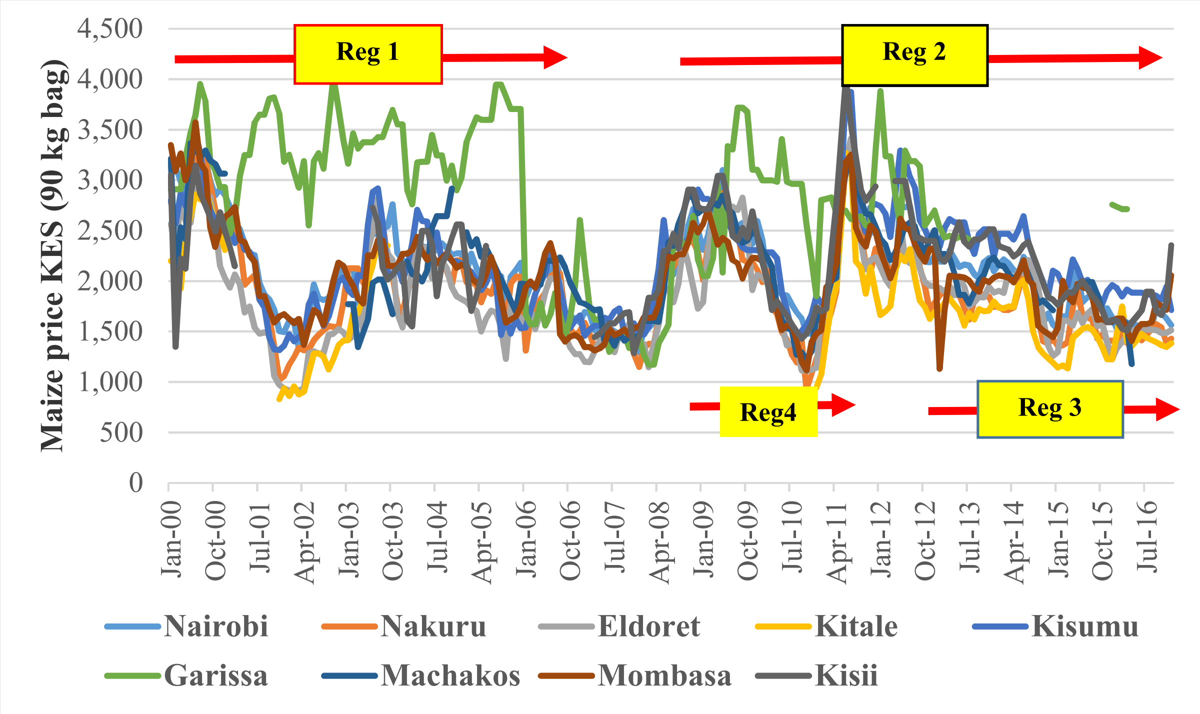

Figure 4.3: Real maze prices for different markets across the four policy regimes

The VECM for the surplus and deficit pairwise markets for the full sample and for Regime 1 and Regime 2 are summarized below in Table 4.7 below. Our interest was in the examination of the long-run relationship and the speed of adjustment between the surplus and deficit markets. From the full sample, Eldoret and its respective pairwise cluster had a long-run relationship with 5 markets. The increases or decreases in prices in the Eldoret market were transmitted into deficit markets with a speed of adjustment of between 3.5 to 4.1 months. This implies that it took between 3.5 to 4.1 months to eliminate half of the shocks coming from the Eldoret market. Kitale and its respective pairwise cluster had a long-run relationship with only 3 markets. The transmission of prices from the Kitale market to the deficit market took between 2 to 2.7 months.

Under Regime 1, Eldoret and its respective pairwise cluster had a long-run relationship with only two markets, and price transmission took between 0.5 and 2 months. Kitale and its respective pairwise cluster had a long-run relationship with 3 markets, with price transmission between the two taking 0.8 and 0.9 months. Under Regime 2, only Eldoret and its respective pairwise cluster had a long-run relationship. The price transmission was between 1.9 and 2.9 months. Under Regime 3, Eldoret and its respective pairwise cluster had a long-run relationship with only two markets, with a price transmission of between 0.4 and 0.5 months, while for the Kitale pairwise cluster, it had only one long-run relationship, with a price transmission of 0.6 months. Under Regime 4, only the Eldoret cluster had a long run-relationship with 3 markets, with price transmissions of between 2.3 and 11.2 months.

Overall, comparing Regimes 1 and 2, price transmission was slower under Regime 2 compared with Regime 1. This implies that markets were less integrated under Regime 2 compared with Regime 1. Since we have different cluster combinations across the different policy regimes, we examine a consistent cluster, which comprised Kisii and Machakos under the Eldoret pairwise cluster. Under Regime 1, the price transmissions were 0.5 and 2.4 months for Kisii and Machakos, respectively. Under Regime 4, the price transmissions for Kisii and Machakos were 5.9 and 11.2 months, respectively. This implies that price transmission was faster under the liberalized regime than under the period of import duty removal. The policies implemented to mitigate soaring food prices resulted in market distortion, and therefore shocks took longer to eliminate. These results are in line with the extended-TAR results and are consistent with other studies that found lower market integration under heavy government interventions (Chapoto and Jayne, 2009; Jayne, 2012; Chapoto and Sitko, 2014).

We carried out residual diagnostic tests on the ECM to ensure that the residual term did not suffer from serial correlations, heteroscedasticity or non-normality. The LM test was used to check for serial correlation. The null hypothesis of the LM test is the lack of serial correlation on the residual term. The null hypothesis for the LM test was accepted. The Breusch-Pagan test was used to test for heteroscedasticity. The null hypothesis of the Breusch-Pagan test is the lack of heteroscedasticity. The null hypothesis was accepted. The p-values of Jarques-Bera test were used to conduct the normality test. The null hypothesis is that the residual terms are normally distributed. The null hypothesis was accepted. In addition, a stability test for the ECM was carried out using the CUSUM test. The results indicated that all the estimated equations were inside the critical bound region, which is a sign of a stable model.

Table 4.7: Error correction model for cointegrated surplus and deficit markets

Policy regime	Markets	Long-run relationship	VECM (short-run parameters)	
			Speed of adjustment	Half-life
Full sample	Eldoret-Nakuru	0.95**	-0.18***	3.5
	Eldoret-Kisii	0.97**	-0.16**	3.9
	Eldoret-Machakos	1.95**	-0.16***	4.1
	Eldoret-Nairobi	0.83**	-0.17***	3.8
	Eldoret-Mombasa	0.79**	-0.16***	3.9
	Kitale- Kisii	1.25**	-0.22***	2.3
	Kitale-Garissa	0.14	-0.29***	2
	Kitale-Mombasa	0.72**	-0.23**	2.7
Regime 1	Eldoret-Kisii	0.8**	-0.78***	0.5
	Eldoret-Machakos	1.9**	-0.25***	2.4
	Kitale-Kisii	0.17	-0.55**	0.9
	Kitale-Garissa	0.09**	-0.57***	0.8
	Kitale-Nairobi	0.06**	-0.64**	0.8
Regime 2	Eldoret-Nakuru	1.06**	-0.30**	1.9
	Eldoret-Garissa	0.12	-0.31**	1.9
	Eldoret-Nairobi	0.90**	-0.20**	2.9
Regime 3	Eldoret-Nakuru	0.8**	-0.74***	0.5
	Eldoret- Mombasa	0.5**	-0.82***	0.4
	Kitale-Nakuru	0.8**	-0.33**	0.6
Regime 4	Eldoret-Kisii	0.1**	-0.11**	5.9
	Eldoret-Machakos	0.09**	-0.06**	11.2
	Eldoret-Mombasa	1.56**	-0.26***	2.3

** and *** denotes significance at 5% and 1% level respectively.

4.2.2 Domestic and regional market integration

Kenya is a net maize importer, and Uganda and Tanzania provide imports to bridge the deficit. Maize imports to Kenya account for half of the traded volume in the EAC region (EAGC, 2018). Kenya imports about 400,000 metric tons from Tanzania and Uganda, with the proportions from each country being estimated at 54% and 41%, respectively. The imports are dependent on the weather (FSNWG, 2018). In the analysis of domestic and regional market integration, we made three assumptions. The first assumption was the homogeneity of commodities, thus any price differential because of varieties and other attributes was ignored.

The second assumption was that Kenya is the deficit market in the region and that both Tanzania and Uganda are the surplus markets. The final assumption concerned the markets across the three countries. For Kenya, the three major deficit markets of Kisumu, Mombasa and Nairobi were selected to represent Kenya. For Tanzania, the maize-producing regions included Arusha, Dodoma, Iringa, Mbeya and Rukwa, but due to limited availability of market data, we selected the Arusha, Iringa and Dar es Salaam markets. In Uganda, the maize producing region included Kapchorwa Iganga, Mbale, Masaka and Masindi. We selected the Busia and Kampala markets to represent Uganda. The Tanzanian and Ugandan monthly price data were sourced from FAO GIEWS, and the study covered the period from January 2002 to December 2016.

The monthly average wholesale maize prices, in US$ per ton, across the respective markets in each country are summarized in Figure 4.4 below. A visual inspection of the graph indicates that there was price volatility across all the markets. Under Regime 2, higher prices and volatility were observed, compared with Regime 1, across all the markets. Prices appear to co-move across all the three countries. Kenya has the highest maize prices, while Ugandan prices are the lowest. This is not surprising, since Kenya is the deficit market in the region.

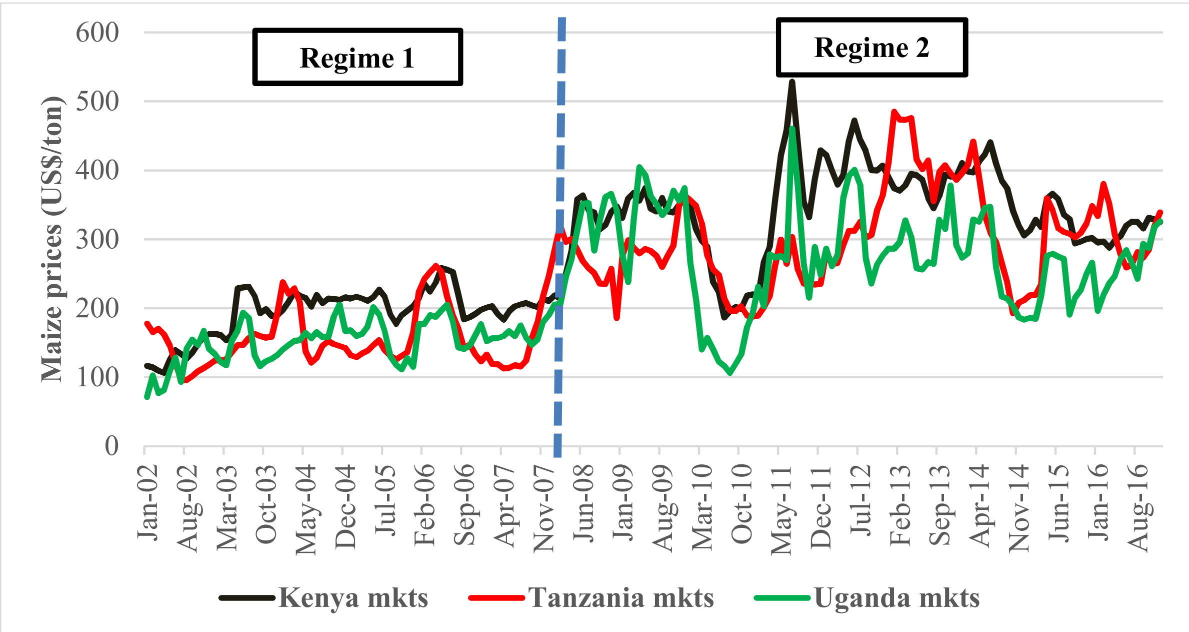

Figure 4.4: Average wholesale maize prices in markets across Kenya, Uganda and Tanzania from 2002 to 2016

Source: Author's compilation using FAO GIEWS (2002-2016) and MOALF (2002-2016)

4.2.2.1 Descriptive statistics

The monthly wholesale maize prices, in US$ per ton, across the different markets in the three countries are summarized in Table 4.8 below. Kenya reported the highest prices, while Uganda reported the lowest prices in the region. The trend was similar across the full sample and under the two different regimes. For the full sample, Tanzania and Uganda reported 15% and 19% lower prices, respectively, than Kenya did. Under Regime 1, both Tanzanian and Ugandan prices were 20% lower than those in Kenya, while under Regime 2, prices are 13% and 19% lower for Tanzania and Uganda, respectively, compared with Kenya. Comparing the two regimes, all the markets recorded higher prices in Regime 2, as compared with Regime 1. On average, markets recorded increases in prices of 77%, 94% and 81% under Regime 2, compared with Regime 1, for Kenya, Tanzania and Uganda, respectively. In addition, the value of CV under Regime 2 averaged 0.68, compared with 0.23 under Regime 1. These results are not surprising, as Regime 1 represents the liberalized era that witnessed increases in the numbers of players along the maize value chain that resulted in the decline in maize prices (Kirimi et al., 2011), while soaring food prices and heavy government interventions characterized Regime 2.

Table 4.8: Descriptive statistics of domestic and regional maize prices for the full sample and for Regime 1 and Regime 2 samples, 2002–2016

Country	Markets	Obs.	Mean	Median	Max	Min	Std. Dev.	CV
		Full sample						
Kenya	Kisumu	180	293	297	590	104	101	0.34
	Mombasa	180	277	279	490	103	92	0.33
	Nairobi	180	281	286	507	99	87	0.31
Tanzania	Arusha	180	239	245	490	0	88	0.37
	Dar	180	258	253	517	96	96	0.37
	Iringa	180	230	215	537	78	111	0.48
Uganda	Busia	150	242	232	468	95	88	0.36
	Kampala	180	218	204	460	71	78	0.36
		Regime 1						
Kenya	Kisumu	72	195	208	263	104	40	0.20
	Mombasa	72	189	197	274	103	36	0.19
	Nairobi	72	198	210	253	99	35	0.18
Tanzania	Arusha	72	162	155	294	89	46	0.28
	Dar	72	166	156	277	96	45	0.27
	Iringa	72	136	124	250	78	43	0.32
Uganda	Busia	60	157	159	220	95	30	0.19
	Kampala	72	153	150	234	71	35	0.23
		Regime 2						
Kenya	Kisumu	108	358	357	590	202	72	0.66
	Mombasa	108	336	334	490	163	69	0.64
	Nairobi	108	337	341	507	167	65	0.60
Tanzania	Arusha	108	290	280	490	0	70	0.65
	Dar	108	319	318	517	187	69	0.64
	Iringa	108	293	258	537	153	97	0.90
Uganda	Busia	90	299	288	468	196	65	0.72
	Kampala	108	262	268	460	106	69	0.64

Note: Dar is the short form of Dar es Salaam market. The CV is covariance of variation.

4.2.2.2 Unit root testing

We tested for unit root without intercept and deterministic trend, as our price series data followed a random walk process, with value rarely reverting to the mean. We used the ADF and PP procedures to test for the presence of a unit root. The results of the ADF and PP tests are summarized in Table 4.9 below. The prices across all the markets were non-stationary at the level, as the null hypothesis of unit root was not rejected. The prices became stationary on first differencing, as the null hypothesis of unit root was rejected at the 1% significant level across all the markets. All our market prices were integrated in the order of one I (1).

Table 4.9: Results of ADF and PP unit root tests on monthly prices across different markets (2002–2016)

		ADF tests		PP tests	
Country	**Market**	**Level**	**1st difference**	**Level**	**1st difference**
Kenya	Kisumu	-0.24	-11.28***	0.03	-12.24***
	Mombasa	-0.34	-10.70***	-0.01	-10.54***
	Nairobi	-0.13	-10.61***	-0.18	-11.06***
Tanzania	Arusha	-0.34	-17.55***	-0.39	-17.57***
	Daressalaam	-0.63	-11.17***	-0.41	-11.03***
	Iringa	-0.85	-10.82***	-0.87	-10.82***
Uganda	Busia	-0.60	-12.29***	-0.12	-16.01***
	Kampala	-0.67	-13.04***	-0.09	-14.86***

ADF and PP critical values are -1.62, -1.94, and 2.58 for 10%, 5% and 1 % significant levels, respectively. Asterisk *** signify rejection of the null hypothesis of a unit root at 1%, significant level.

4.2.2.3 Pairwise cointegration

To establish whether the domestic markets were integrated with the regional markets, a pairwise Johansen cointegration test was undertaken on the logarithmic maize prices. The lag order in the Johansen cointegration test was established by running the unrestricted VAR, using one Kenyan market against one regional market. From the results, we used the lag structure to derive the lag order as selected by the AIC criterion. Results for the full, Regime 1 and Regime 2 samples are summarized in Table 4.10 below. The results show that the null hypothesis (absence of cointegration relation) between the three domestic and five regional market pairs was rejected. The test confirms the presence of one cointegrating vector (r=1) across all our markets during the full sample or under a different regime. Despite the heavy policy interventions under Regime 2, Kenyan markets were cointegrated with the regional markets. As discussed earlier, cointegration only reports whether the markets were integrated or not. It does not provide the extent or level of integration. Therefore, we are not able to tell if the market was less or more integrated under Regime 2 than under Regime 1.

Table 4.10: Johansen cointegration tests between domestic and regional markets

Market pairs	Full sample	Regime 1	Regime 2
	r=0	r=0	r=0
Kisumu-Arusha	27***	19**	20***
Kisumu-Dar es Salaam	28***	25***	17**
Kisumu-Iringa	21***	21***	18**
Kisumu-Busia	23***	27***	23***
Kisumu-Kampala	24***	22***	18**
Mombasa-Arusha	28***	19**	20**
Mombasa- Dar es Salaam	30***	24***	16**
Mombasa-Iringa	22***	21***	18**
Mombasa-Busia	18**	23***	24***
Mombasa-Kampala	27***	20***	19**
Nairobi-Arusha	36***	26***	21***
Nairobi- Dar es Salaam	34***	31***	23***
Nairobi-Iringa	26***	26***	25***
Nairobi-Busia	21***	25***	26***
Nairobi-Kampala	37***	35***	26***

*** and ** signify the rejection of null hypothesis of no cointegration vector at 1% and 5% significant levels, respectively

4.2.2.4 Long-run relationship

The ECM for domestic and regional pairwise markets for the full sample and Regimes 1 and 2 are summarized below in Tables 4.11, 4.12 and 4.13, respectively. Our interest was in the examination of the long-run relationship and the speed of adjustment between domestic and the regional markets. Regarding the full sample (Table 4.11), a long-run relationship exists between all our domestic and regional markets. The increases or decreases of prices in the regional markets were transmitted slowly into the domestic markets, with the speed of adjustment ranging from 3 to 9 months. It took between 3 to 9 months to eliminate half of the shocks coming from the regional markets. Shocks coming from Ugandan markets dissipated quicker, between 3 and 5 months, than shocks from Tanzanian market, which were eliminated after 4 to 9 months. This implies that there is lower integration between the domestic and Tanzanian markets than between the domestic and Ugandan markets. These results concur with those of other studies that found market pairs with at least one Tanzanian market were less integrated (World Bank, 2009; Ihle et al.,2010;Ihle et al., 2011). The authors attributed the low market integration between Tanzania and other markets in the region (Kenya and Uganda) to poor infrastructure, higher transaction costs within Tanzania and across the border, size of the country, and the distortive policy interventions such export bans.

