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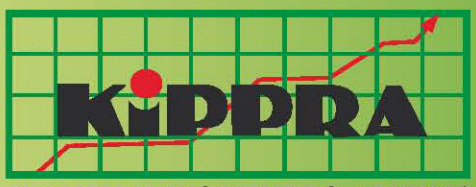

The KENYA INSTITUTE for PUBLIC POLICY RESEARCH and ANALYSIS

Analysis of Price Transmission for Selected Staple Food Commodities in Kenya

Nancy Laibuni and John Omiti

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THE KENYA INSTITUTE FOR PUBLIC POLICY RESEARCH AND ANALYSIS (KIPPRA)

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Productive Sector Division
Kenya Institute for Public Policy
Research and Analysis

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Abstract

Markets play a primary role in facilitating forces of demand and supply to interact such as through price adjustments across time and space. In many developing countries such as Kenya, food markets are characterized by high transaction costs, liquidity constraints, information asymmetry, lack of profitable opportunities and inadequate infrastructure that impede traders from taking advantage of the price differences between markets from one period to another. This creates economic inefficiencies and loss of opportunities to improve the economic well being.

This study seeks to estimate how the food markets respond to price changes and the implications for food security. Price transmission and market integration of dry maize, green maize and beans were evaluated in two major consumption markets; Nairobi and Mombasa, and two major production markets, Nakuru and Eldoret. Monthly data from January 1995 to May 2011 was used, the vector error correction model (VECM) was applied to examine the relationship between the commodity prices and the markets.

The results show that the markets are integrated and price transmission does occur for most staple food commodities. However, price transmission is incomplete in the short run, as implied by the spatial arbitrage conditions which are deficient in the selected markets. This implies that wholesalers and/ or middlemen possess considerable market power in the food marketing chain.

The proposed interventions to mitigate food insecurity include facilitation and upscaling market information sharing and investments in physical infrastructure (for example, storage and roads) to facilitate trading activities. There is need for incentives and relevant institutions to encourage the engagement of public private partnerships in the distribution and marketing of food commodities. From a policy perspective, efforts should be made to develop storage and physical market infrastructure to promote optimal arbitrage, in addition to developing commodity exchange and warehouse receipting systems. Areas for further research include measuring the threshold price difference below which price co-movement ceases.

Abbreviations and Acronyms

ASDS	Agriculture Sector Development Strategy
COMESA	Common Market for East and Southern Africa
EAC	East African Community
FAO	Food and Agricultural Organization of the United Nations
ICT	Information Communication Technology
KENFAP	Kenya Federation of Agricultural Producers
KIPPRA	Kenya Institute for Public Policy Research and Analysis
KNBS	Kenya National Bureau of Statistics
MoA	Ministry of Agriculture
RATIN	Regional Agricultural Intelligence Network
UNCTAD	United Nations Conference on Trade and Development
VECM	Vector Error Correction Model

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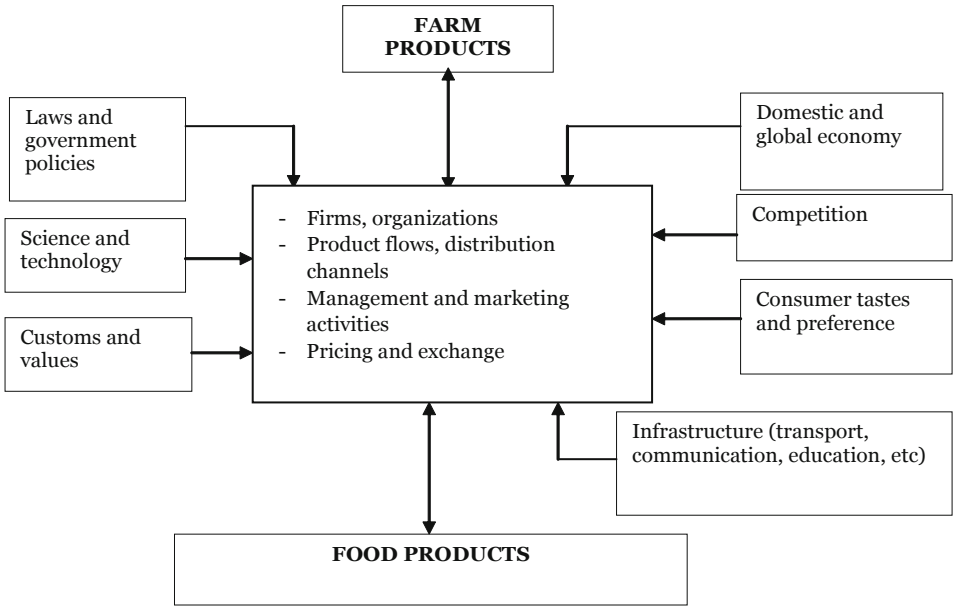
1. Linking Price Analysis and Food Markets

Food markets play the important role of food distribution by linking different actors in the agricultural value chains, from production to consumption. Missing markets and/or market failure disrupt the status quo, thus affecting the opportunities for the producers and various supply chain actors. Food availability for consumers is determined by production (how much and which types of food), distribution (physically, processing, storage and market segmentation), carry-over stocks and exchange systems (import/export). Properly functioning markets are a result of interactions between institutions which facilitate assembly and exchange (Barrett and Mutambatsere, 2005; Reardon and Timmer, 2005).

On the supply side, agricultural food production in Kenya tends to exhibit certain characteristics. First, there is considerable variation in annual output since the production system largely depends on weather conditions and biotic and abiotic factors (for example, pests and diseases). Second, the demand for agricultural products does not quickly respond to changes in prices or supply in the short-run due to supply response lags (that is, relatively inelastic). Third, most agricultural products have geographic concentration depending on agro-ecological suitability of enterprises, thus making distribution critical for food availability. Fourth, most of the farm produce is bulky and perishable, especially in their semi-processed form, therefore requiring large storage capacities, speedy handling and preservation. Finally, increased production of a particular crop triggers increases in the derived demand for other complementary products such as fertilizer and pesticides, packaging material, transportation services and extension services (Omiti *et al.*, 2011; United Nations, 2011; Benson *et al.*, 2008; Smale and Jayne, 2003).

On the demand side, the major determinants include price of food, purchasing power, spatial distribution, transport, market systems, tastes and preferences and socio-economic and demographic factors. The food market system encompasses two major types of activities: first, distribution involves the physical handling storage, processing and transfer of raw and finished goods as they move from producers to consumers. Second, the exchange and price setting process. Dynamics in the food marketing system are an influence on the organization and operation of the system. Figure 1.1 shows the different components of a generic agri-food system and how different factors are necessary for the system to operate efficiently.

Figure 1.1: Components of a dynamic generic agrifood system



Source: Kohls and Uhl, 2002

1.1 Rationale for Price Analysis in Food Markets

In Kenya, the food basket comprises cereals (maize, rice, wheat, etc); starchy roots and tubers (irish potatoes, cassava, sweet potatoes, etc); pulses (beans, peas, etc); vegetables (tomato, onion, etc); meat (beef, mutton, chevron, etc); milk; eggs; fish and seafood (Kenya National Bureau of Statistics-KNBS, 2011).

In 2007–2008, there was a food crisis worldwide where average prices of food staples doubled, and this phenomenon re-occurred again in 2010-2011. The effect of the food crisis saw the price of food staples increase by over 100 per cent, especially in 2010-2011. The impact was food riots and most citizens now focus their available resource on acquiring food and food-related activities. The drastic increase in food prices was attributed to increased international fuel prices that resulted in increased cost of inputs (fertilizer and transportation), and the increased use of cereals for bio-fuel production. This was compounded by drought and variable weather conditions. Average incomes have been increasing at a much lower rate compared to inflation, leading to a significant decline in real disposable incomes, hence purchasing power. The challenge facing policy makers is how to keep farm gate prices high enough to provide incentives for farmers so as to continue in production, while simultaneously keeping food affordable and accessible to consumers. In the food markets, commodity prices vary within and across seasons. Some intra-seasonal variation is inevitable, given the seasonality of local supply and the cost of storage.