Results on long-run relationship under Regime 1 (Table 4.12 below) indicate there was an increase in the speed of adjustment, with shocks being eliminated relatively fast, at between 1 and 5 months. Shocks from Ugandan markets were eliminated faster, at between 1 and 3 months, as compared with Tanzania at between 3 and 5 months. Under this regime, we found no long-run relationship between the Kisumu, Mombasa and Nairobi markets and Dar es Salaam and Iringa in Tanzania and Busia in Uganda. The faster elimination of shocks from the region under this regime is an indication of better integration between the domestic and regional markets. Market liberalization and minimal policy intervention into the maize sector could explain why markets were better integrated.

Results for Regime 2 (Table 4.13 below) indicate there was a decline in the speed of adjustment in Regime 2, compared with Regime 1. The shocks were eliminated relatively slower, at between 2 to 7 months, compared with Regime 1. Similar to the full sample and Regime 1, the price shocks from Ugandan markets were eliminated quickly, from 2 to 4 months, as compared with Tanzanian markets which took from 4 to 7 months to eliminate shocks. Only the Kisumu and Mombasa markets had no long-run relationships with Dar es Salaam and Iringa in Tanzania and Busia and Kampala in Uganda under this regime. When we compare the two regimes, markets under Regime 2 were less integrated than they were under Regime 1. Heavy policy intervention to mitigate the soaring food prices may explain the decline in market integration between domestic and regional markets. Several studies have shown that policy intervention may insulate domestic markets, thus resulting in little or no price transmission (Cudjoe et al., 2010; Minot, 2011; Baltzer, 2013).

Residual diagnostic tests carried out on the residual term of our ECM indicated that there was no serial correlation or heteroscedasticity, and that the residual terms were normally distributed. The results from the CUSUM test indicated that the model was stable, as all the estimated equations were inside the critical bound region.

Table 4.11: Error correction model for cointegrated domestic and regional market pairs full sample

Market pairs	Long-run relationship		ECM (short-run parameter)		
	Exist	Adjustment	Short-run	Speed Adj.	Half-life
Kisumu-Arusha	Yes	0.80***	0.20***	-0.14***	5
Kisumu-Dar	Yes	0.70***	0.20***	-0.12***	5
Kisumu-Iringa	Yes	0.51***	0.12**	-0.09***	7
Kisumu-Busia	Yes	0.70***	0.25***	-0.19***	3
Kisumu-Kampala	Yes	0.84***	0.23***	-0.18***	4
Mombasa-Arusha	Yes	0.80***	0.20***	-0.13***	5
Mombasa-Dar	Yes	0.71***	0.16***	-0.10***	6
Mombasa-Iringa	Yes	0.53***	0.19***	-0.07***	9
Mombasa-Busia	Yes	0.65***	0.16***	-0.14***	5
Mombasa-Kampala	Yes	0.82***	0.16***	-0.21***	3
Nairobi-Arusha	Yes	0.73***	0.18***	-0.15***	4
Nairobi-Dar	Yes	0.65***	0.17***	-0.13***	5
Nairobi-Iringa	Yes	0.47***	0.09*	-0.09***	7
Nairobi-Busia	Yes	0.60***	0.18***	-0.19***	3
Nairobi-Kampala	Yes	0.77***	0.18***	-0.24***	3

***, ** and * are the 1%, 5% and 10% significant levels, respectively. Half-life is computed as $\ln(0.5)/\ln(1+\alpha)$, where α is the speed of adjustment. It is measured in months and represents the period taken to eliminate the shocks to half size.

Table 4.12: Error correction model for cointegrated domestic and regional market pairs, Regime 1

Market pairs	Long-run relationship		ECM (short-run parameter)		
	Exist	Adjustment	Short-run	Speed Adj.	Half-life
Kisumu-Arusha	Yes	0.46***	0.24**	-0.19***	3
Kisumu-Dar	No	0.26**	0.16*	-0.16***	4
Kisumu-Iringa	No	0.03	0.02	-0.14***	4
Kisumu-Busia	Yes	0.47***	0.42***	-0.51***	1
Kisumu-Kampala	Yes	0.66***	0.22***	-0.25***	2
Mombasa-Arusha	Yes	0.53***	0.27***	-0.21***	3
Mombasa-Dar	No	0.36***	0.21***	-0.14***	5
Mombasa-Iringa	No	0.14*	0.14**	-0.12**	5
Mombasa-Busia	No	0.29***	0.30***	-0.21**	3
Mombasa-Kampala	Yes	0.64***	0.15***	-0.30***	2
Nairobi-Arusha	Yes	0.41***	0.08	-0.19***	3
Nairobi-Dar	No	0.24**	0.12	-0.15***	4
Nairobi-Iringa	No	0,01	0.01	-0.13**	5
Nairobi-Busia	Yes	0.07	0.03	-0.41***	1
Nairobi-Kampala	Yes	0.59***	0.08	-0.27***	2

***, ** and * are 1%, 5% and 10% significant levels, respectively. Half-life is computed as ln(0.5)/ln(1+α), where α is the speed of adjustment. It is measured in months and represents the period taken to eliminate the shocks to half size.

Table 4.13: Error correction model for cointegrated domestic and regional market pairs, Regime 2

	Long-run relationship		ECM (short-run parameter)		
Market pair	**Exist**	**Adjustment**	**Short-run**	**Speed Adj**	**Half-life**
Kisumu-Arusha	Yes	0.46***	0.14*	-0.16***	4
Kisumu-Dar	Yes	0.32***	0.21***	-0.14***	4
Kisumu-Iringa	Yes	0.11	0.18***	-0.13***	5
Kisumu-Busia	Yes	0.23***	0.10*	-0.21***	3
Kisumu-Kampala	no	0.49***	0.20***	-0.23***	3
Mombasa-Arusha	Yes	0.63***	0.13*	-0.12**	5
Mombasa-Dar	no	0.48***	0.11	-0.12***	5
Mombasa-Iringa	No	0.26***	0.22***	-0.09**	7
Mombasa-Busia	No	0.21***	0.03	-0.17***	4
Mombasa-Kampala	Yes	0.54***	0.13***	-0.23***	3
Nairobi-Arusha	Yes	0.58***	0.23***	-0.16***	4
Nairobi-Dar	Yes	0.51***	0.19***	-0.16***	4
Nairobi-Iringa	Yes	0.22***	0.17***	-0.13***	5
Nairobi-Busia	Yes	0.34***	0.22***	-0.23***	3
Nairobi-Kampala	Yes	0.53***	0.20***	-0.28***	2

***, ** and * are 1%, 5% and 10% significant levels, respectively. Half-life is computed as $\ln(0.5)/\ln(1+\alpha)$, where α is the speed of adjustment. It is measured in months and represents the period taken to eliminate the shocks to half size.

4.2.3 Domestic and world market integration

As discussed earlier, Kenya is a net importer of maize. The country has imported maize from the world market during poor harvest seasons (2009 and 2011). Maize imported from outside the EAC and Common Markets for Eastern and Southern Africa (COMESA) region attracts a 50% import duty. Since 2000, Kenya has experienced droughts during the 2008/09 and 2010/11 harvest seasons, and imports were sourced from outside the region. To ensure the timely arrival of the imported maize for consumers, the MOALF needs to establish the required stocks and shares this information with the Treasury. In addition, the ministry is responsible for awarding tenders to successful companies to import maize. The Treasury is required to gazette the removal or reduction of the import duty. Coupled with the lag[9] period required for imported maize to arrive at the country's port, all these activities need to be well coordinated to ensure the timely arrival of imported maize on the market. This has not been the case, going by experiences that have been noted (Annex B.2).

In order to investigate the integration between domestic and world markets, we made four assumptions. The first assumption was that Kenya is a small country and its demand and supply of maize has no influences on world maize prices, although the world maize market does have an influence on the domestic market. The second assumption was that commodities are homogenous; thus, any price differential because of varieties and other attributes was ignored. The third assumption was with respect to Kenyan maize prices. We averaged the maize prices of the three major deficit markets of Kisumu, Mombasa and Nairobi to represent the country maize price. This is more realistic than using the Nairobi price to be representative of the country. The final assumption was about the import ban on GMO foodstuffs, which the government imposed on November 2012. Although the export ban was in force between November 2012 and December 2016, the country did not experience drought during that period, which then would have necessitated importing maize from the world market, which would have been affected by the ban of imports and thus excluded imports from the USA and South Africa. We include these two markets under Regime 2, as the ban has not been effected.

Because Kenya is a net importer of maize and trades under the IPP regime, the difference between the domestic and world market prices is represented by the exchange rate, import taxes, transfer costs from the country of origin, port charges, and internal transportation costs. The world maize prices in US$ for the world and Kenyan markets are illustrated in Figure 4.5 below. A visual inspection of the graph indicates there was price volatility across all the markets. Higher prices and volatility were observed under Regime 2 than under Regime 1, with the

9 Loading of maize in the Gulf of Mexico takes 10–15 days. Thereafter, the vessel travels for about 40 days from the Gulf of Mexico to Mombasa. On arrival at Mombasa port, it takes about 10 days to off-load the maize. At a minimum, it takes about 60 days for the maize to arrive on our shores, before factoring in the inland transportation required for deliveries to the consumers.

Kenyan market demonstrating higher price volatility. The world prices appear to co-move together during the period under review, while that was not the case for maize prices in Kenya.

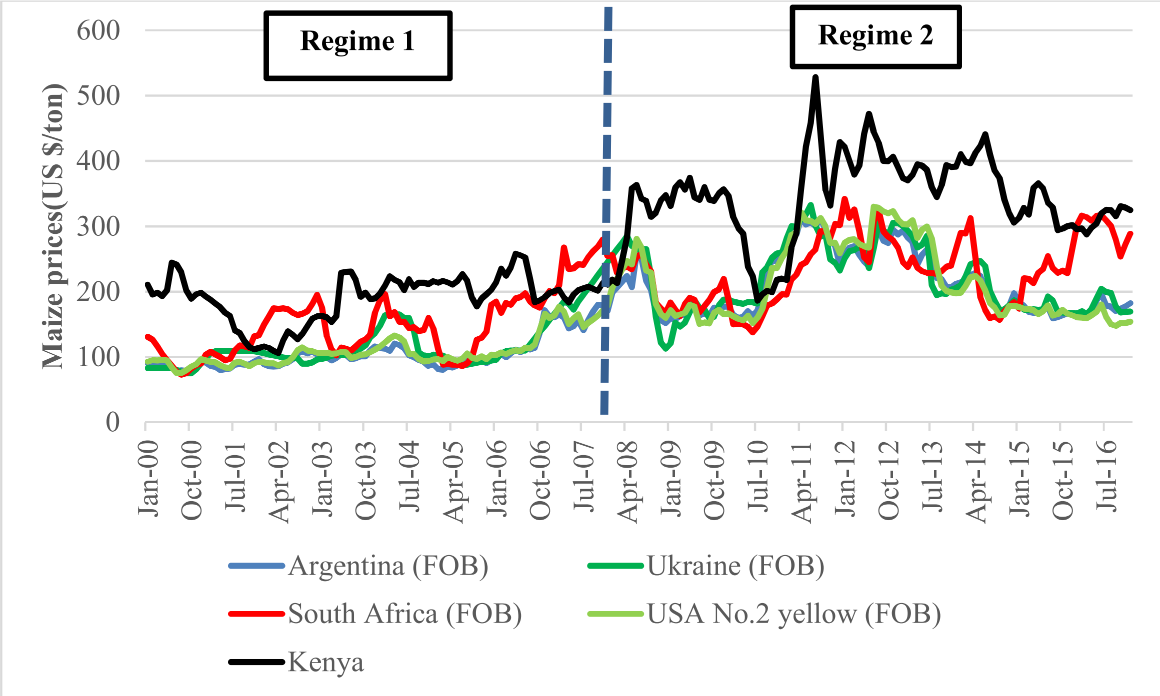

Figure 4.5: Comparison between the domestic and world maize prices (2000–2016)
Source: Author's compilation using FAO GIEWS and MOALF data on monthly prices.

Descriptive results for monthly maize prices, in US$ per ton, for Argentina, Ukraine, the USA, South Africa and Kenya for the full sample and different regimes are summarized in Table 4.14 below. Kenya reported the highest prices across the three samples. When comparing the two regimes, maize prices were higher under Regime 2. Maize prices increased by 80%, 20%, 56%, 53% and 26% in Kenya, South Africa, the USA, Ukraine and Argentina, respectively, under regime 2, when compared with Regime 1. Kenya recorded the highest increase of 80% in respect of the high maize prices under Regime 2. The increase in prices under Regime 2 are consistent with the soaring food prices and heavy government interventions experienced, while the lower prices under Regime 1 reflect the liberalization of the maize sector and declines in maize prices.

Table 4.14: Descriptive statistics for domestic and world markets

Sample	Statistics	Argentina	Ukraine	USA	South Africa	Kenya
Full	Mean	163	172	166	195	272
	Median	163	169	160	186	240
	Maximum	314	333	330	342	528
	Minimum	79	75	75	73	106
	Std. Dev.	66	68	70	66	93
	Observations	204	204	204	204	204
Regime 1	Mean	106	119	110	150	191
	Median	98	106	103	144	199
	Maximum	180	245	179	280	258
	Minimum	79	75	75	73	106
	Std. Dev.	26	38	25	51	36
	Observations	96	96	96	96	96
Regime 2	Mean	213	219	216	234	344
	Median	201	202	198	234	346
	Maximum	314	333	330	342	528
	Minimum	152	113	148	138	186
	Std. Dev.	48	52	58	52	65
	Observations	108	108	108	108	108

4.2.3.1 Unit root testing and pairwise cointegration

Testing for unit root did not include an intercept and deterministic trend, as our price series data followed a random walk process, with value rarely reverting to the mean. We used the ADF and PP procedures to test for presence of a unit root. The results of the ADF and PP tests are summarized in Table 4.15 below. The world and domestic prices were non-stationary at the level, as the null hypothesis of unit root was not rejected. The prices became stationary on first differencing, as the null hypothesis of unit root was rejected at 1% significant level for all the markets. The domestic and world market prices were integrated in the order of one I (1).

Table 4.15: Results of ADF and PP unit root across domestic and world markets (2000–2016)

	ADF test		PP test	
Country	**Level**	**1st difference**	**Level**	**1st difference**
Argentina	-1.47	-12.47***	-1.56	-12.47***
Ukraine	-2.24	-9.92***	-2.07	-9.96***
USA	-1.69	-11.33***	-1.73	-11.46***
South Africa	-2.22	-11.60***	-1.75	-11.48***
Kenya	-2.38	-10.15***	-1.81	-10.10***

ADF and PP critical value are -1.62, -1.94, and 2.58 for 10%, 5% and 1 % significant levels, respectively. Asterisk ***, ** and * signify rejection of the null hypothesis of a unit root at 1%, 5% and 10% significant levels, respectively.

4.2.3.2 Pairwise cointegration

We applied a pairwise Johansen cointegration test on the logarithmic maize prices to determine integration between domestic and the world markets. To determine the lag order, we ran the unrestricted VAR, using one domestic market against one world market. Using the AIC criterion, we selected the lag order. The results of Johansen cointegration test on the full sample, Regime 1 and Regime 2 are summarized in Table 4.16 below. For the full sample, the null hypothesis of the absence of a cointegration relation between domestic and world market pairs was rejected. The test confirms the presence of one cointegrating vector (r=1) across all our markets during the full sample. Under Regime 1, we had no cointegration between the domestic market and the world market, while under Regime 2 cointegration was present. These results are surprising as they indicate that during the period of liberalization and minimal policy interventions, domestic markets were not integrated with the world market, but they became integrated during the period of heavy policy interventions (Regime 2). Heavy policy interventions are expected to block transmission from the world market thus resulting in no cointegration. The lack of cointegration in Regime 1 could be the result of using a short span of data to represent Regime 1. The liberalization of the maize sector started in 1990, but due to data limitations, the data available for this period was limited to a range from January 2000 to December 2007 (96 months). This short period may have influenced cointegration.

The explanation for cointegration during a period of heavy policy interventions may be attributed to information flow, as this contributes to spatial market integration in the absence of physical trade flow between markets (Stephens et al., 2008). The early warning system implemented by MOALF in 2007 indicated that poor harvests were expected during 2008/09 in the region, implying that imports from the world market would be required. Private traders then lobbied for the Treasury to waive duty in early 2008 to allow for the timely importation of maize. Treasury delayed duty waiver and lifted the duty waiver in November 2008, thus the first consignment of duty-free maize arrived in March 2009. Consequently, consumers had to cope with higher prices for a period of 15 months.

A similar situation occurred in 2011. Tanzania experienced poor weather conditions and therefore the Tanzanian harvest of 2011 was below average. This prompted the Tanzanian government to restrict exports as a measure for securing Tanzanian food security. Tanzanian imports account for the highest proportion of imports into Kenya. With an anticipated poor harvest in Tanzania, stakeholders in the Kenyan maize sector started lobbying for a duty waiver at the beginning of 2011. This time, the duty waiver was given timely, and the Treasury granted a duty waiver of 6 months (June–December, 2011), which allowed traders to import maize in time for harvest. The uncertainty in the grain sector could indirectly result in a long-run relationship between domestic and world markets.

Table 4.16: Johansen cointegration tests between domestic and world markets

Market pairs	**Full sample**	**Regime 1**	**Regime 2**
	r=0	**r=0**	**r=0**
Kenya-Argentina	20**	5	18**
Kenya-Ukraine	17**	5	24***
Kenya-USA	17**	5	25***
Kenya-South Africa	20***	8	24***

Source: Author's computation using FAO GIEWS FPMA Tool Monitoring and Analysis of Food Prices.
Notes: *** and ** represent 1% and 5% significant levels of rejection of the null hypothesis of no cointegration

4.2.3.3 Long-run relationship

The error correction models for domestic and world pairwise markets are summarized below in Table 4.17. Our interest was in the examination of the long-run relationship and the speed of adjustment between domestic and the world markets. Regarding the full sample, long-run relationship exists between the domestic and world markets. The increases or decreases of prices in the world markets were transmitted slowly into the domestic markets, with the speed of adjustment ranging from 7 to 13 months. It took between 7 to 13 months to eliminate half of the shock coming from the world markets. Shocks from the South African market took the longest to dissipated (13 months).

Under Regime 1, there was no long-run relationship between the domestic and world markets. Only Argentina and the USA reported significant speed of adjustments, of 10 and 11 months, respectively. These were higher speeds of adjustment than those recorded for the full sample. Under Regime 2, all the domestic markets had a long-run relationship with the world market. There was an increase in the speed of adjustment, ranging from 5 to 6 months, when compared with Regime 1. The shorter span of data used to analyse Regime 1 and the role of information flow, as it contributes to spatial market integration in the absence of physical trade flow between markets, may explain our results.