In response to this challenge, certain policy interventions have been taken. On the supply side, input subsidies have been provided through the distribution of seeds and fertilizers, though not to an adequate level to stimulate large surpluses. Food imports and producer price support measures and credit schemes have been put in place to stimulate supply. On the demand side, consumers have been given reprieve by removal of tariffs, implementation of price controls and provision of cash transfers to vulnerable people.

On trade, the country has reduced import tariffs and zero-rated imports of all agricultural inputs. Despite all these measures, food price instability and food insecurity still persist. An alternative/additional food market policy and investment option would be to review trends in food consumption, production and price levels and the forces shaping these trends. This can be achieved by evaluating the characteristics of the food market in the country and understanding why the system cannot accommodate and distribute short-lived surpluses.

1.2 Problem Statement

Perceived higher prices in markets in consumption zones (towns) should attract inflows from markets in producing zones. The effect is a lower price in the importing market and a higher price in the exporting market, keeping the prices close to each other (spatial price transmission) in general, both sides gain from trade. However, if transportation costs or high trade barriers make trade unprofitable, price transmission does not take place and prices remain too high in one market and too low in the other. Imperfect substitutes may limit cross-price transmission. If imported, rice is greatly favoured over local rice, a rise in the price of the imported rice may do nothing to the price of local rice. On the other hand, lowering the price of local rice may do nothing to the price of imported rice. In addition, lack of information about prices in other markets can reduce the effect of food price transmission. Not knowing that prices have spiked in a certain market, traders in neighbouring market may miss an opportunity to sell their relatively low cost commodities. Finally, lagged food price transmission can occur if the time to transport from one market to another is exceptionally long. Anticipating a price spike, a trader may begin transporting a commodity from a producing area, only for the price to change before the commodity arrives in the targeted market. This study seeks to measure price transmission between markets in producing zones and those in consumption zones, so as to inform policy on strategic interventions to reduce food insecurity.

1.3 Objectives of the Study

i. Examine recent trends of domestic prices of food commodities in production and consumption zones

ii. Investigate the relationship between prices of major food commodities in different key markets

iii. Describe some of the possible explanations for any observed trends in prices of major food commodities in different markets

iv. Highlighting strategic interventions to reduce food insecurity

1.4 Organization of the Paper

The paper is structured as follows: Chapter one presents the introduction and relevance of the study, including objectives. Chapter two provides an overview of the agricultural food sector and conceptual issues on price transmission and market integration. Chapter three highlights the methodology, while Chapter four presents the results. Chapter five highlights the implications for policy and areas for further research.

2. Literature Review

2.1 Overview

The Agricultural sector has recorded positive growth since 2009. In 2010, 6.4 per cent growth was recorded; however in 2011, there was a decline to 1.5 per cent growth. Table 2.1 highlights the importance of the different commodities in the food balance sheet. Maize is top of the list in terms of food utilization, wastage and per capita supply. Other important items are wheat, potatoes, beef, rice and beans.

Table 2.1: Food balance sheet for Kenya in 2010

Commodity	Domestic supply (MT)	Domestic utilization (MT)		Per capita food supply Kg/yr
		Food	Waste	
Maize	4,328	2,635	1,540	66.2
Wheat	1,422	1,338	28	33.7
Potatoes	508	353	51	8.9
Beef	461	461	n.a	11.6
Rice	436	425	9	10.7
Beans	426	363	64	9.1
Sweet potatoes	383	345	38	8.7
Tomatoes	335	302	33	7.6
Cassava	325	315	10	7.9
Eggs	80	63	n.a	1.6
Onions	68	61	7	1.5
Mutton and goat meat	4	85	n.a	2.1

n.a - not available

Source: Kenya National Bureau of Statistics, 2011

Taking into account the production of food crops over the last five years, it is evident that maize production is the largest both in area and volume. In terms of output, maize, irish potatoes, rice and millet top the list, in that order (Table 2.2).

For the purposes of this study, the criteria for selecting the major food commodities was:

i) Importance of selected commodities in terms of quantities and share of household food basket composition

This entailed the dominance of those commodities in the agri-food marketing system, and the representative volume available.

Table 2.2: Average food crops production statistics, 2006-2010

Crop	Area (Ha)	Output (MT)
Maize	2,008,346	3,464,541
Irish potatoes	131,047	3,148,213
Rice	20,181	889,357
Millet	99,124	598,678
Wheat	160,043	511,994
Beans	689,377	390,598
Sweet potatoes	42,313	383,590
Sorghum	225,782	164,066

Source: Ministry of Agriculture, 2011

ii) Food consumption patterns

Complementary food items in the food basket are maize and beans, while supplementary foods are the different combinations of the carbohydrates or the different combinations of proteins.

iii) Availability of consistent data

Based on this criterion, dry maize, green maize, and beans were selected. There was no consistent data on the production of green maize, although price data was available (MoA, 2011).

The criterion for choosing the markets is based on availability[1] of continuous monthly wholesale price data. Nairobi and Mombasa cities were selected to represent two consumption areas, while Nakuru and Eldoret represent two producing areas within the grain basket regions in the country.

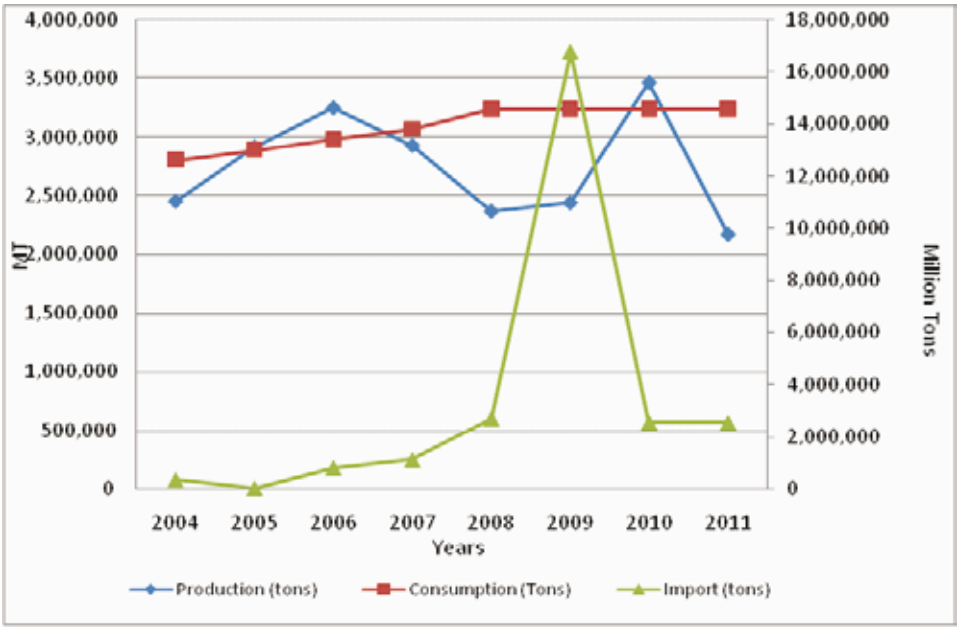
2.2 Overview of Staple Food Sub-Sectors

2.2.1 Maize

Maize is grown for both subsistence and commercial crops. More than two-thirds of the maize produced is from approximately 3.5 million small-scale producers, who operate less than two hectares of land. The other portion is approximately 1,000 large-scale farmers who own large tracts of land, mainly in Trans-Nzoia and Uasin Gishu counties (Kirimi *et al.*, 2011). Maize production has not increased as fast as demand, which is driven by population growth. In 2010, maize consumption was estimated at 34 million bags per year (Figure 2.1).

[1] This data was obtained from the Ministry of Agriculture under the agriculture market information programme.

Figure 2.1: Maize production and consumption in Kenya, 2004-2011



Source: Ministry of Agriculture, 2011

To bridge the gap between supply and demand, imports of maize have been taking place both formally and informally across the border from Uganda and Tanzania, in addition to large offshore imports (MoA, 2011).