Residual diagnostic tests carried out on the residual term of our ECM indicated that there was no serial correlation or heteroscedasticity, and that the residual terms were normally distributed. The results from the CUSUM test indicated that the model was stable, as all the estimated equations were inside the critical bound region.

Table 4.17: Error correction model for cointegrated domestic and world market pairs

Sample	Market pair	Long-run relationship		ECM (Short-run parameters)		
		Exist	Adjustment	Short-run	Speed Adj	Half-life
Full	Kenya-Argentina	Yes	0.68***	-0.01	-0.09***	7
	Kenya-Ukraine	Yes	0.61***	0.03	-0.06***	11
	Kenya-USA	Yes	0.68***	-0.03	-0.09***	7
	Kenya-S. Africa	No	0.57***	-0.01	-0.05***	13
Regime 1	Kenya-Argentina	No	0.21**	0.05	-0.06*	11
	Kenya-Ukraine	No	0.11	0.05	-0.06	12
	Kenya-USA	No	0,25**	-0.05	-0.07**	10
	Kenya-S. Africa	No	-0.02	-0.05	-0.06	5
Regime 2	Kenya-Argentina	Yes	0.29***	-0.08	-0.13***	5
	Kenya-Ukraine	Yes	0.15*	0.05	-0.10***	6
	Kenya-USA	Yes	0.36***	-0.04	-0.13***	5
	Kenya-S. Africa	Yes	0.33***	0.02	-0.13***	5

Source: Author's computation using FAO GIEWS FPMA Tool Monitoring and Analysis of Food Price.
Notes: *** and ** are 1% and 5% significant levels. LR pt represents long-run price transmission. The speed of adjustment λ

4.3 MODELLING THE KENYAN MAIZE MARKET

Kenya is a net importer of maize, hence it operates under the IPP trade regime. we developed a maize sector model by combining the country's trade regime and the assumptions discussed in Subsection 3.4.2.2,. The historical data covered time series data over the periods from 1995 to 2016.

4.3.1 Descriptive statistics

The descriptive results of selected exogenous and endogenous variables from 1995 to 2016 are summarized in Table 4.18 below. Regarding the exogenous variables in the period under review, the Kenyan population averaged 35 million people, while the country received an average rainfall of 1,169 millimetres. Concerning the endogenous variables, 1.8 million hectares of maize, on average, was harvested, averaging yields of 1.57 tons per hectare. Maize production during the period under review averaged 2.8 million tons per year, with an average per capita consumption of 80 kilograms per year. The prevailing maize price was KES 15,882 per ton.

Table 4.18: Descriptive results for the exogenous and endogenous variables from 1995 to 2016

Variable	Units	Obs.	Mean	Max	Min	Std. Dev.
$\mathrm{POP_t}$	Millions	22	34.78	45.25	26.38	5.90
$\mathrm{RAINYS_t}$	Millimetres	22	1,169	1,545	851	161
$\mathrm{RMZPRIC}_t$	KES/ton	17	15,882	23,646	11,367	3,222
$\mathrm{RPTSPRIC}_t$	KES/ton	17	22,754	34,478	13,317	8,016
$\mathrm{INPTINDEX_t}$	Number	22	3.25	4.43	1.63	0.67
$\mathrm{IMPRVSEED_t}$	'000 hectares	22	1,315	1,634	1,020	210
$\mathrm{MZAREA_t}$	'000 hectares	22	1,816	2,174	1,500	236
$\mathrm{MZYIELD_t}$	Tons/ha	22	1.57	1.81	1.29	0.15
$\mathrm{MZPRDN_t}$	'000 tons	22	2,862	3,780	2,160	578
$\mathrm{PCONS_t}$	Kgs/year	22	80.33	105.25	56.49	12.07

4.3.2 Domestic supply block

4.3.2.1 Maize area harvested

We investigated the supply responses of farmers to own and substitute price incentives to determine their decisions on the area harvested. As discussed earlier, the area harvested provides a better proxy, as farmers have no control over their output. In addition, data on the area planted is not available. Supply response studies have adopted cointegration and ECM procedures to overcome the problem of running spurious regression (Alemu et al., 2003; Mose et al., 2007). For this study, we adapted cointegration and ECM techniques to compute the supply response to own and substitute prices by farmers. The area harvested is a function of own maize prices, substitute prices, input index, rainfall, and trends in technology.

The first step is to establish the order of integration between our variables. We used the ADF method to test for unit root and the order of integration. The order of integration represents the number of times that a variable is differenced before it becomes stationary (Gujarat and Porter, 2009). Table 4.19 below summarizes the unit root testing and order of integration for the variables used in the supply response equation. For the maize area and trend in technological advancement, the unit root test included an intercept, while for the rest of the variables, the unit root test was carried out without an intercept. All our variables are non-stationary at the level and became stationary on first differencing, except for the trend in technology, which is stationary at level. Hence, our variables are integrated of order one *I* (1). We cannot use our level variables in estimating our supply response function as this would lead to spurious regression.

Table 4.19: Unit root test for maize area harvested variables

Variables	ADF unit root test intercept	ADF unit root test no intercept
log MZAREA_t	-0.828	
Δ log MZAREA_t	-7.39***	
log RMZPRIC_t,		-0.55
Δ log RMZPRIC_t,		-5.81***
log RPTSPRIC_t		-1.66
Δ log RPTSPRIC_t		-4.97***
log INPTINDEX_t		-0.21
Δ log INPTINDEX_t		-5.94***
log RAINYS_t,		-0.46
Δ log RAINYS_t,		-4.96***
LNTREND_t	-14.06***	

Notes: *ADF critical values with intercept, ***1% -3.788 and **5% -3.012. Without intercept ***1% -2.72 and ** 5% -1.96. Δ represents first difference.

Since our variables are co-integrated of order one, the model was estimated via a two-step approach. The first step involved running the long-run equilibrium regression model represented by Equation (3.19), which is set out above. Using the ADF unit root test, stationarity in the error term is tested. If the null hypothesis is rejected, it implies that the error term is stationary; hence, there exists a long-run relationship. The second step consists of running the dynamic ECM, which provides us with the short-run dynamics. The variable used was the first difference of the variables, explained on Table 4.5 above, and the lagged residual term of Equation (3.19). The lagged residual term provides the speed of adjustment. The speed of adjustment represents how fast the disequilibrium in the previous period is corrected. The ECM for short-run dynamics was specified as follows

Δ $\mathrm{MZAREA_t} = \alpha\ \Delta\ \mathrm{RMZPRIC}_t - \beta\ \Delta\ \mathrm{RPTSPRIC}_t\ - \delta\Delta\ \mathrm{INPTINDEX_t} + \theta\ \Delta\ \mathrm{RAINYS_t} + \kappa\mathrm{LNTREND_t} - \mu_{\varepsilon_{t-1}} A = \pi r^2$ (3.32)

where Δ represents the first difference of our variables discussed on Table 4.5 and $\mu_{\varepsilon_{t-1}}$ represents the lagged residual error term of Equation (3.19). We ran the long-run model in Equation (3.19), using ADF, and we tested for stationarity in the error term (rejection of the null hypothesis for unit root). Table 4.6 above illustrates the results of the ADF unit root testing. The null hypothesis states there is a presence of unit root in the error term. The t-values, with and without intercept, were both greater than the critical value, as recommended by Engle and Granger (1987), of -4.49 at 5% significant level (Table 4.20 below). Hence, we reject the null hypothesis of presence of a unit root at the 5% significant level. This implies that the alternative hypothesis of stationarity in the error term holds, and we that have a long-run relationship between maize area harvested and the respective variables.

Table 4.20: ADF Unit root test to establish a long-run relationship or cointegration between area harvested and its respective variables (1995–2016)

	ADF unit root test – no intercept	**ADF unit root test – with intercept**
t-values of the residual error term (ε_t) of Equation (3.19)	-4.77	-4.55

The Engle and Granger (1987) critical values are -4.20, -4.49 and -5.09 for 10%, 5% and 1 % significant levels, respectively

The ECM results, with short- and long-run dynamics for area harvested on own and substitute prices, input index, rainfall, and technology trend from 1995 to 2016, are illustrated in Table 4.21 below. For ease of interpretation of elasticity, the variables were converted into logarithmic form. The results from both the long- and short-run dynamics appear with the expected signs. Regarding the short-run elasticities, the estimated model captures 61% of the variation in maize area harvested, as indicated by the adjusted R^2The F statistic is significant at 1% level, from which it is inferred that the estimated model, as a whole, was capable of capturing changes in maize area harvested in the short run. For the long-run supply, the estimated model captures 64% of the variation in maize area harvested, as indicated by the adjusted R^2. The F statistic is significant at 1% level, from which it is inferred that the estimated model, as a whole, was capable of capturing changes in maize area harvested in the long run.

In the short-run elasticities, only the rainfall variable is significant, at 10% level. If rainfall increases by 10%, the area harvested will increase by 2%. Kenyan maize production is mainly rain-fed, consequently, an increase in rainfall prior to a planting season will have a positive effect on the area harvested. The rainfall information captures both long and short rainfall periods and the maize planting seasons across the different regions. Both own and substitute prices are inelastic and insignificant in the short run. The adjustment parameter of the short-run model represented by $\mu_{\varepsilon_{t-1}}$ was significant at the 1% level. This implies that the disequilibrium in the previous year is corrected at the rate of 0.1%, which is a low speed of adjustment. Insignificant variables in the short run and a low level of adjustment parameter may be attributed to the nature of the agricultural production process. It is difficult to shift factors of production in the short run after farmers have already made their decisions. However, over a longer period of time, farmers may be able to shift factors of production to respond to factors such as prices.

For the long run, the supply response equations, both for own and substitute prices, have the expected sign and are significant at the 1% level. Own and substitute prices are inelastic, and a 10% increase in maize prices resulted in a 2% increase in area harvested, while a 10% increase in Irish potato prices resulted in a decline by 2.1% in area harvested, which are all significant at the 1% level. Although the rainfall, input index and trend in technological variables had the correct signs, they were not significant. The low supply response of farmers to pricing incentives supports those studies that have been carried out in Kenya and other developing countries that have attributed the low supply response to constraints in credit facilities, market information system, irrigation and infrastructure, and to the subsistence nature of maize farming and inconsistent agricultural policies (Alemu et al., 2003; Mose et al., 2007; Conte et al., 2014).

Table 4.21: Error correction model for the maize supply response

Variables		
Short-run elasticities	**Coefficient**	**Standard error**
Constant	-0.002	0.047
D($RMZPRIC_t$)	0.097	0.069
D($RPTSPRIC_t$)	-0.11	0.065
D($INPTINDEX_t$)	-0.042	0.106
D($RAINYS_t$)	0.22*	0.100
$LNTREND_t$	0.006	0.042
$\mu_{\varepsilon_{t-1}}$	-0.001***	0.000
Adjusted R^2	61	
F-statistics	6.44***	
Long-run supply response		
Constant	6.34**	0.97
$RMZPRIC_t$	0.22***	0.07
$RPTSPRIC_t$	-0.21***	0.06
$RAINYS_t$	0.14	0.14
$INPTINDEX_t$	-0.03	0.08
$LNTREND_t$	0.07	0.05
Adjusted R^2	64	
F-statistics	8.23***	

***P<0.01, **P<0.05,* P<0.1 denotes significance level

We carried out residual diagnostic tests on the ECM to ensure that it did not suffer from serial correlation or heteroscedasticity, and that the residual term was normally distributed. The LM test null hypothesis is accepted. The null hypothesis for normality test, using p-values of Jarques-Bera, is accepted and the Breusch-Pagan null hypothesis is accepted. This implies that we do not have a serial correlation, that the residual term is normally distributed, and that the residual term does not suffer from heteroscedasticity. The results from the CUSUM test indicated that the model was stable, as all the estimated equations were inside the critical bound region.

4.3.2.2 Maize yield

The maize yield equation is a function of the proportion of area planted with improved maize seed, the input costs index ((maize yield*price)/fertilizer costs), rainfall received, and technological development in the maize seed industry captured by time trend in technology. In

Kenya, 77 % of the households used hybrid maize seeds in maize production (Njagi et.al. 2014). The use of hybrid maize seed has always been accompanied by fertilizer application. Due to the high costs of fertilizer, the consistent use of hybrid seed and fertilizer has not always been the case. Gitau et al. (2012) reported that 41%, 33% and 26% of the households were consistent, inconsistent and non-consistent users of hybrid seed and fertilizer, respectively, in Kenya between 2000 and 2010. A summary of the estimated results of the maize yields is illustrated in Table 4.22 below.

For ease of interpretation of elasticity, variables were converted into logarithmic form. Overall, the model captures 53% of the variation in maize yields, as indicated by the adjusted R^2. The F statistic is significant at the 1% level, from which it is inferred that the estimated model, as a whole, was capable of capturing changes in maize yields. All the variables in the model had the expected signs. Improved maize seed, rainfall, and technological development were positively correlated with maize yields, while the input index was negatively correlated. Improved seed and rainfall had significant effects on maize yields at the 5% significant level. When the proportion of area planted under improved maize seed increases by 10%, the maize yield increased by 2.7%, while a 10% increase in rainfall resulted in a 2.9% increase in maize yields. The input index and technological development in maize seed, although reporting the expected sign, were not significant. The maize yield increase is inelastic, given that a 10% increase in both improved maize seed and rainfall resulted in a modest increase in maize yields. Over the past two decades (1996–2005 and 2006–2016), maize yields in Kenya have been almost constant, changing by a small margin of about 0.7% (ERA, 2015). Kenya’s maize yields of about 1.6 tons/ha are low, compared with other countries within the SSA region. For example, Ethiopia and South Africa produce over 3tons/ha, and Zambia and Uganda over 2.5 tons/ha, while Malawi produces over 2 tons/ha (Abate et al., 2015).

Table 4. 1: Estimated results for maize yields

Variables	Robust OLS	Elasticity
$IMPRVSEED_t$	0.0003**	0.27
	(0.0002)	
$RAINYS_t$	0.0004**	0.29
	(0.0002)	
$INPTINDEX_t$	-0.009	0.04
	(0.038)	
$LNTREND_t$	0.038	0.0231
	(0.047)	
Constant	0.66	
	(0.295)	
Adjusted R^2	53	
F-statistics	4.76***	

Robust standard errors in parenthesis, significance level ***P<0.01, **P<0.05, *P<0.1 respectively.

Domestic supply block

The beginning maize stock for every production year is the ending stock of the previous season. Hence, the lagged ending stock equates to the beginning stocks. The domestic maize produced was an identity computed by multiplying maize area harvested with yields. The total maize supply (domestic supply block) was an identity computed by adding beginning maize stocks to domestic maize produced, which was tallied with domestic maize supply in Kenya. Refer to Table B.2 in Annex B.

4.3.3 Domestic demand block

The domestic demand block had three single equations, consisting of per capita consumption, ending stocks and total domestic demand. The three single equations are discussed below.

4.3.3.1 Per capita consumption

Maize is the most important staple food in Kenya. It is consumed both as green and dry grain at the household level. The per capita consumption of maize in Kenya is the highest (103 kg per annum), compared with its neighbours (Abate et al., 2015). Urban and rural consumption studies have shown a declining importance of maize in the household food basket, with the increasing consumption of Irish potatoes, rice and plantains. Although the decline was witnessed across all the income groups, the highest decline was recorded among households in the highest income group. Hence, maize still plays an important role among poor rural and urban households (Kamau et al., 2011; Onyango et al., 2016). Per capita consumption is influenced by a household's income (real per capita GDP), own and substitute prices, a trend variable to capture changes in consumption behaviour of maize consumers over time, and a shift variable representing the period of high food prices experienced from 2008.

For ease of interpretation of elasticity, variables were converted into logarithmic form. The per capita consumption results are illustrated in Table 4.23 below. Overall, the model captures 74% of the variation in per capita consumption, as indicated by the adjusted R^2. The F statistic is significant at 1% level, from which it is inferred that the estimated model, as a whole, was capable of capturing changes in per capita consumption. All the variables reported the expected signs. Real per capita GDP, own and substitute prices, and the changes in consumption behaviour significantly affect per capita consumption. Increases in real GDP have a positive and significant increase in per capita consumption. As households' incomes increased, the per capita consumption increased, but at a slower rate as illustrated by the elasticity of 0.685. A 10% increase in real GDP resulted in a 6.8% increase in per capita consumption. High food prices imply that households have to adjust and buy less food, hence the decline in per capita consumption. A 10% increase in maize prices resulted in a 3.4% decline in per capita consumption. The decline is inelastic. The increase in the price of the substitute does result in an increase in per capita consumption of maize as the households switch over. The switch is inelastic, as a 10% increase in the price of the substitute will result in a 3.4% increase in per capita consumption. These results are consistent with the economic theory of staple food being highly inelastic with respect to income and prices. The shift variable, although insignificant, indicates that per capita consumption declined during the period of high food prices after 2008, as compared with the period before 2008.

Changes in economic and social structure, over time, affect consumption patterns and dietary preferences. The changes in households' consumption patterns and dietary preferences have been attributed to urbanization. It is reported that households have changed their consumption from coarse grain to wheat, dairy and animal protein (Jayne et al., 2009; Kamau et al., 2011; Onyango et al., 2016). From our results, the trend variable elasticity is -0.104, which implies that the per capita consumption of maize has been declining each year by 10%. In 2017, the Kenyan urban population constituted 27% of the total population. Over the past two decades, the annual Kenyan urban population growth rate has been 2.21% (World Bank, 2017). This may explain the decline in per capita consumption. The per capita maize consumption in Kenya demonstrated that it is unresponsive to rising high food prices and income, which concurs with other studies that showed that the consumption of food staples was highly price inelastic (Jayne et al., 2009).

Table 4.22: Estimated results for per-capita maize consumptions

Variables	Robust OLS	Elasticity
$RPCGDP_t$	191.184**	0.685
	(71.841)	
$RMZPRIC_t$	-0.0020***	0.351
	(0.0005)	
$RPTSPRIC_t$	0.001***	0.341
	(0.0003)	
$TRCONS_t$	-3.199***	0.104
	(0.993)	
SHIFT2009	-9.254	0.222
	(6.103)	
Constant	-35.27	
	(50.10)	
Adjusted R^2	74	
F-statistics	13.13***	

Robust standard errors in parenthesis ***P<0.01, **P<0.05, P<0.1

4.3.3.2 Ending stock

The ending stock is a function of maize production, prevailing wholesale maize prices, and the beginning stocks. Results of the ending stock equation are summarized in Table 4.24 below. For ease of interpretation of elasticity, variables were converted into logarithmic form. All the variables reported the expected signs. Overall, the model captures 58% of the variation in ending stocks, as indicated by the adjusted R^2. The F statistic is significant at the 1% level, from which it is inferred that the estimated model, as a whole, was capable of capturing changes in ending stocks.

Maize production and beginning stocks have a significant and positive effect on ending stocks at the 10% and 5% significant levels, respectively. Hence, an increase in maize production and the beginning stock will lead to an increase in ending stocks. The elasticities show an inelastic relationship between ending stock and beginning stock, as a 10% increase in beginning stock will result in a 1.5% increase in ending stock. Ending stocks were sensitive to maize production. An increase in 10% in maize production led to a 9.2% increase in ending stocks. Maize production during the season does affect the ending stock, as during years of bumper harvests, the ending stocks are high and the reverse is true during poor harvest seasons. David et al. (2016) have noted the important role played by stock levels on influencing price volatility in ESA.

Table 4.23: Estimated results for ending stocks

Variables	Robust OLS	Elasticity
$D(WMZPRIC_t)$	-0.0001	0.291
	(0.004)	
$D(MZPRDN_t)$	0.095*	0.924
	(0.053)	
$D(BEGSTOCK_t)$	0.436**	0.156
	(0.201)	
Constant	-77.08	
	(112.37)	
Adjusted R^2	58	
F-statistics	8.31***	

Robust standard errors in parenthesis ***P<0.01, **P<0.05, P<0.1

Domestic demand block

Maize consumed as food was computed by multiplying the per capita consumption by the population. Other than food consumption, maize is also utilized for other uses such as animal feed. Hence, to determine the total maize consumption in Kenya, food use, animal feed and other uses were summed up and added to the ending stocks to determine the total domestic demand block. See Table B.2 in Annex B.

4.3.4 Price linkage

Kenya is a net maize importer, and thus operates under the IPP trade regime. Maize to cover the deficits is mainly sourced from the region (Tanzania and Uganda), and occasionally from the world market during times of poor harvests. Consequently, domestic maize prices consist of import parity price, exchange rate, import taxes and transfer costs (transport and port clearance costs). The use of a price linkage, rather than relying on equilibrium price formation, provides a more realistic domestic price formation under the IPP trade regime (Meyer, 2006). The price linkage equation is a function of import parity prices, the ratio of consumption over production, and policy shift capturing the policies implemented to mitigate high food prices from 2008. To capture the two scenarios of imports from the region and the world market, we estimated two price linkage equations. The price linkage equation also gives information on price transmission to the domestic market (Conforti, 2001; Meyer, 2006). The results of the price linkage equation are illustrated in Table 4.25 below. For ease of interpretation of elasticity, variables were converted into logarithmic form.

Regarding the regional market, 71% of the variation in domestic prices is explained by the model, as indicated by the adjusted R^2. The F statistic is significant at the 1% level, from which it is inferred that the estimated model, as a whole, was capable of capturing changes in domestic prices. Regarding the world markets, 77% of the variation in domestic prices is explained by the model, as indicated by the adjusted R^2. The F statistic is significant at the 1% level, from which it is inferred that the estimated model, as a whole, was capable of capturing changes in domestic prices. Both models reported variables in the expected signs. In both equations, import parity prices are significant, at the 10% and 5% levels for the regional and world markets, respectively. Elasticities represent price transmission across the respective markets. A 10% increase in the regional price resulted in a 2.7% price transmission to the domestic market. When world prices increase by 10%, only 0.25% of these prices are transmitted to the domestic markets. There is low price transmission from the world to the domestic market, as compared with the regional markets. These results confirm earlier findings on market integration between the domestic and regional and world markets. The speed of adjustment from the regional to the domestic markets ranged between 3 and 9 months, while it ranged between 7 and 13 months from the world markets. This implies that transmissions from the regional to the domestic markets were better than from the world markets. Although policy shift is not significant, it indicates that prices were higher during Regime 2 than during Regime 1. The higher prices under Regime 2 are consistent with the heavy government intervention and soaring prices experienced under Regime 2.

These results are consistent with other studies that have found low price transmission from the world market to a domestic market. The reasons advanced for low price transmission include high transaction costs, policy that insulates domestic markets, countries being self-sufficient in the staple food, and active regional staple markets (Minot, 2014; Chapoto and Sitko,2014; Bryan, 2015; Gitau and Meyer, 2018).

Table 4.24: Estimated results for price linkage using regional and international prices

	Regional market		World market	
Variables	**Robust OLS**	**Elasticity**	**Robust OLS**	**Elasticity**
$IMPRIC_t$	0.07*	0.27	0.40**	0.025
	(0.27)		(0.191)	
$CONPDNR_t$	50.40	0.27	48.94	0.32
	(68.00)		(55.24)	
$SHIFT08_t$	136.911	0.50	93.22	0.53
	(27.05)		(29.25)	
Constant	120.21		91.518	
	(69.82)		(63.42)	
Adjusted R^2	71		77	
F-statistics	18.92***		24.76***	

Robust standard errors in parenthesis ***P<0.01, **P<0.05, P<0.1

4.3.5 Model closure

Kenya is a net importer of maize and so operates under the IPP trade regime. Consequently, we close the model as an identity on imports as follows:

$$IMPRT_t = TDOMCON_t + EXPRT_t + ENDSTOCK_t - BEGSTOCK_t - MZPRDN_t \qquad (3.33)$$

The market clearing identity is solved by means of a Gauss-Seidel iterative algorithm involving a step-wise iterative procedure to estimate a solution (Meyer, 2006).

4.3.6 Model performance

Models are used in forecasting and in policy analysis. Before we can use the models for these purposes, the models need to be evaluated and tested to ascertain the extent to which they mirror or replicate the current phenomena. Different approaches have been adopted to evaluate the models. These techniques use either graphical or statistical methods. Once researchers validate and establish that the model is adequate in tracking actual values, they are able to use the model for simulation analysis in the agricultural sector. In addition, the models may be used in answering the 'what if' questions that are of interest to policy makers. For this study, we adopted both graphical and statistical techniques to evaluate the estimated model's power of forecasting.

Graphical evaluation

For graphical evaluation, we used the dynamic approach for forecasting that takes the estimated value of the lagged dependent variable to forecast current value. The predicted and actual graphs for our estimated four equations are shown in Figure 4.6 below. The visual inspection of area harvested, maize yield and per capita consumption shows that these models performed well in capturing a turning point in the actual values. The predicted ending stock values missed capturing some actual turning points.

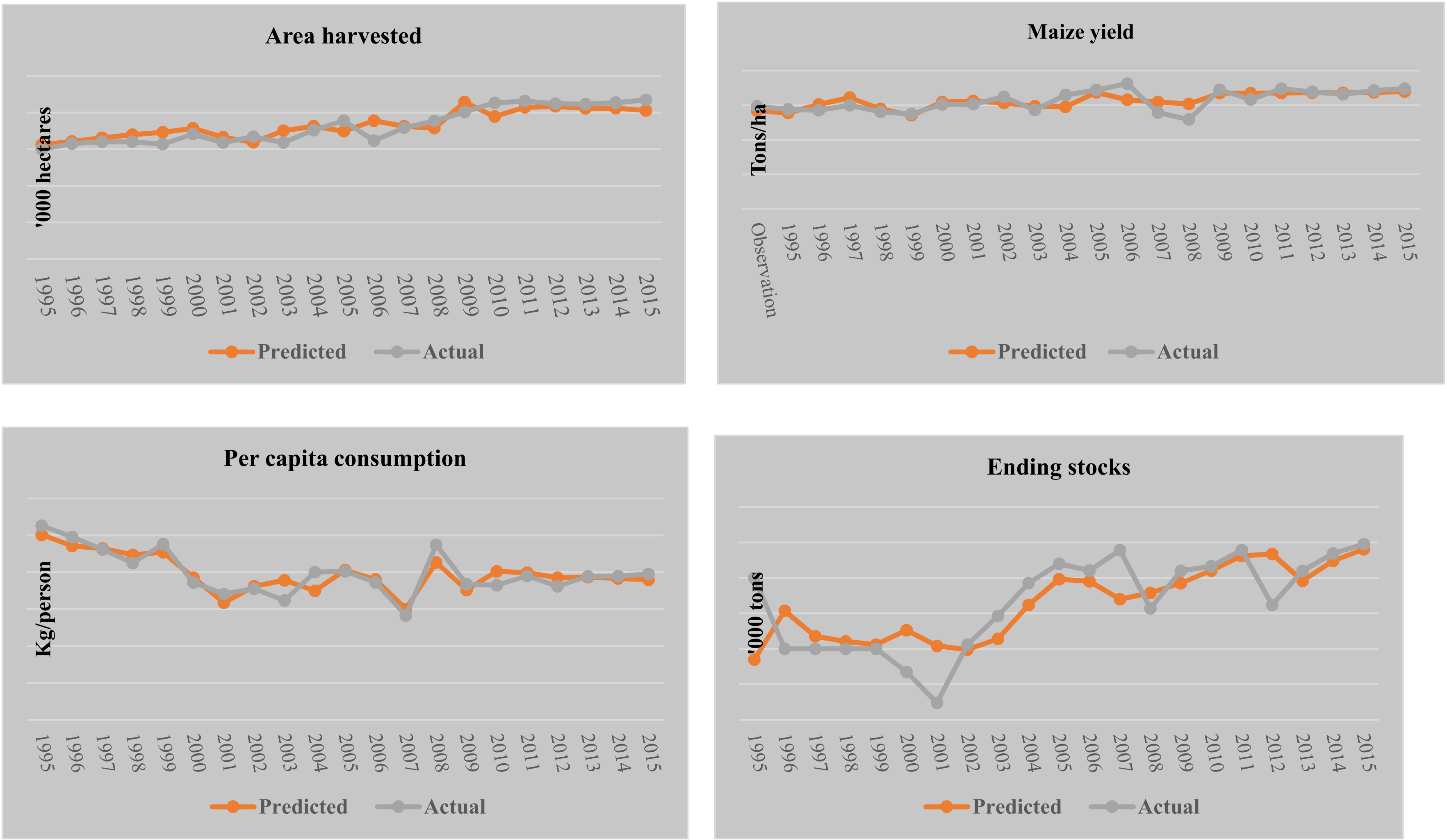

Figure 4.6: Actual versus predicted values of four estimated equations, 1995-2016

Statistical evaluation

Statistical evaluation is based on the forecasted error value. Error values are computed as the deviation of the forecast value from the actual value. Low error values imply that the forecasting abilities of the model are good. The values of MAE, RMSE, MAPE (%) and U for our variables are summarized in Table 4.26 below. RMSE and MAE are dependent on the scale of the variables, while MAPE and U are scale invariant. Therefore, MAPE and U are the variables used to determine the goodness of fit of the model in forecasting. The value of U is usually between 0 and 1. When U is approaching zero, it is an indication that the model is good for forecasting, and the reverse is true. All our variables have a U value that is approaching 0. This is a good indication that our model is good for forecasting. For MAPE, a value of less than 10% is a good sign that the model is good for forecasting. All our variables have a MAPE of less than 10%, except for ending stocks. The value for MAPE for ending stock is 29.2%, which result confirms the visual representation of ending stock.

The maize area, maize yield and per capita consumption have a value of U approaching 0 and MAPE of less than 10%; hence, the predictive power of these models is very good. The interaction of maize yield and area harvested contributes to maize supply in the economy, and when we introduce consumption, it will have an effect on stocks in the country. Since the predictive power of these three equation is good, the distortion brought about by ending stock will not be so large. Ending stocks are highly sensitive to maize production (refer to Table 4.26 below), for which the predictive power is good. Ending stocks are inelastic to beginning stock, and they constituted about 10% of the total domestic supply between 1995 and 2016. Simulation and projection will be distorted by the impact of ending stock; the impact may not be very large as to interfere with whole system.

Table 4.25: Statistical evaluation of the accuracy of stochastic variables

Variables	MAE	RSME	MAPE (%)	U
$MZAREA_t$	109.17	130.10	6.1	0.000
$MZYIELD_t$	0.08	0.10	5.1	0.041
$PCONS_t$	4.23	5.22	5.4	0.001
$ENDSTOCK_t$	64.62	87.10	29.2	0.001

4.3.7 Maize market outlook

The maize market outlook is crucial for providing information on the effects of shocks on the maize sector. These shocks may include weather, government policies, and technological advancement thus including details of these factors will aid in evidence-based policy interventions. Simulation analysis does provide for disaggregated impacts of the shocks on the maize sector, thus making it easier for targeted policy interventions. The partial equilibrium model considers the demand and supply block as endogenous variables, while exogenous variables include factors that influence these endogenous variables, such as macroeconomic factors, population, weather, technological advancements and policy interventions. The Kenyan government releases official statistics through KNBS every year in July. Statistics on area harvested, yields, production and consumption are based on details of the previous year. Hence, for our simulations, the first year of the outlook is 2018. The outlook period for this study is 2018–2026. The four single behavioural equations discussed earlier were used in the forecasting of our endogenous variables. Forecasts for exogenous variables were obtained from OECD, IMF, Global Insight and WB.

4.3.7.1 Assumptions for maize outlook

Key major world macroeconomic indicators mainly drive the simulation of the exogenous variable. These factors include the global energy price outlook, which is closely interlinked with domestic factors. Kenya is a net importer of inputs; hence, high transportation costs and weaker exchange rates have contributed to high input costs locally, despite the decline in global prices. The global outlook on commodity food prices is another key factor for consideration. There is evidence of a decline in commodity prices in the world during the period 2008–2016. During the same period, staple food prices have remained high in the ESA region (Minot, 2014; OECD-FAO, 2016). Another key factor is climate variability. This phenomenon has become prominent over the past two decades. The spatial variability effects across different regions have elevated the debate on the effects of climate change. Due to climate change, a decline in agricultural productivity has been noted in rain-fed production, with maize recording the highest decline of 22% and cassava recording the lowest decline of 8% (Schlenker and Lobell, 2010). In Kenya, agricultural production is rain-fed; hence, the effects of climate variables in Kenya are varied. Ochieng et al. (2016) noted that temperature had a negative impact on crop revenues, while rainfall had positive effects. The authors projected that climate change would adversely affect agriculture, with greater effects on the tea sector.

Based on the discussion above, we made the following assumptions on the baseline projections in Kenya. The first assumption was with respect to policy: no changes in current domestic and international policies. It is assumed that in the global context, all the countries will honour their bilateral and multilateral trade obligations and commitments. There will be free trade among countries and only relevant tariffs shall be imposed. Domestically, the number of market players and other structural and policy changes that affect agriculture are expected to remain the same. The second assumption was with respect to global macroeconomic indicators. The United Nations Population Council has projected that the world population is expected to increase by 10% between 2015 and 2024. In addition, the IMF projects that the global economy will expand by 3.2%. Domestically, steady population, economic growth rate and a continued liberalized exchange rate are expected. Thirdly, the assumption regarding climate variability is that no major climate variability is expected in the next decade, both domestically and in the world.

4.3.7.2 Macroeconomic outlook

A summary of the baseline and the projected macroeconomic indicators are illustrated in Table 4.27 below. The projection of the macroeconomic indicators is sourced from OECD, Global Insight, and IMF. The Kenyan population is expected to maintain its annual growth rate of about 3 % and to reach 59 million in 2026. The Kenyan GDP is expected to continue growing at an annual rate of 6.5% in the next decade, attaining 82.6 billion US$ in 2026 (2010=100). The per capita GDP is also expected to grow by 40% to reach 1,407 US$ per person per year in 2026. Inflation is expected to increase in the next decade

Table 4.26: Key macroeconomic variables for the baseline and projections 2017-2026

Variables	Units	2017	2018	2019	2020	2023	2024	2025	2026
GDP	%	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5
Per capita GDP	USD/person	1,000	1,038	1,079	1,121	1,258	1,308	1,359	1,407
CPI	2010=100	214.47	223	231	239	263	272	281	290
Population	millions	46	48	49	50	54	56	57	59

4.3.7.3 Maize outlook

The baseline and projected values for the area harvested and maize prices are summarized in Figure 4.7 below. The area under maize and maize production has been on the increase since the year 2008, and this peaked in 2012 with approximately 2.2 million hectares under maize and 3.8 million tons of maize being produced. There was a decline in the area under maize in subsequent years. More farmers shifted to the cultivation of potatoes, fruit and vegetables, which brought more income to the households, and resulted in reduced maize prices (ERA, 2010). Poor weather conditions, especially the less-than-average rainfall received in 2009, 2011 and 2016, meant greater amounts of maize had to be imported. The maize lethal necrosis disease (MLND) that affected most crops during the 2014/15 maize season contributed to the decline in the area under maize. These factors have contributed to a decline in maize productivity (ERA, 2013; ERA, 2015).

In the next decade, the area under maize is expected to decline by about 5%, to stand at about 2 million hectares in 2026. Maize demand and depreciation in the local currency will result in a 15% the increase in nominal maize prices. Factoring inflation, the real maize prices are expected to decline by 22%. Increase in population and the sub-division of land have put pressures on the amount of land available for cultivation. To increase maize production, Kenya will have to adapt crop intensification techniques through the dissemination of the already developed high yielding maize varieties and integrated crop farming management.

Figure 4.8 below summarizes the baseline and the projections of consumption, production and net trade for maize. Over the past decade, the demand for maize increased by 26% between 2006 and 2016. The increase in demand is attributable to the increase in the population. The increase in incomes during the same period resulted in greater consumption of animal protein and animal by-products, leading to an increase in animal feed of 41%. In Kenya, there is competition for maize utilization between food use and animal feed, as both use white maize (Njagi et al., 2013). Local maize production increased by 55% between 2009 and 2016. Despite the increase in production, the country still depends on imports to meet domestic demand. Imports have been sourced from the neighbouring countries (Tanzania and Uganda), which are consistent surplus producers, except during times of drought when Kenya country is obliged to import maize from the world market.

In the next decade, the demand for maize is expected to increase by 34%, to stand at 5.6 million tons in 2026. Human consumption of maize is the main demand driver. Maize consumption is slated to increase to 5.0 million tons in 2024, with animal feed only accounting for about 7% of total maize consumed. Since animal feed competes for the same white maize used for human consumption, we assume that the government will resort to importing yellow maize for animal feed to reduce the pressure from the feed sector on white maize. In the next decade, maize production is expected to decline by about 28%, and Kenya will continue being a net-importer of maize from its neighbours, who are expected to remain consistent producers.