Price control, export ban and import tariffs are the commonly used instruments to support maize prices. Maize market reforms started in the mid 1980s under the cereal sector reform programme. Previously, the government practiced pan-territorial and pan-seasonal pricing adjusted once per year at the beginning of the planting season (Ariga and Jayne, 2009). Table 2.3 summarizes the market reforms that have taken place. The table highlights some of the policy directives that have continued to inhibit the development of both competitive input and output markets in the maize sub-sector. These policy directives tend to hinder efficient allocation of productive resources, as well as inhibit reduction in price risks by preventing price volatility. While almost all farmers in Kenya grow maize, an estimate of 2 per cent in the smallholder sector, account for over 50 per cent of the national marketed supply (Odhiambo, 2012). Therefore, maize production and marketed sales are highly concentrated in the hands of the few large scale farmers and supply chain operators (e.g., importers).

Table 2.3: Summary of market reforms in the maize sector

State marketing agency	Market regulation and pricing policy
1988: National Cereal and Produce Board (NCPB) financially restructured, phased closure of NCPB depots, NCPB debts written-off, crop purchase fund established but not replenished.	1988: Cereal Sector Reform Programme envisages widening of the NCPB price. Proportion of grain that millers are obliged to buy from NCPB declines. Limited unlicensed maize trade allowed.
1995: NCPB restricted to limited buyer and seller of last resort role. NCPB market share declines from 10-20% of marketed maize trade. NCPB operations confined mainly to high-potential areas of western Kenya. 2000 –onwards: NCPB provided with funds to purchase a greater volume of maize. NCPB's share of total maize trade rises from 25-35% of total marketed maize.	1991: Further relaxation of inter district trade. 1992: Restrictions on maize trade across districts re-imposed. NCPB unable to defend ceiling prices. 1993: Maize meal prices deregulated. Import tariff abolished. 1995: Full liberalization of internal maize and maize meal trade, maize import tariff re-imposed to 30%. 1996: Export ban imposed after poor harvest. 1997: Import tariff lifted imposed after poor harvest. 1997 –onwards: External trade and tariff rate levels change frequently and become difficult to predict. NCPB producer prices normally set above import parity levels. 2005 –onwards: The government withdraws the maize import tariff from maize entering Kenya from EAC member countries. An official 2.75% duty is still assessed. Variable import duty still assessed on maize entering through Mombasa port.

Source: Ariga, 2009

2.2.2 Green maize

Though no reliable statistics are available on the sale of green maize, it has become a common phenomenon, which has a ready market both in rural and urban areas. Green maize is consumed as a snack (roasted or boiled). In addition, green maize is easier to cook than dry maize in terms of energy requirements. The sale of maize when green, reduces the volume of dry maize grain available at the end of the growing season. Green maize is sold at a farm gate price of Ksh 6–10 (2009), depending on size and quality. The traders usually harvest the crop for themselves, relieving the farmer from other costs like stalking, shelling, harvesting and storage, while making available land to produce another crop. As a result, the profit margins for the farmers are higher, making the green maize business

lucrative. According to Kenya National Federation of Agricultural Producers (KENFAP), in Trans-Nzoia county, at least 1,000 bags of green maize are sold every week for a few months in the year (Owour, 2010). There have been many policy attempts (for example, public *baraza*) to discourage sale of green maize, but have been largely unsuccessful.

2.2.3 Beans

Rosecoco is the most widely grown followed by Canadian wonder bean types. Rosecoco and Canadian wonder are high yielding, but require heavy rains and high soil fertility to yield well. Bean production is generally considered by farmers as a low input requirement crop, and is the preferred choice in making local recipes such as cooked maize and beans mixture (*githeri/nyoyo/muthokoi*, etc.). There is a moderate to high growth potential for the cooked maize and beans mixture (Figure 2.4) due to increased demand from low-income population in urban areas (Katungi *et al.*, 2009).