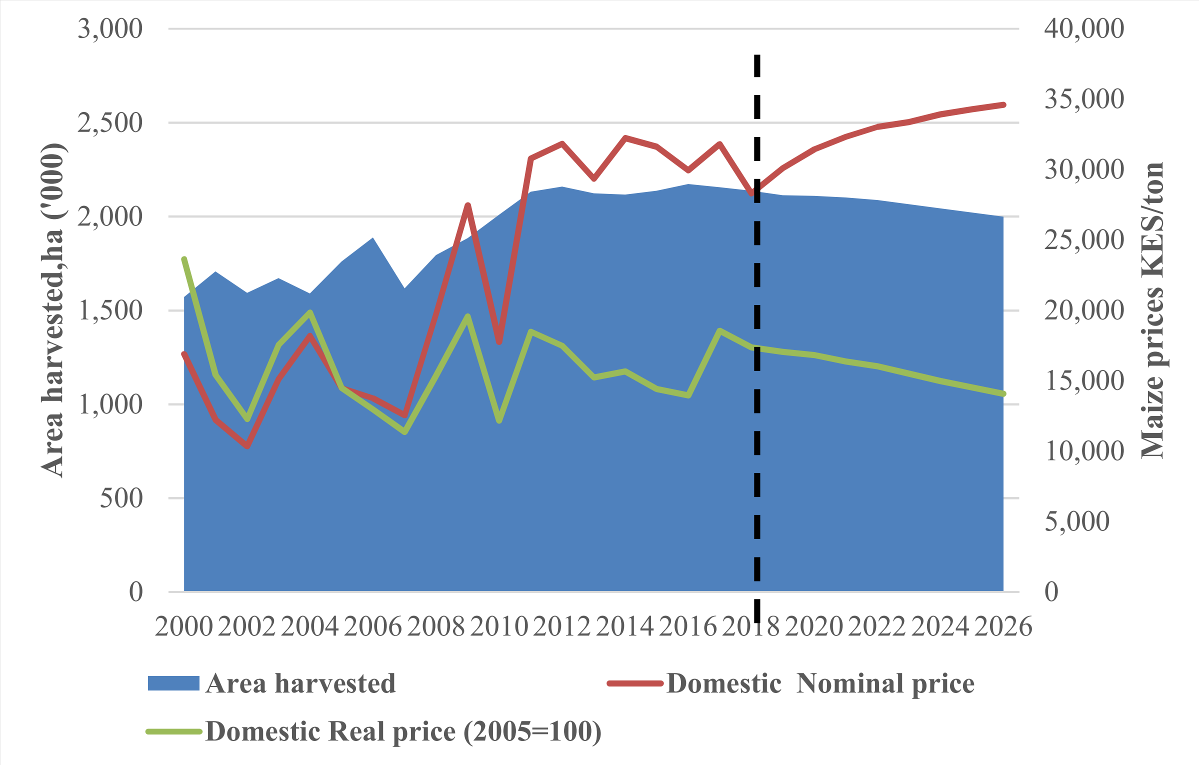

Figure 4.7: The baseline and projected area harvested, nominal and real prices for maize

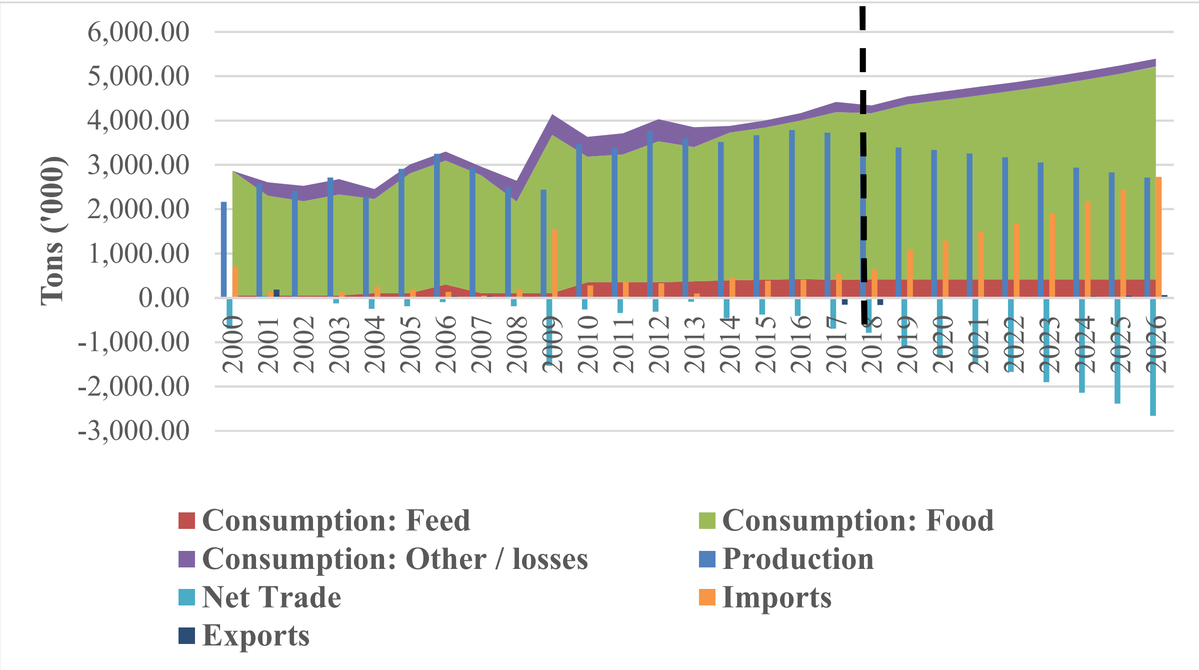

Figure 4.8: The baseline and projected consumption, production and net trade for maize

4.3.8 Simulation analysis and projection

The dynamic effects of different shocks in the partial equilibrium model of the maize sector in Kenya were analysed. Simulation analysis is important as it provides responses to "what if" questions. The set-up of the model allows for the disaggregated effects of different shocks to be introduced into the system. We simulated three exogenous shocks being introduced into the model and analysed their effects on supply, demand and prices of maize. The shocks introduced included weather, policy and technology. These shocks were informed by the historical and current situations within the maize sector. The baseline period represents the outlook for the period 2018–2026, while the scenario period represents the outlook period following the introduction of the shock. The difference between the scenario and the baseline period was reported.

Weather shocks

Maize production in Kenya is dependent on rainfall. Despite Kenya being a deficit maize producer, it has occasionally been self-sufficient during seasons of high rainfall. Consequently, weather plays a significant role in maize production. The debate on the effects of climate variability has continued to elicit mixed reactions, since the effects vary across different regions. The decline in productivity and production in the agricultural sector attributable to climate variability has been accepted by consensus among different studies (Schlenker and Lobell, 2010; Ochieng et al., 2016). To capture the effects of weather on the maize sector, we simulated two scenarios. In the first scenario, we envisioned a once-off 15% increase in rainfall in 2019. In the second scenario, we introduced a 15% decrease in rainfall. We compared the scenario results to the baseline.

Policy shocks

To simulate policy shocks, we considered two policies in the maize sector. The first policy considered was the maize import duty. As discussed earlier, Kenya imposes a duty of 50% on maize imported from outside the EAC and COMESA regions. During a poor harvest, the government turns to the world market to import maize. Consequently, the government either reduces or zero-rates the duty to allow for the importation of maize. For the import duty policy, we simulate two scenarios. The first scenario involves a once-off removal of the import duty in 2019. In the second scenario, we simulate a once-off removal of import duty and a 15% decrease in rainfall in 2019. The second scenario is similar to the period when Kenya imports maize from world markets. The second policy considered for simulation is the fertilizer subsidy programme. Between 2008 and 2016, the programme cost the government US$ 214 million. During the implementation of the programme, the availability of funds from the Treasury has been the biggest challenge. Over its implementation period, the funding has fluctuated (ERA, 2013; Opiyo et al., 2015; Makau et al., 2018). The government usually removes these kinds of programmes (i.e. subsidies) over a period of time. For the purpose of this study, we simulate a scenario where the Treasury does not have funds to allocate to the programme in 2019 due to limited finances, but the funding is then reinstated in 2020. We introduce a once-off shock in 2019. This provides a disaggregate effect of the fertilizer subsidy on the dynamics of supply, demand and price.

Technological shock

The third shock introduced into our model for simulation is the technological shock in the form of a high-yielding maize variety. The rationale behind the technological shock is to simulate the increase in yield attributable to adopting new technology (a higher-yielding maize variety). The driver of the shock is the adoption of new technology, introduced through an endogenous variable (yield). The weather and inputs remain the same. The Kenyan maize yield of 1.6 tons/ha is among the lowest in SSA when compared with countries such as Ethiopia, Uganda, Zambia and Malawi, which have yields above 2 tons/ha (Abate et al., 2015). Kenya is land constrained, hence intensification strategies are better suited to increased production, as opposed to opening up new land for cultivation (Jayne and Muyanga, 2012; Muyanga and Jayne, 2014). As noted by Abate et al. (2015), there are many hybrid maize seeds already commercially available to farmers that have a yield potential of between 3 and 8 tons/ha. We simulate the adoption of a hybrid maize seed that increases the current yield by 20% in 2019.

The impact of the three shocks, being weather, policy and technology, are analysed by comparing the scenario period with the baseline period in three steps. The first step enumerates the immediate and long-run responses of different endogenous variables in the model. The second step involves analysing the direction and proportion of the shift in endogenous variables, and finally, the impact of dynamic changes in the supply and demand on the maize prices are assessed.

4.3.8.1 Weather shocks

As discussed earlier, two scenarios were simulated. The first scenario was a once-off 15% increase in rainfall in 2019. The results of this scenario are presented in Table 4.28 below. This scenario simulates higher rainfall season in the country. From the analysis, the component most impacted upon by the increase in rainfall was imports, which declined by 35% in 2019. The decline continued in the subsequent years, at 5% and 2% in 2020 and 2021, respectively. Maize production increased by 6%. The increase in maize production was driven mainly by yields (4%), as opposed to area harvested (2%). The increase in maize production resulted in a 4% decline in maize prices, consequently increasing domestic use by 1%. The decline in maize prices and the increase in maize production led to a 5% increase in ending stocks. The impact of increased rainfall in 2019 resulted in some components taking longer for the disturbance to dissipate before the system returned to equilibrium. The area harvested, maize production and wholesale prices shocks dissipated in 2020, while the ending stocks shock persisted until 2021.

Maize production in Kenya is dependent on weather. Consequently, an increase in rainfall results in the decline in imports from the region. As discussed earlier, the country has occasionally been self-sufficient during the years of high rainfall. Decomposing the increase in maize production as a result of rainfall in 2019 indicates that the increase was mainly driven by maize yield, as opposed to area harvested. Domestic maize use is inelastic to maize prices, and this may explain the changes in domestic use as a result of the decline in prices.

Table 4.27: Impact of 15% increase in rainfall on the maize sector in 2019

Model variables	2019	2020	2021	2022	2023	2024	2025	2026
Area hvt				**Thousand hectares**				
Baseline	2,142	2,147	2,151	2,153	2,147	2,142	2,139	2,137
Scenario	2,179	2,158	2,155	2,155	2,148	2,142	2,139	2,137
absolute change	36	11	4	1	0	0	0	0
% change	**2%**	**1%**	**0%**	**0%**	**0%**	**0%**	**0%**	**0%**
Maize yields				**Tons/ha**				
Baseline	1.74	1.75	1.75	1.75	1.75	1.75	1.75	1.75
Scenario	1.81	1.75	1.75	1.75	1.75	1.75	1.75	1.75
absolute change	0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00
% change	**4%**	**0%**	**0%**	**0%**	**0%**	**0%**	**0%**	**0%**
Maize prodn				**Thousand hectares**				
Baseline	3,728	3,759	3,769	3,772	3,759	3,753	3,750	3,748
Scenario	3,951	3,784	3,778	3,774	3,760	3,753	3,750	3,748
absolute change	224	25	8	3	1	0	0	0
% change	**6%**	**1%**	**0%**	**0%**	**0%**	**0%**	**0%**	**0%**
Imports				**Thousand hectares**				
Baseline	418	496	610	693	819	964	1,096	1,241
Scenario	271	471	601	690	818	964	1,095	1,241
absolute change	-147	-25	-10	-3	-1	0	0	0
% change	**-35%**	**-5%**	**-2%**	**0%**	**0%**	**0%**	**0%**	**0%**
Domestic use				**Thousand hectares**				
Baseline	4,154	4,239	4,347	4,443	4,544	4,653	4,763	4,891
Scenario	4,201	4,250	4,352	4,445	4,544	4,654	4,763	4,891
absolute change	47	11	5	2	1	0	0	0
% change	**1%**	**0%**	**0%**	**0%**	**0%**	**0%**	**0%**	**0%**
Ending stocks				**Thousand hectares**				
Baseline	507	509	510	510	509	508	507	506
Scenario	530	520	515	513	510	508	507	506
absolute change	24	11	5	2	1	0	0	0
% change	**5%**	**2%**	**1%**	**0%**	**0%**	**0%**	**0%**	**0%**
Maize prices				**KES/ton**				
Baseline	18,971	19,424	19,964	20,537	21,136	21,783	22,437	23,190
Scenario	18,222	19,257	19,895	20,510	21,126	21,780	22,436	23,190
absolute change	-749	-168	-69	-27	-10	-4	-1	0
% change	**-4%**	**-1%**	**0%**	**0%**	**0%**	**0%**	**0%**	**0%**

The second scenario regarding weather shock simulated a 15% decrease in rainfall. This scenario simulates low rainfall (drought) in the country. The results of the once-off shock of a 15% decline in rainfall in 2019 are presented on Table 4.29 below. The results of the 15% decline in rainfall indicated that imports comprised the component mostly impacted upon by the decline. Imports increased by 33% in 2019. The disturbance persisted in the subsequent years through increases in imports by 5% and 2% in 2020 and 2021, respectively, before the system returned to equilibrium. There was a 6% decline in maize production. The decline was yield driven, as opposed to maize area harvested. The decline in maize production resulted in a 4% increase in maize prices, consequently reducing domestic use by 1%. The increase in maize prices and the decline in maize production led to a 5% decline in ending stocks. Other than imports, some components also took longer for the shock introduced in 2019 to dissipate before the system returned to equilibrium. The maize production and wholesale prices shocks dissipated in 2020, while the ending stocks shock persisted until 2021.

Table 4.28: Impact of 15% decline in rainfall on the maize sector in 2019

Model variables	2019	2020	2021	2022	2023	2024	2025	2026
Area hvts				**Thousand hectares**				
Baseline	2,142	2,147	2,151	2,153	2,147	2,142	2,139	2,137
Scenario	2,106	2,137	2,147	2,152	2,147	2,142	2,139	2,137
absolute change	-36	-10	-4	-1	0	0	0	0
% change	**-2%**	**0%**	**0%**	**0%**	**0%**	**0%**	**0%**	**0%**
Maize yields				**Tons/ha**				
Baseline	1.74	1.75	1.75	1.75	1.75	1.75	1.75	1.75
Scenario	1.67	1.75	1.75	1.75	1.75	1.75	1.75	1.75
absolute change	-0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00
% change	**-4%**	**0%**	**0%**	**0%**	**0%**	**0%**	**0%**	**0%**
Maize pdn				**Thousand hectares**				
Baseline	3,728	3,759	3,769	3,772	3,759	3,753	3,750	3,748
Scenario	3,509	3,735	3,761	3,769	3,759	3,753	3,750	3,748
absolute change	-218	-24	-8	-2	-1	0	0	0
% change	**-6%**	**-1%**	**0%**	**0%**	**0%**	**0%**	**0%**	**0%**
Imports				**Thousand hectares**				
Baseline	418	496	610	693	819	964	1,096	1,241
Scenario	558	520	619	696	820	964	1,096	1,241
absolute change	140	24	9	3	1	0	0	0
% change	**33%**	**5%**	**2%**	**0%**	**0%**	**0%**	**0%**	**0%**
Domestic use				**Thousand hectares**				
Baseline	4,154	4,239	4,347	4,443	4,544	4,653	4,763	4,891
Scenario	4,104	4,228	4,342	4,441	4,543	4,653	4,763	4,890
absolute change	-50	-11	-4	-2	-1	0	0	0
% change	**-1%**	**0%**	**0%**	**0%**	**0%**	**0%**	**0%**	**0%**
Ending stocks				**Thousand hectares**				
Baseline	507	509	510	510	509	508	507	506
Scenario	484	498	505	508	508	508	507	506
absolute change	-23	-11	-5	-2	-1	0	0	0
% change	**-5%**	**-2%**	**-1%**	**0%**	**0%**	**0%**	**0%**	**0%**
Maize prices				**KES/ton**				
Baseline	18,971	19,424	19,964	20,537	21,136	21,783	22,437	23,190
Scenario	19,764	19,590	20,031	20,563	21,146	21,787	22,438	23,190
absolute change	793	165	67	26	10	3	1	0
% change	**4%**	**1%**	**0%**	**0%**	**0%**	**0%**	**0%**	**0%**

4.3.8.2 Policy shocks

The 50% import duty on imported maize and the fertilizer subsidy programme were the two policies analysed under policy shock simulation. Two scenarios were envisioned regarding import duty policy, while we simulated one scenario regarding the fertilizer subsidy programme. Scenario one under the import duty on maize simulated a once-off removal of the 50% import duty in 2019. The results of this scenario are summarized in Table 4.30 below. The removal of the 50% import duty in 2019 has no impact on maize area harvested, yield and maize production. As expected, there was an increase in imports by 52%. The increase in imports led to a 7% decline in maize prices, resulting in a 2% increase in domestic use. The shock of the import duty removal in 2019 dissipates in 2020, when the system returns to equilibrium. Kenya is deficit maize producer and operates under the IPP trade regime. Consequently, domestic prices are a function of import parity prices, exchange rate, import taxes and transfer costs. With the removal of the import duty, the imported maize arrives in the domestic market at a lower price. This places downward pressure on local prices, resulting in a decline in maize prices.

Table 4.29: Removal of 50% import duty on maize in 2019

Model variables	2019	2020	2021	2022	2023	2024	2025	2026
Imports				**Thousand hectares**				
Baseline	418	496	610	693	819	964	1,096	1,241
Scenario	635	511	610	693	819	964	1,096	1,241
absolute change	217	15	0	0	0	0	0	0
% change	**52%**	**3%**	**0%**	**0%**	**0%**	**0%**	**0%**	**0%**
Domestic use				**Thousand hectares**				
Baseline	4,154	4,239	4,347	4,443	4,544	4,653	4,763	4,891
Scenario	4,235	4,234	4,344	4,441	4,543	4,653	4,763	4,890
absolute change	81	-5	-3	-1	-1	0	0	0
% change	**2%**	**0%**	**0%**	**0%**	**0%**	**0%**	**0%**	**0%**
Maize prices				**KES/ton**				
Baseline	18,971	19,424	19,964	20,537	21,136	21,783	22,437	23,190
Scenario	17,696	19,507	20,006	20,557	21,144	21,787	22,439	23,191
absolute change	-1,276	83	42	20	9	4	1	1
% change	**-7%**	**0%**	**0%**	**0%**	**0%**	**0%**	**0%**	**0%**

Kenya usually bridges its deficit through imports from the region (Tanzania and Uganda). During a poor harvest, the country turns to the world market for imports. In scenario two under import duty policy, we simulate a poor harvest (drought), with the consequence that the country has to import maize from the world market. Therefore, the Treasury either reduces or zero-rates the import duty. We simulate the removal of the 50% import duty and a 15% decline in rainfall in 2019. Table 4.31 below summarizes the results of the combined removal of the import duty and a 15% decline in rainfall. This scenario mostly affects imports, as they increase by 75%. There is a decline in maize production by 6%, and this decline is driven mostly by yield at 4%, compared with area harvested which declines by 2%. The decline in maize production results in a 2% increase in maize prices, which reduced domestic use by 1%. The combined effects of the decline in maize production and an increase in maize prices resulted in a 5% decline in ending stocks.

The shocks introduced by a 15% decline in rainfall and the removal of the 50% import duty in 2019 persisted in subsequent years before the system returned to equilibrium for some components. For area harvested, production and maize prices, the shocks dissipated in 2020 when the system returns to equilibrium, while for imports and ending stocks, the disturbance persisted until 2021 when the system returned to equilibrium. The importation of duty-free maize from the world market during the period of drought helps to cushion consumers against high food prices. As the imported maize places downward pressure on local prices, this minimizes the effects of high prices arising from a poor harvest.

Table 4.30: Removal of 50% import duty on maize and 15% decline in rainfall in 2019

Model variables	2019	2020	2021	2022	2023	2024	2025	2026
Area hvts				**Thousand hectares**				
Baseline	2,142	2,147	2,151	2,153	2,147	2,142	2,139	2,137
Scenario	2,106	2,127	2,143	2,151	2,147	2,142	2,139	2,137
absolute change	-36	-21	-8	-3	-1	0	0	0
% change	**-2%**	**-1%**	**0%**	**0%**	**0%**	**0%**	**0%**	**0%**
Maize yields				**Tons/ha**				
Baseline	1.74	1.75	1.75	1.75	1.75	1.75	1.75	1.75
Scenario	1.67	1.75	1.75	1.75	1.75	1.75	1.75	1.75
absolute change	-0.07	-0.01	0.00	0.00	0.00	0.00	0.00	0.00
% change	**-4%**	**0%**	**0%**	**0%**	**0%**	**0%**	**0%**	**0%**
Maize pdn				**Thousand hectares**				
Baseline	3,728	3,759	3,769	3,772	3,759	3,753	3,750	3,748
Scenario	3,509	3,712	3,752	3,766	3,758	3,752	3,750	3,748
absolute change	-218	-47	-17	-6	-2	-1	0	0
% change	**-6%**	**-1%**	**0%**	**0%**	**0%**	**0%**	**0%**	**0%**
Imports				**Thousand hectares**				
Baseline	418	496	610	693	819	964	1,096	1,241
Scenario	765	535	626	699	821	965	1,096	1,241
absolute change	347	39	16	6	2	1	0	0
% change	**75%**	**8%**	**3%**	**1%**	**0%**	**0%**	**0%**	**0%**
Domestic use				**Thousand hectares**				
Baseline	4,154	4,239	4,347	4,443	4,544	4,653	4,763	4,891
Scenario	4,112	4,223	4,340	4,440	4,542	4,653	4,763	4,890
absolute change	-42	-16	-7	-3	-1	-1	0	0
% change	**-1%**	**0%**	**0%**	**0%**	**0%**	**0%**	**0%**	**0%**
Ending stocks				**Thousand hectares**				
Baseline	507	509	510	510	509	508	507	506
Scenario	484	496	504	507	508	507	507	506
absolute change	-23	-13	-7	-3	-1	-1	0	0
% change	**-5%**	**-3%**	**-1%**	**-1%**	**0%**	**0%**	**0%**	**0%**
Maize prices				**KES/ton**				
Baseline	18,971	19,424	19,964	19,964	19,964	19,964	19,964	19,964
Scenario	19,351	19,618	19,981	19,974	19,973	19,971	19,965	19,965
absolute change	380	194	17	10	9	7	1	1
% change	**2%**	**1%**	**0%**	**0%**	**0%**	**0%**	**0%**	**0%**

The fertilizer subsidy policy was the second policy to be simulated. Taking into account the funds available for the programme, we simulated a scenario where the government does not allocate funds to MOALF to facilitate imports in 2019 due to limited available funding. The funding is then reinstated in 2020. The results of the scenario simulation are summarized in Table 4.32 below. The component affected the most under this scenario comprised imports, which increased by 87%. Without the fertilizer subsidy in 2019, maize production declined by 16%, with the decline being mainly driven by the area harvested, which declined by 12%, compared with yields that declined by 4%. The decline in maize production results in a 12% increase in maize prices, which reduced domestic use by 3%. The combined effects of the decline in maize production and the increase in maize prices resulted in a 12% decline in ending stocks.

The shocks of funding the subsidy in 2019 persisted in the subsequent years before the system returned to equilibrium for some components. For area harvested, production and maize price, the shocks dissipated in 2022 when the system returned to equilibrium. Imports and ending stocks disturbances persisted until 2023, while the yield shocks dissipated in 2021. With no fertilizer subsidy in 2019, the country imports 364,000 metric tons. Taking the price of 166 US$ as the price of a ton of maize, imports in 2019 will cost the government about US$ 60.4 million. The cost of the subsidy during the 2017/18 financial year was US$ 50.3 million (Makau et al., 2018). Assuming that the same amount is spent for the 2018/19 financial years and that no funds are allocated for the fertilizer subsidy in 2019, the government will save US$ 50.3 million and incur US$ 60.4 million in importing maize. The government will spend 20% more in 2019 to import maize than they would have spent on the subsidy programme. These results are not surprising as the subsidy programme only covers 20% of the total amount of fertilizer procured, with the remaining proportion being provided by the private sector (Opiyo et al., 2015; Makau et al., 2018).

Table 4.31: Subsidy fertilizer not provided in 2019 due to lack of funding

Model variables	2019	2020	2021	2022	2023	2024	2025	2026
Area hvts				**Thousand hectares**				
Baseline	2,142	2,147	2,151	2,153	2,147	2,142	2,139	2,137
Scenario	1,879	2,044	2,112	2,139	2,143	2,141	2,139	2,137
absolute change	-264	-104	-39	-14	-5	-2	0	0
% change	**-12%**	**-5%**	**-2%**	**-1%**	**0%**	**0%**	**0%**	**0%**
Maize yields				**Tons/ha**				
Baseline	1.74	1.75	1.75	1.75	1.75	1.75	1.75	1.75
Scenario	1.67	1.72	1.74	1.75	1.75	1.75	1.75	1.75
absolute change	-0.07	-0.03	-0.01	0.00	0.00	0.00	0.00	0.00
% change	**-4%**	**-2%**	**-1%**	**0%**	**0%**	**0%**	**0%**	**0%**
Maize pdn				**Thousand hectares**				
Baseline	3,728	3,759	3,769	3,772	3,759	3,753	3,750	3,748
Scenario	3,143	3,523	3,680	3,739	3,748	3,749	3,749	3,747
absolute change	-585	-236	-90	-32	-11	-3	-1	0
% change	**-16%**	**-6%**	**-2%**	**-1%**	**0%**	**0%**	**0%**	**0%**
Imports				**Thousand hectares**				
Baseline	418	496	610	693	819	964	1,096	1,241
Scenario	782	667	684	723	831	968	1,097	1,241
absolute change	364	171	74	30	11	4	1	0
% change	**87%**	**35%**	**12%**	**4%**	**1%**	**0%**	**0%**	**0%**
Domestic use				**Thousand hectares**				
Baseline	4,154	4,239	4,347	4,443	4,544	4,653	4,763	4,891
Scenario	4,009	4,168	4,314	4,428	4,537	4,651	4,762	4,890
absolute change	-144	-71	-33	-15	-6	-3	-1	0
% change	**-3%**	**-2%**	**-1%**	**0%**	**0%**	**0%**	**0%**	**0%**
Ending stocks				**Thousand hectares**				
Baseline	507	509	510	510	509	508	507	506
Scenario	445	462	484	497	503	505	506	506
absolute change	-62	-47	-27	-13	-6	-3	-1	0
% change	**-12%**	**-9%**	**-5%**	**-3%**	**-1%**	**0%**	**0%**	**0%**
Maize prices				**KES/ton**				
Baseline	18,971	19,424	19,964	20,537	21,136	21,783	22,437	23,190
Scenario	21,255	20,522	20,461	20,751	21,225	21,819	22,451	23,195
absolute change	2,284	1,097	497	214	89	35	13	5
% change	**12%**	**6%**	**2%**	**1%**	**0%**	**0%**	**0%**	**0%**

4.3.8.3 Technological shift

The final shock simulated is the technological shift. This shock was represented by the adoption of high-yielding maize seed in 2019. The country's maize yield is among the lowest in the SSA region, despite the commercial availability of high-yielding seed varieties with the potential of producing 3–8 tons/ha (Abate et al., 2015). The rationale behind the technological shock is to simulate a 20% yield increase attributable to farmers adopting higher-yielding maize seed in 2019. The simulation of the 20% yield increase is summarized in Table 4.33 below. The component affected the most under this scenario comprised imports, which declined by 70%, while the area harvested was not affected. A 20% increase in yield in 2019 resulted in a 20% increase in maize production. The increase in maize production results in a 12% decline in maize prices, which increased domestic use by 3%. The combined effects of the increase in maize production and a decline in maize prices resulted in a 16% increase in ending stocks. The system returns to equilibrium in 2020 for ending stocks and maize prices.

From the simulation, the adoption of high-yielding maize variety will increase production and reduce maize imports. The inelastic demand for staple food implies a difficulty for expanding and sustaining crop production. When local markets are not able to absorb surplus production, this results in swift price drops. These price drops are key factors in the subsequent 'dis-adoption' of improved technology (Vitale and Sanders, 2005). Several measures may be adopted to deal with glut seasons to mitigate the effects of price swings, such as government purchases for SGR, exports, and the warehousing receipt system.

Table 4.32: A 20% increase in yield attributable to adopting high-yielding seed in 2019

Model variables	2019	2020	2021	2022	2023	2024	2025	2026
Maize yields				**Tons/ha**				
Baseline	1.74	1.75	1.75	1.75	1.75	1.75	1.75	1.75
Scenario	2.09	1.75	1.75	1.75	1.75	1.75	1.75	1.75
absolute change	0.35	0.00	0.00	0.00	0.00	0.00	0.00	0.00
% change	**20%**	**0%**	**0%**	**0%**	**0%**	**0%**	**0%**	**0%**
Maize pdn				**Thousand hectares**				
Baseline	3,728	3,759	3,769.3	3,772	3,759	3,753	3,750	3,748
Scenario	4,484	3,759	3,769.3	3,772	3,760	3,753	3,750	3,748
absolute change	756	0	0	0	0	0	0	0
% change	**20%**	**0%**	**0%**	**0%**	**0%**	**0%**	**0%**	**0%**
Imports				**Thousand hectares**				
Baseline	418	496	610	693	819	964	1,096	1,241
Scenario	125	495	609	693	819	964	1,095	1,241
absolute change	-293	-1	-1	0	0	0	0	0
% change	**-70%**	**0%**	**0%**	**0%**	**0%**	**0%**	**0%**	**0%**
Domestic use				**Thousand hectares**				
Baseline	4,154	4,239	4,347	4,443	4,544	4,653	4,763	4,891
Scenario	4,258	4,260	4,349	4,444	4,544	4,653	4,763	4,891
absolute change	104	21	2	1	0	0	0	0
% change	**3%**	**0%**	**0%**	**0%**	**0%**	**0%**	**0%**	**0%**
Ending stocks				**Thousand hectares**				
Baseline	506.55	508.92	510.18	510.47	509.29	507.83	506.89	506.13
Scenario	588	512	512	511	510	508	507	506
absolute change	81	3	2	1	0	0	0	0
% change	**16%**	**1%**	**0%**	**0%**	**0%**	**0%**	**0%**	**0%**
Maize prices				**KES/ton**				
Baseline	18,971	19,424	19,964	20,537	21,136	21,783	22,437	23,190
Scenario	16,695	19,230	19,933	20,524	21,130	21,781	22,436	23,190
absolute change	-2,277	-194	-31	-13	-6	-2	-1	0
% change	**-12%**	**-1%**	**0%**	**0%**	**0%**	**0%**	**0%**	**0%**

4.4 SUMMARY

This chapter combines spatial market integration and modelling of the maize markets in a Kenyan framework to investigate the causes of high food prices. Stand-alone spatial market integration studies have been criticised for overlooking local dynamics in demand and supply, which play a significant role in domestic price formation. This study addresses this criticism by adopting a framework that combines these two approaches, thereby providing a holistic approach for addressing the high food prices in Kenya. For spatial market integration, we investigated three market clusters to determine the extent and level of integration. In addition, we investigated the effects of policy on market integration.

The first market cluster investigated was for domestic market integration. All our surplus and deficit markets were integrated in the order of one. When transaction costs were assumed to be constant, the model under-estimated the threshold parameters, thus reporting a lower speed of adjustment and higher half-life. Overall, the farther away the markets were from each other, the higher the transaction threshold cost was. Markets closer to each had a higher speed of adjustment and lower half-life, compared with markets that were farther apart. This implies that markets that are closer to each other were better integrated than the markets farther apart were. Eldoret and its respective pairwise cluster reported lower threshold costs and a higher speed of adjustment compared to Kitale and its respective pairwise cluster. The milling capacity of Eldoret town, the presence of large- and medium-scale maize traders, and its role as a major assembly point for maize are the reasons attributed for these results. Regarding the effects of policies, markets were not integrated under Regime 2, attesting to the effects of heavy government interventions. Policies implemented to mitigate high food prices resulted in market distortion, thereby blocking price transmission between surplus and deficit markets under Regime 2.

The second market cluster investigated comprised domestic and regional markets. There was a long-run relationship between the domestic and regional markets. We observed a faster elimination of shocks in the domestic markets that emanated from the Ugandan markets, as compared with shocks emanating from the Tanzanian markets. This implies a better integration of the domestic markets with the Ugandan markets than with the Tanzanian markets. Regarding the effect of policy on domestic and regional markets, shocks were eliminated relatively slower under Regime 2 than under Regime 1. This implies that markets were less integrated under Regime 2 than under Regime 1 due to the heavy government interventions that block price transmission under Regime 2.

The third market cluster investigated comprised the domestic and world markets. Long-run relationships existed between the domestic and the world markets, with the exception of the South African market. Shocks emanating from the world market took relatively longer to eliminate, when compared with shocks from the regional market. This implies that the domestic and world markets are less integrated than the domestic market is with the regional markets. Regarding the policy effects, under Regime 1, there was no long-run relationship between the domestic and world markets, except for Argentina and the USA, while under Regime 2, all the domestic and world markets had a long-run relationship. This implies that the heavy policy intervention under Regime 2 did not block price transmissions. The shorter span of data used to analyse Regime 1 and the role of information flow under Regime 2 may explain our results.

Regarding the modelling of the maize markets in Kenya, we estimated five single equations, with two being estimated under the supply block (supply response and maize yield), two being estimated under the demand block (per capita and ending stock), and one under the price block (price linkage). The supply response equation reported that both own price and substitute prices were inelastic and significantly influenced supply response. The proportion of the area under improved maize seed and rainfall had a significant and inelastic effect on the maize yield. Regarding the demand block, household income, own price and substitute prices, and the changing consumption pattern of the households significantly affected per capita consumption. The effects of income and prices on per capita consumption were inelastic. Maize production and beginning stocks had a significant effect on the ending stocks. Ending stocks were sensitive to maize production, but had an inelastic effect on the beginning stocks.

The results of both the graphical and statistical evaluations of our five models indicated that they could be used for projection and simulations. The three exogenous variables used for simulations were weather, policy and technological shifts. Regarding the weather, the increase in rainfall resulted in reduced imports, increased production, a decline in maize prices, and an increase in domestic use. The reverse was true when the rainfall declined. Regarding policy simulation, the removal of the import duty helps in cushioning consumers against high food prices attributable to poor harvests. The fertilizer subsidy has a positive effect on maize production, and the government would incur costs of importation that are 20% higher than the costs of the programme, if the programme were to be suspended. Adopting a high-yielding seed variety will result in a reduction of imports and a decline in maize prices, resulting in an increase in domestic consumption.

CHAPTER 5: SUMMARY, CONCLUSION AND POLICY RECOMMENDATIONS

5.1 SUMMARY AND CONCLUSION

Food prices in Kenya have been on an upward trend from 2009, and this trend has persisted despite the stabilization and subsequent decline in world food prices. This is surprising, as theoretically, the decline in world food prices ought to have been transmitted to the domestic market, thereby resulting in lower food prices. To mitigate the effects of high and volatile food prices, the government has implemented various marketing and trade policies that are aimed at stabilizing food prices in Kenya. To understand the causes of high food prices in Kenya, we need to discern the possible market-related causes for high food prices. There are two market-related causes of high food prices. The first is with respect to the transmission of price shocks from the world to the domestic markets, while domestic supply and demand dynamics comprise the second market-related causes of high food prices.

Well-functioning markets ensure that prices are efficiently transmitted and act as the most efficient allocator of resources, especially in circumstances of scarcity. The goal of this study was to examine whether the Kenyan markets were functioning well. In addition, the study examined the effects of government policy interventions on the stability of food prices. To understand the market-related causes of high food prices as mentioned above, it was necessary to develop a theoretical framework that combined price transmission and local demand dynamics approaches. For this study, we combined spatial market integration and a single commodity partial equilibrium modelling of the maize markets in Kenya. Adopting a framework that combines both approaches addressed the main goal of this study in three ways. Firstly, we addressed the criticism levelled against stand-alone spatial market integration of excluding local dynamics in demand and supply. Secondly, the combined approach provided information on changes in local demand and supply dynamics following various shocks. Finally, it provided a holistic approach for addressing the causes of persistent high food prices in Kenya. Using a holistic approach to investigate the persistent high food prices in Kenya will lead to the formulation of sound policies, aimed at stabilizing food prices.

Price transmission measures how well markets are integrated across space. In the literature, the low extent and level of spatial market integration has been identified as the main cause of persistent high food prices. Spatial price analysis studies have been applied in literature to analyse the extent and level of market integration,. To address the persistent high food prices in Kenya, the following three objectives were investigated: (1) to examine the degree and extent of spatial market integration across the domestic, regional and world markets; (2) to examine the effects of government policy interventions on spatial market integration across domestic, regional and world markets; and (3) to examine the effects of shifts in domestic commodity supply and demand dynamics on maize price formation. We selected maize, which is the main staple food in Kenya.

Kenya is a net importer of maize. The maize needed to bridge the deficit is mainly sourced from the regional markets (Tanzania and Uganda) and occasionally from the world market during poor harvest seasons. In pursuance of the first objective, an extended-TAR approach was used to investigate the extent and level of domestic spatial market integration in the presence of varying transaction costs across the surplus and deficit markets. The results indicated that out of all 14 market pairs, 13 were integrated. Market pairs that were farther apart displayed higher transaction costs thresholds and were less integrated than the market pairs that were closer to each other. Higher transaction costs hindered arbitrage, leading to the low market integration between the surplus and deficit markets. Eldoret and its respective pairwise cluster had a higher speed of adjustment and low half-life than Kitale and its respective pairwise cluster did. Factors that might have contributed to this result is the milling capacity of Eldoret, its role as the main assembly point for maize, and the presence of large- and medium-scale maize traders.

All our domestic and regional markets were cointegrated and had a long-run relationship with each other. A comparison of the market integration between the domestic markets with the market integration between the domestic and regional markets indicated that the domestic markets were better integrated than the domestic and regional markets, as shocks took a shorter time to dissipate within the domestic markets, as compared with the domestic and regional markets. A domestic market pair that had at least one Tanzanian market was less integrated than a domestic market pair with one Ugandan market was. All our domestic and world markets were cointegrated and had a long-run relationship. The domestic markets were less integrated with the world markets than with the regional markets, as the shocks from the world markets took longer to eliminate when compared with shocks emanating from the regional markets.

Our second objective examined the effects of policy implemented by the government across the domestic, regional and world markets. To investigate the effects of policy on the domestic market, a policy regime-dependent extended-TAR model approach was used. The results indicated that the surplus markets were integrated with the deficit markets under the regime with minimal or no policy intervention, and were not integrated during the regime of heavy government policy interventions. We used a VECM policy regime-dependent approach to complement the extended-TAR approach. The results indicated that the markets were less integrated during the regime of heavy government interventions, as shocks took a long time to dissipate, as compared with the minimal policy intervention regime.

Domestic and regional markets were less integrated during the regime of heavy policy interventions, as shocks took a longer period to dissipate when compared with the period of minimal policy interventions. The results from the domestic and world markets indicated the opposite, where the two markets had a long-run relationship and were integrated under the heavy policy intervention, while a few markets did not have a long-run relationship under the regime with minimal policy intervention. These results were surprising. Policy interventions insulate the domestic market from price transmission shocks that emanate from the world markets. Consequently, during heavy policy interventions, the domestic and the world markets should not be integrated or have a long-run relationship. Kenya mainly depends on the neighbouring region for its maize, and resorts to importing from the world market during times of poor harvest. The maize outlook reports prepared by MOALF and other stakeholders provide information on expected harvests, current stocks, and anticipated imports required to bridge the deficit. This information is available to traders and other stakeholders in the sector. The information flow among traders might contribute to spatial market integration in the absence of physical trade.

The third objective entailed examining the effects of the shift in local demand and supply dynamics. We used a single commodity, partial equilibrium model approach that incorporated eight equations. We estimated five behavioural equations, of which three were identity. The approach used for the estimation of the five behavioural equations was a combination of OLS and ECM. We used the ECM approach where the variables were non-stationary and cointegrated, while OLS was applied on stationary variables. The maize area harvested variables were non-stationary; hence, we used ECM, while OLS was used on maize yields, per capita consumption, ending stock, and price linkage behavioural equations. The decision as to what area to plant to maize is less influenced by price incentives (own and substitute). Maize is highly inelastic with respect to changes in price and income. The simulation analysis results indicated that rainfall and technology play a significant role in maize production in Kenya. The country, being a net importer of maize, reduces imports when rainfall increases and there is a consequent decline in prices. Adopting a new high-yielding maize seed variety indicated a larger impact on the decline in imports and maize prices. The removal of the import tariff during times of poor harvest would help to shield consumers from higher prices, as the price is lower when compared to simulating drought periods only. The removal of the fertilizer subsidy would be detrimental to maize production, with imports and maize prices being increased by a higher margin, which would result in the government incurring costs in importing food that are 20% higher than the costs of the subsidy programme.

The persistent high food prices in Kenya may be attributed to market-related causes and the dynamics in local demand and supply shifts. The perception held by the government that the market was not functioning well, resulting in high food prices, is supported by our results. Market pairs farther apart had higher transaction costs and were less integrated than market pairs that were closer to each other did. Transaction costs were inhibiting arbitrage between markets. One of the factors contributing to high transaction costs is the poor state of the roads in Kenya. Although a breakdown of transport costs was beyond the scope of this study, studies that have been done in Kenya have linked high transport costs to the poor states of the roads.

The importance of the regional markets in addressing high food prices cannot be overstated. Kenya depends on the regional markets to bridge its maize deficit. Our results indicated that the domestic and regional markets were less integrated than the domestic markets were. In addition, the market pair with at least one Tanzanian market was less integrated than the market pair with at least one Ugandan market. Deepening the regional trade, allowing for free trade by removing non-tariff barriers, and addressing the challenges facing the markets, collectively, would result in better regional market integration, thus triggering lower food prices.

Although the government's perception that the markets were not working well may have been correct, our results indicated that the government's interventions to stabilize food prices not only failed to do so, but also further exacerbated the situation by causing the low extent and degree of market integration. Regarding the local dynamics in demand and supply, the factors of weather and technology shift had a significant effect on maize production, as opposed to price incentives, as indicated by the decline in imports and maize prices. The fertilizer subsidy programme has assisted in reducing imports and lowering maize, while the removal or zero-rating of import duty cushions consumers against higher maize prices during poor harvest seasons.

5.2 POLICY RECOMMENDATIONS

The policy implications that arise from our study are set out below.

Creating a conducive policy environment in the grain sector: The heavy government intervention intended to stabilize food prices in the liberalized Kenyan economy not only failed, but also resulted in distortions across the domestic and regional markets, as markets then became less integrated. The government should create a conducive policy environment where its roles in the grain sector include performing regulatory functions and facilitating the markets to operate optimally. In instances where the government has to intervene in the market, the interventions should be carried out in a transparent manner. The involvement of stakeholders in the grain sector by the government would cultivate trust and reduce the uncertainty in the grain sector, as opposed to discretionary, sudden and inconsistent interventions by government. The proper implementation of policies determines the success of those policies in achieving their intended goals. For example, the price stabilization policy implemented by the NCPB should strictly adhere to the purchasing of maize at prevailing market prices, without succumbing to pressure from politicians and large-scale producers.

Regional trade: The results of this study indicated that the domestic and regional markets are less integrated than the domestic markets are. In addition, the Tanzanian market is less integrated with the domestic markets than the Ugandan market is. Regional trade may help in stabilizing food prices and addressing food security in the region. The harmonization of policies that affect regional trade and that address common challenges, such as those that contribute to the high transaction costs within and across the borders, would improve market integration. Improved regional trade would result in welfare gains for producers and the consumers across the region.

Reduction in input costs: The simulation analysis indicated the importance of the fertilizer subsidy in reducing imports and reducing maize prices. The costs of importing food are higher than the costs of implementing the subsidy programme are. The government should pursue long-term measures that are aimed at reducing input costs. The government should fast-track the construction of the fertilizer-blending factory that is being set up in Uasin Gishu County, and increase its capacity in the future, which is a long-term approach for addressing input costs.

Revisit the GMO foodstuffs ban: Import parity prices, as shown by our simulation analysis, have an impact on cushioning consumers against high food prices during poor harvest seasons. With the import ban of GMOs in effect, during a poor harvest season, Kenya will be forced to import from non-GMO producing countries, and the imports will come at premium prices. Hence, the urban and rural consumers will be exposed to higher maize prices, as the country will have to forego cheaper GMO maize because of the import ban.

Removal of the import tariff: Kenya has imposed a 50% duty on imported maize coming from outside the EAC and COMESA regions. The simulation analysis showed that the removal of import tariffs would benefit consumers through lower food prices. The government should remove the import duty on maize, which will benefit the consumers through lower prices for maize that will come from either the world or regional markets, depending on arbitrage conditions.

5.3 LIMITATIONS OF THE STUDY AND AREA OF FUTURE RESEARCH

Due to the complexities of agricultural markets, the methodological approaches developed for price transmission and market integration may have a few limitations. Market operations determine market responses. The frequency of data compilation (weekly, monthly, quarterly, yearly, etc.) may not reflect market operations due to data aggregation. The effects of aggregation on price transmission have been documented in the literature. The use of the market pair derived from two markets is a common approach. In instances where more than two markets are interlinked, the use of pairwise market prices will result in misspecification. The over-reliance on price data for analysis due to the lack of time series data on trade flows and transaction costs continues to be a limiting factor, to date.

The trade-off in the PEM methodology is its approach to the in-depth analysis of a sector. The whole economy is interlinked where the different sectors feed into each other to contribute to the whole economy. The focus on a sector and treating the other sectors as exogenous may miss the nuances of competing factors in other sectors.

High transactions costs inhibit arbitrage, leading to low market integration. The framework used for this study was able to establish transaction costs between markets and their contributions to marketing integration. Attributing the proportion of transaction costs due to the poor road or marketing costs. Besides being beyond the scope of this study, the framework used would not be able to capture specific effects of poor roads on market integration.

Regional markets play an important role in achieving food security and in the operation of domestic markets. Due to the porous nature of Kenya's borders, many quantities of maize cross into Kenya from Uganda and Tanzania through informal border crossings. Such maize is not officially documented; therefore, it is difficult to establish the effect that the informal maize trade has on the domestic markets.

Areas for further research include:

- The role of poor roads in price transmission

- the role of informal trade in the domestic and regional markets
- The role of the MIS platform in price transmission across markets
- Further studies should be carried out on market integration by using newer data. In addition, newly developed sophisticated approaches should be used to analyse the works done earlier. This would give an in-depth understanding of the complex nature of the markets.

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ANNEXES

ANNEX A

Table A.1: Various MIS platforms available in Kenya and services provided

Platform	Type/form of platforms	Services provided
Food and Marketing Information System (FAMIS)	Web-based trade platform for the COMESA region	Various commodity prices, production data, the list of major transporters, allows for placing of orders for sale and purchases,
Regional Agricultural Trade Intelligence Network (RATIN)	Web-based and short message service (SMS), online subscription for East Africa region	Provide early warning market and trade information, regional food balance and trade flows, monthly price information for major staples, warehouse mapping, news and bulletin such as weather, government policy,
Kenya Agricultural Commodity Exchange (KACE)	Commodity exchange platform, SMS, interactive voice response, online subscription, market information centres, daily radio bulletins and a live radio auction	Link buyer and seller, facilitate exchange between buyers and seller, provided up-to-date daily market prices, equip farmers/traders with business and technical skills
ESOKO	Web-based, SMS and mobile application	Provide up-to-date daily market prices, allows placing of orders of sale and purchases ,weather reports
M-FARM	Web-based, SMS, mobile application	Link up buyers and seller , facilitates group buying and selling , provide up-to-date daily market prices, monthly price analysis
M-Shamba	Web-based, SMS , mobile application	Link buyers and seller , link to various transport agencies, provide comprehensive farm management to farmers

Source: Author's compilation

Table A.2: Percentage composition of the different road categories from 1990 to 2015

Road category	1990-1995		1996-2000		2001-2005		2006-2010	
	Bitumen	Earth/gravel	Bitumen	Earth/gravel	Bitumen	Earth/gravel	Bitumen	Earth/gravel
A- International	73	27	75	25	77	23	77	23
B- National	50	50	49	51	53	47	56	44
C- Primary	31	69	32	68	33	67	35	65
D- Secondary	10	90	10	90	11	89	11	89
E- Minor	2	98	3	97	3	97	2	98
F- Special Purpose	2	98	2	98	2	98	1	99
Total roads	23	77	24	76	14	86	14	86

Sources: Statistical Abstract various issues (1990-2015). Kenya National Bureau of Statistics

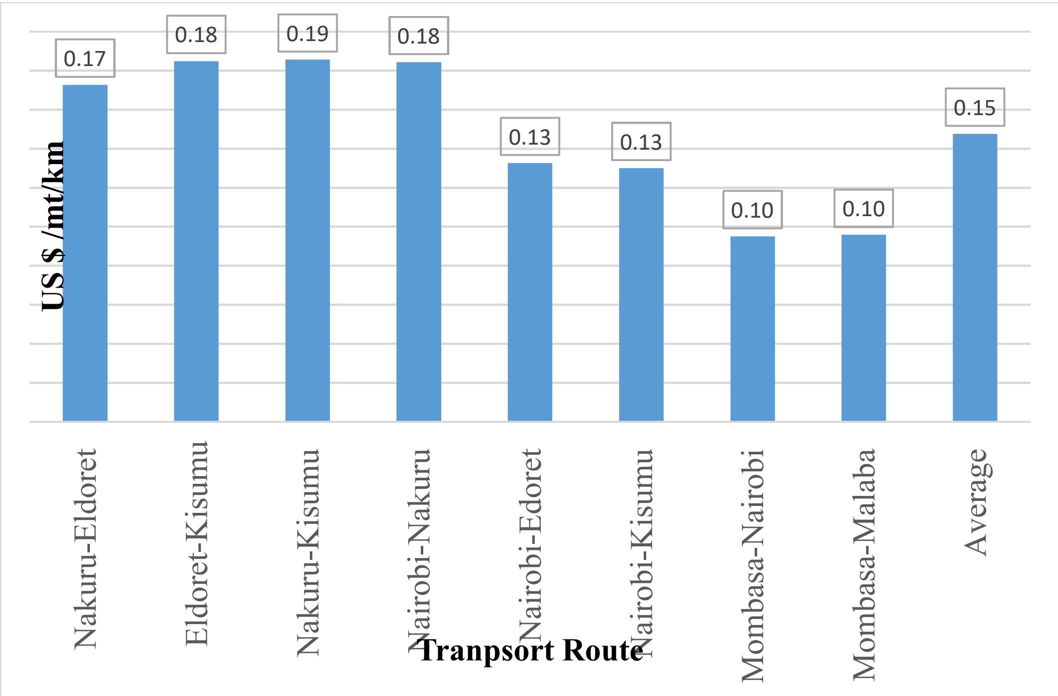

Figure A.1: Transportation cost of one ton per kilometre across different routes

Source: Logistic cluster Kenya, 2008. Note the costs apply to dry and wet seasons

Table A.3: Policies associated with the maize sector in Kenya

National Policy	Objective, Aim and Goal related to maize sector	Activities undertaken
National seed policy 2012	• Review of research & development, plant germplasm conservation/preservation, seed production, processing and quality control, marketing & distribution, institutional and legal framework to which the problems relate be undertaken in the seed industry to spur agricultural growth. Agricultural development.	• Increase the availability of affordable high quality maize seed • Increase maize productivity at the household level and improve food security
	• Harmonization of all seed related activities and laws to tap synergies in the agricultural and forestry sector. Recognizes the role of both public and private seed in the development of the industry and build capacity and infrastructure	• Harmonize regional seed policies and regulations to enhance cross border trade in seed.
National Agribusiness Strategy 2012	• To guide the agricultural sector development and its transformation to a competitive commercial oriented sector	• Development of market information platform • Development of the standard • Value addition on maize
	• Creating a conducive environment for private sector investment in agribusiness and related opportunities	• Development and upgrading of markets
Agricultural Sector Development Strategy (ASDS) 2010-2020	• Increasing productivity ,commercialization, and competitiveness of agriculture commodity and enterprise • Developing and managing key factors of production • Divesture in the state corporation dealing in production process and marketing to private sector • Reform and streamline agriculture service institutions such as research extension	• Establishment of maize irrigation schemes in Tana River and Taita Taveta • Organizing maize producers into groups • Research on high maize yielding varieties by Food Crop Research Institute (FCRI) • Credit to maize farmers from agricultural finance cooperation • Subsidized fertilizer for maize farmers • Privatization of NCPB • Merger of various crop and animal research institutions under one institution the Kenya

		Agriculture & Livestock Research Organization (KALRO)
National Agriculture Sector Extension Policy (NASEP) 2012	• Improve extension service systems through manpower development , better utilization of ICT and efficiency in resources • Improve the link among research extension (both private and public) • Provision of a pluralistic demand driven well formulated and harmonized extension services	• Decentralization and empowering of clientele/community to provide extension services at the different levels • Use of mass media , ICT to disseminate information • Involvement of maize farmers in technology development, packaging and learning by research institutions e.g. International Centre for Improving Maize and Wheat (CIMMYT)
National Agricultural Research System Policy 2012	• Creating an enabling environment for a vibrant research system that contribute to national development • Improve agricultural research policy framework • Harmonize and provide direction to national research for sustainable development • Strengthen legal , institutional and legal framework • Coordinated planning •	• Amalgamation of the different research institution under parastatal, state corporations, public and private universities under six commodity semi-autonomous publicly funded institutes • Maize fall under food crops thus-FCRI
National Food Security and Nutritional Policy 2012	• Food access and availability through increased production of diversified foods • Better storage and post-harvest handling	• The import of subsidized fertilizer • Establishment of a strategic grain reserve and government purchases of maize from the market • Storage facilities by NCPB
	• Food safety and standard and quality controls • Enforcement of guidelines and standard regulation	• Moisture content, high quality of the standard of maize coming from the regional and also imported maize • Harmonization of regional quality standards on maize
	• Nutritional improvement	• Food fortification, bio-fortification and vitamin

		and mineral supplementation for children
	• Food security and nutrition	• Establishment of an inter government agency that annually collects a maize balance sheet. The agency is also involved in the early warning systems of maize shortage in the country

Source: Author's compilation from various National strategies and policies documents.

Table A 4: Summary of studies on spatial and vertical market integration across ESA region

Author(s)	Country	Commodity	Method	Results
Loveridge S (1991)	Rwanda	Dry beans,	Correlation coefficient	price narrowed as a result of new road built
Golletti, F & Babu, S (1994)	Malawi	Maize	Cointegration/causality	low MI after liberalization no downward rigidity with price shock
Dercon, S (1995)	Ethiopia	Teff	Cointegration/causality	reduced margins and MI after liberalization
Chirwa, E.W. (1999)	Malawi	Maize & rice	Cointegration/VAR	high MI
Chirwa, E.W (2001)	Malawi	Maize, rice, beans & grdnuts	Cointegration/causality	improvement in market efficiency over time
Rashid , S (2004)	Uganda	Maize	Cointegration/VECM	MI improved after liberalization no MI in the north
Conforti, P (2004)	Egypt/Ethiopia	Food &cash crops	Cointegration/causality	price transmission between retail , producer price and world price
Jaleta, M.,& Gebremedhin, B.,(2009)	Ethiopia	Wheat & Teff	Cointegration	MI for close markets no MI far away markets
Wondemu Kifle (2015)	Ethiopia	Maize &Teff	TVECM	asymmetry in teff prices and not maize, inefficiencies in the market

Guvheya, E, Mabaya E., & Christy, R.D.,(1998)	Zimbabwe	Tomatoes	Causality/houck	bidirectional flow of price of wholesale prices symmetric price transmission
Nagessa, A (1998)	Ethiopia	Grain	Correlation coefficient/causality	high degree of vertical and spatial integration
Minten, B & Kyle, S (2000)	Zaire	Food	SURE/houck	wholesale prices transmitted to retail prices TC more important than marketing costs
Traub, L.N., & Jayne, T.S.,(2004)	South Africa	Maize	OLS/GLS	low producer price and high maize meal price
Getnet, K, Verbeke, W. & Viane, J (2005)	Ethiopia	White Teff	Cointegration/ARDL	wholesale prices determine producer price in the short and long run
Loy, J.P. & Wichern, R (2000)	Zambia & Malawi	Maize	Cointegration/causality	low regional MI , high transaction costs
Baffes, J & Gardner, B. (2003)	Madagascar	Coffee, rice & sugar	Cointegration/ECM	moderate improvement in MI
Kilima, F.T.M (2006)	Tanzania	Sugar, cotton, wheat & rice	Cointegration/causality	border price not co-integrated with world prices unidirectional causal relationship
Rapsomanikis, G., Hallam, D., & Conforti, P., (2006)	Ethiopia, Rwanda & Uganda	Coffee	Cointegration/causality	domestic price integrated with international price in UG and ETH no integration for RWA
Acosta, A. (2012)	Mozambique & South Africa	Maize	Cointegration	price from SA to MZQ only co-integrated in the long run , asymmetric price transmission

Source: Abdulai, 2007 and updated by the authors Note MI= market integration

ANNEX B

Table B.1: Description of exogenous and endogenous variables and their sources

Variable	Description	Units	Sources
Macro-economic variables			
$\mathrm{POPL_t}$	Total population	Millions	Global Insight/KNBS
$\mathrm{RGDP_t}$	Real GDP	Billions USD	IMF
$\mathrm{DFGDP_t}$	GDP deflator	% change	Global Insight
$\mathrm{RPCGDP_t}$	Real per-capita GDP	KES/person	Calculated
$\mathrm{CPI_t}$	Consumer price index	(2000=100)	IMF
$\mathrm{EXCHRT_t}$	Exchange rate	LCU/USD	Global Insight
Policy implemented by the government			
SHIFT2008	Importation & distribution of subsidized fertilizer	1 from 2008, 0 otherwise	MOALF
SHIFT2009	Soaring high food prices period	1 from 2009, 0 otherwise	
Weather variable			
$\mathrm{RAINYS_t}$	Amount of rain received	Millimetres	KMD
Input variables			
$\mathrm{IMPRVSEED_t}$	Area under improved maize seed	Hectare	TAPRA/MOALF
$\mathrm{INPTINDEX_t}$	(Wholesale price*yield)/fertilizer prices	Index	Calculated
Trends			
$\mathrm{LNTREND_t}$	Log-linear trend technological improvement	Logarithm	Calculated
$\mathrm{TRCONS_t}$	Linear trend to capture changes in population consumption habits	Time trend	Calculated
Prices of maize and its substitute			
$\mathrm{WMZPRIC_t}$	Nominal wholesale maize price	KES/ton	MOALF
$\mathrm{RMZPRIC}_t$	Real maize price	KES/ton	Calculated
$\mathrm{RPTSPRIC_t}$	Real potato price (substitute)	KES/ton	Calculated
Demand and supply variables			
$\mathrm{MZAREA_t}$	Area harvested under maize	Hectares	MOALF
$\mathrm{MZPRDN_t}$	Maize produced	Tons	MOALF
$\mathrm{MZYIELD_t}$	Maize yields	Ton/ha	Calculated
$\mathrm{IMPRT_t}$	Maize imports	Tons	MOALF
$\mathrm{EXPRT_t}$	Maize Exports	Tons	MOALF
$\mathrm{FEEDUSE_t}$	Animal feed use	Tons	MOALF
$\mathrm{FOODUSE_t}$	Human food use	Tons	MOALF
$\mathrm{OTHUSE_t}$	Other uses/loses	Tons	MOALF
$\mathrm{TDOMCON_t}$	Total maize consumed	Tons	MOALF
$\mathrm{ENDSTOCK_t}$	Ending maize stocks	Tons	MOALF
$\mathrm{BEGSTOCK_t}$	Beginning maize stock	Tons	Calculated
$\mathrm{CONPDNR_t}$	Self-sufficiency ratio	%	

*Note calculated imply the variable was arrived after calculation. Three variables were calculated, $\mathrm{INPTINDEX_t}$,$\mathrm{LNTREND_t}$, $\mathrm{TRCONS_t}$ representing input index, technology improvement and consumptions patterns respectively.

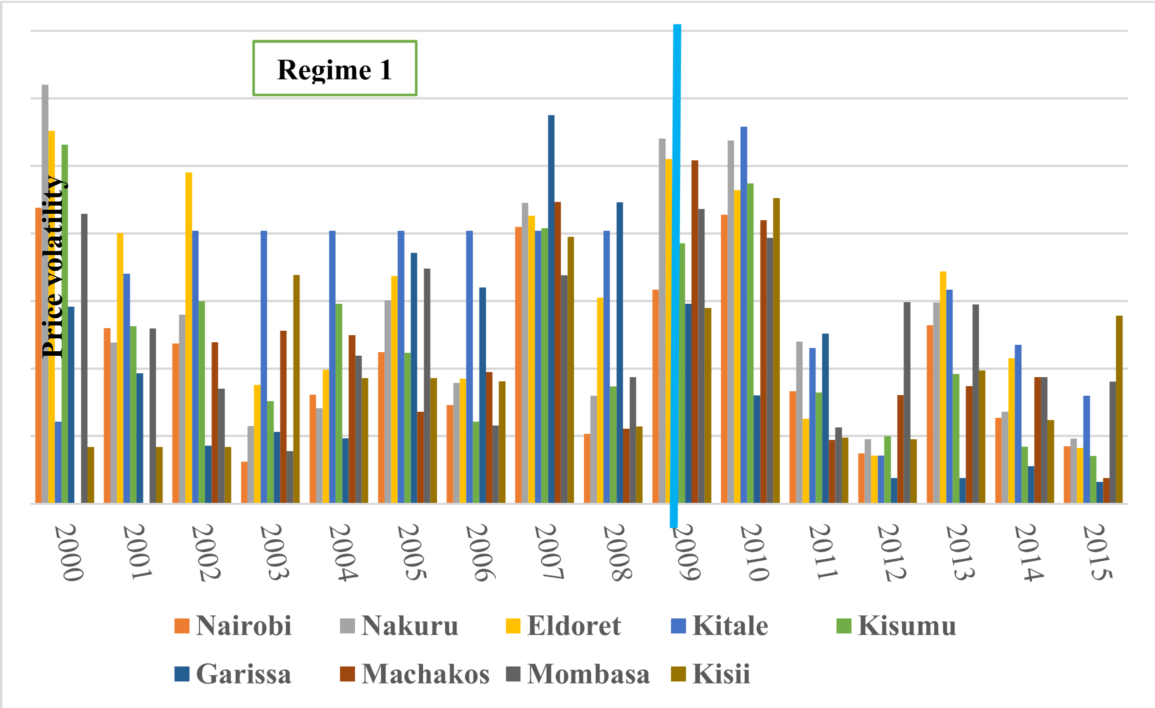

Figure B.1: Yearly unconditional price volatility for the harvest period 2000-2016

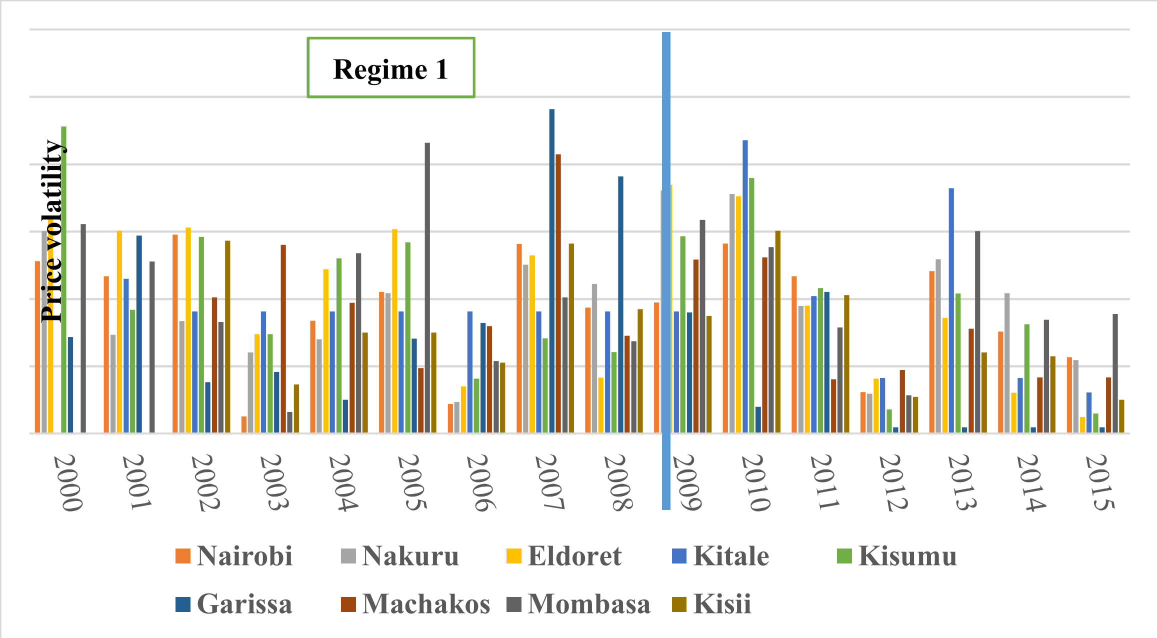

Figure B.2: Yearly unconditional price volatility for the lean period 2000-2016

ANNEX B.2
An example of discretionary removal of import duty by the Treasury

An example of discretionary policy response by the government and its effects on the market can be illustrated by experience of 2008 and 2011. During the 2007/08 maize season, MOALF and other stakeholders, through their early warning system predicted poor harvest during the 2008/09 season. Kenya and its neighbouring countries were expected to receive below than average maize harvests due to poor weather conditions. This implied that Kenya had to rely on imports from ROW. The government needed to waiver duty early in the 2008/09 season to allow for importation of maize. Despite the early warning, the Treasury delayed on the duty waiver, only implementing it in November of 2008.

The first consignment of duty free maize from South Africa arrived in March 2009. This implied that consumers had to cope with higher prices for a period of 15 months, despite the imported maize price being cheaper at that particular time. The Treasury zero-rated the import tariff at their discretion, despite intensive lobbying by stakeholders to remove the duty early in 2008. A similar situation occurred in 2011. Tanzania experienced poor weather conditions and therefore the harvest of 2011 was below average. This prompted the Tanzanian government to restrict export as a measure for food security. Though Kenya gets maize from both Tanzania and Uganda, the bulk of the imports come from Tanzania. With an anticipated poor harvest in Tanzania, stakeholders in the maize sector started lobbying for duty waiver in the beginning of 2011. This time the duty waiver was timely as the Treasury granted 6 month's duty waiver from June to December 2011. This resulted in a decline in the domestics prices that had started to rise. Figure 2.8 summarizes the relationship between domestic price, SAFEX South Africa price and the Import parity price. This example illustrates the effects that a discretionary response by the government may have on the market. In addition, the conflict of interest between different departments also plays a role. The objective of Treasury is to collect taxes and duties on behalf of the government and their target is, the more money they collect, the better. On the other hand, the MOALF's main duties include achieving food security and lobbying for duties and taxes that have an effect on food security.

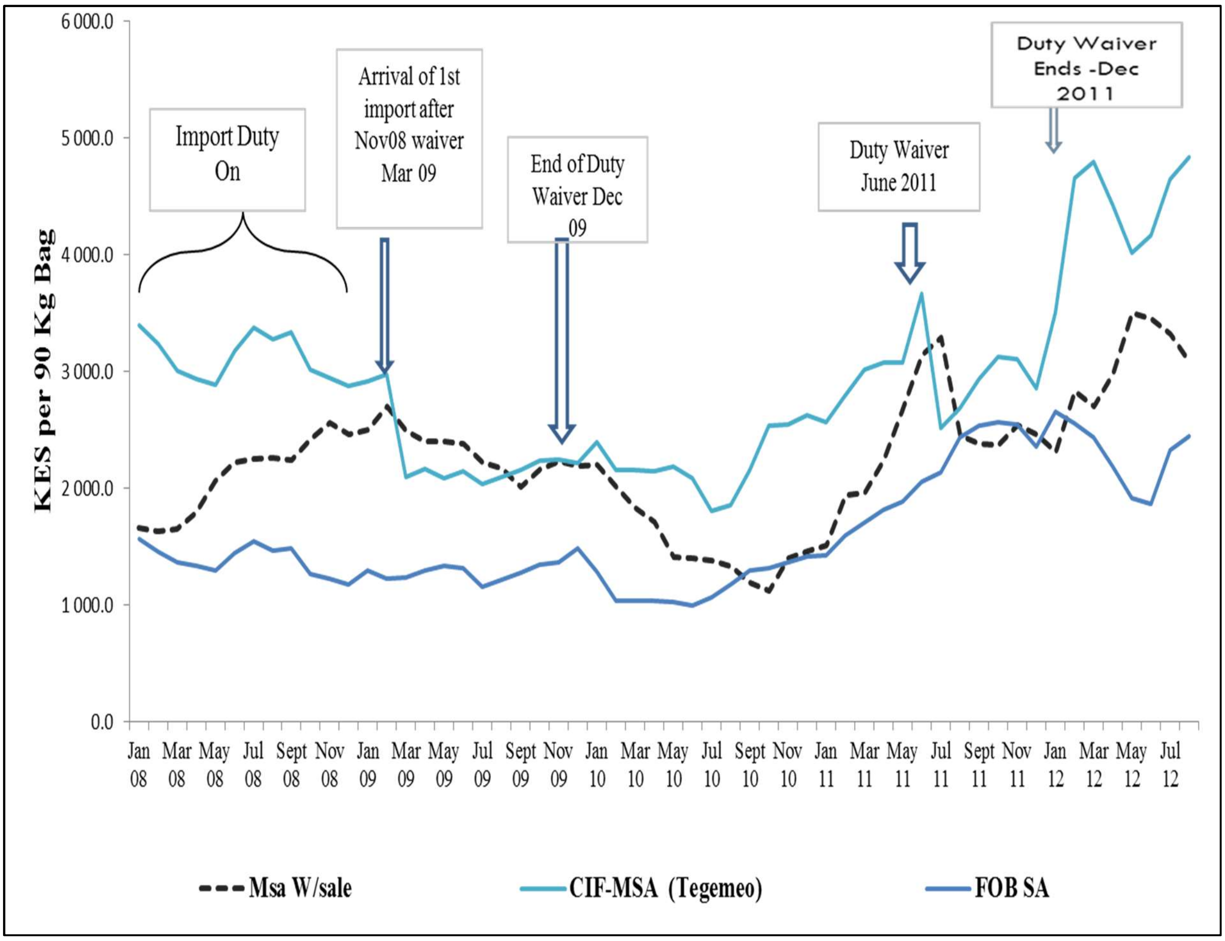

Figure B.3:Comparison of domestic prices to maize prices from outside the EAC region.

Source: Kamau et al,. 2013

Table B.2: Balance sheet of the maize sector in Kenya 2003-2016

Variables	Units	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Yields	Tons/ha	1.6	1.4	1.7	1.7	1.8	1.4	1.3	1.7	1.6	1.7	1.7	1.7	1.7	1.7
Production	000 tonnes	2,711	2,277	2,905	3,247	2,932	2,498	2,439	3,465	3,377	3,757	3,598	3,513	3,664	3,780
Beginning stocks	000 tonnes	48	212	293	385	440	421	479	314	420	433	479	324	420	469
Imports	000 tonnes	130	253	194	135	47	206	1,545	278	359	325	93	459	383	409
Total supply	**000 tonnes**	**2,889**	**2,741**	**3,393**	**3,767**	**3,419**	**3,125**	**4,463**	**4,057**	**4,156**	**4,515**	**4,170**	**4,296**	**4,467**	**4,658**
Export	000 tonnes	-	-	-	31	38	9	4	9	14	7	1	-	-	-
Feed use	000 tonnes	50	100	100	300	100	100	100	350	350	350	370	389	405	422
Other uses	000 tonnes	350	220	200	200	200	464	471	450	480	500	450	150	156	161
Domestic Consumption	000 tonnes	2,677	2,448	3,008	3,296	2,960	2,637	4,145	3,628	3,709	4,029	3,845	3,876	3,997	4,162
Ending stocks	000 tonnes	212	293	385	440	421	479	314	420	433	479	324	420	469	495
Total demand	**000 tonnes**	**2,889**	**2,741**	**3,393**	**3,767**	**3,419**	**3,125**	**4,463**	**4,057**	**4,156**	**4,515**	**4,170**	**4,296**	**4,467**	**4,658**

Note. The Kenyan maize balance sheet covers the period 1995-2016 we only presented from 2003-2016 as 1995-2016 cannot fit

Table B.3: White maize import parity calculations 2007-2016

Import Parity Price		2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Maize (FOB)-SA	US$/Ton	255	218	178	178	226	282	269	217	250	295
Maize(FOB)US Gulf ROW	US$/Ton	155	218	173	163	277	284	299	203	182	172
Freight (Durban-Mombasa)	US$/Ton	50	60	60	69	41	42	37	35	33	35
Non-GM premium	US$/Ton	18	21	19	19	24	25	23	24	24	24
Freight (Gulf-Mombasa)	US$/Ton	48	67	44	55	77	69	66	63	39	42
Maize(CIF)-SA	US$/Ton	324	299	257	266	292	349	331	276	308	355
Maize (CIF)-ROW	US$/Ton	204	286	217	219	355	355	366	267	222	215
Import tariff on (CIF)-SA	50%	10,904	10,350	0	10,545	0	14,754	14,242	12,149	15,108	17,753
Import tariff on (CIF)-ROW	50%	6,873	9,882	0	8,671	0	14986	15747	11743	10,901	10,741
IDF on (CIF)-SA	2.25%	491	466	447	475	584	664	641	547	680	799
IDF (CIF)-ROW	2.25%	309	445	378	390	709	674	709	528	491	483
Port charges handling	KES/Ton	1,529	1,796	2,008	2,057	2,510	2,384	2,155	2,063	2,175	2,337
KPA charges	KES/Ton	3,147	9,238	3,287	3,367	3,819	3,550	3,210	3,073	3,239	3,480
Maize price from SA	KES/Ton	37,877	42,550	25,628	37,535	32,846	50,859	48,731	42,132	51,417	59,875
Maize price from ROW	KES/Ton	25,603	41,126	22,466	31,828	38,532	51,566	53,315	40,893	38,607	38,524
GBHL handling loses -SA	0.05%	18.9	21.3	12.8	18.8	16.4	25.4	24.4	21.1	25.7	29.9
GBHL handling loses-ROW	0.05%	12.8	20.6	11.2	15.9	19.3	25.8	26.7	20.4	19.3	19.3
landed at store in Mombasa port -SA	KES/Ton	37,896	42,572	25,641	37,553	32,862	50,884	48,755	42,153	51,443	59,905
landed at store in Mombasa port-ROW	KES/Ton	25,616	41,146	22,478	31,844	38,551	51,592	53,342	40,914	38,627	38,543
Parity price -SA maize - Nairobi	**KES/Ton**	**40,241**	**45,350**	**28,974**	**40,664**	**35,862**	**53,773**	**51,319**	**44,557**	**53,712**	**62,207**
Parity price -ROW maize - Nairobi	**KES/Ton**	**27,960**	**43,924**	**25,811**	**34,955**	**41,551**	**54,481**	**55,905**	**43,317**	**40,896**	**40,845**

Source: The port handling charges Louis Dreyfus (2007-2016), KRA (2007-2016), South Africa maize prices from World Insight (2007-2016).Note SA=South Africa and ROW=World market