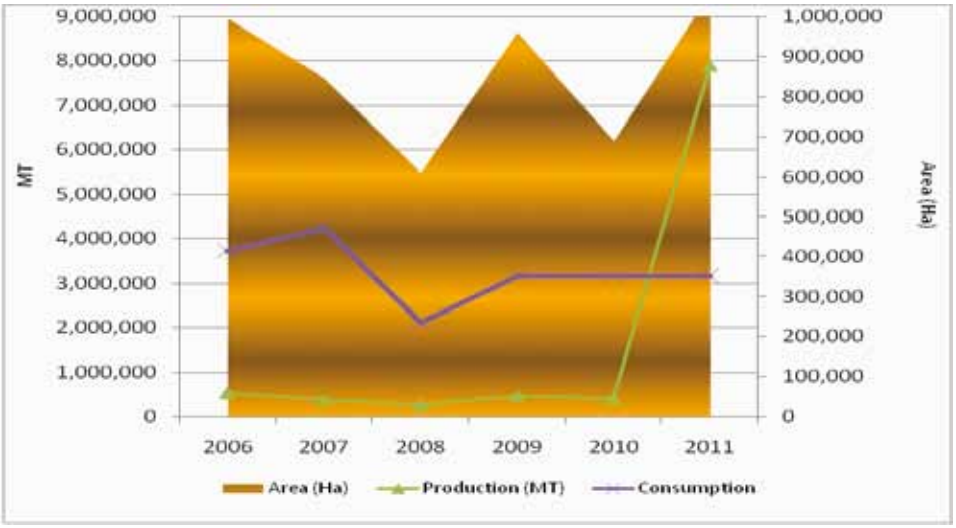
The important policy changes in the sub-sector include:

i) Limited availability of the certified and clean planting seed from the seed vendors and the national research institutes.

ii) Beans are an important component of the food balance sheet both locally and in the region. Thus, there are opportunities for inter-regional trade in the commodity which already takes place informally.

iii) Beans are considered a suitable cheaper substitute for meat. As a source of protein, it is affordable to the poor people.

Figure 2.2: Bean area, production, and consumption 2006 -2010



Source: Ministry of Agriculture, 2011

2.3 Seasonality of Agricultural Production and Price Fluctuations

The food marketing system is, often, a complex system of channels, actors and activities that facilitate the production, distribution and exchange of food commodities. It is important to understand the entrepreneurial motivation for business firms engaged in physical, technological and economic activities to ensure that food products transferred to the consumers are largely driven by profit maximization. The nature and form in which products are initially offered to the marketing system influence the organization and operation of the whole system, subject to laws and regulations that govern the system. Marketing is a transformative process that adds form, place, time and possession utility to farm commodities, the value added in the food marketing process complements the productive process in the farm. Marketing provides the bridge between food producers and consumers and is influenced by social resources, technology, and the laws and norms of society (Amikuzuno and Cramon-Taubadel, 2012; Goodwin, 1994).

Markets play a primary role in leveraging the risk associated with demand and supply shocks by facilitating adjustment flows across time, therefore, reducing the price variability. Inefficiencies in market functions are usually as a result of high transaction costs, liquidity constraints, information asymmetry, lack of opportunities and infrastructure for arbitrage and inadequate physical infrastructure. Consumption is continuous and predictable, while food supply can be distorted by changes in weather patterns, making seasonal or spatial arbitrage critical. Demand for food is relatively inelastic to price and income changes up to a certain limit, additional supply for present consumption is not needed once maximum utility is achieved (Goodwin and Piggot 2001; Poulton, Kydd and Dorward, 2006). As much as consumption is continuous and relatively predictable, it is influenced by incomes, tastes and preference, and exhibits an elastic demand because of the possibility of substitution (McCorriston, *et al*., 2000).

Where markets are competitive, they make individual farmers to be price takers. Commodity price volatility is closely linked with the ability to store commodities. The inventory serves to bridge the gap between physical supply and demand. Without these inventories, prices dictate supply and demand.

Competition harnesses rivalry and profit–seeking behaviour at the market place, which in turn encourages the firms involved to seek innovations and new technologies, develop rules and regulations to govern the market place and, to some extent, regulate prices so as to minimize cost and maximize profits (Goodwin, 1994). Along the food marketing chain, the firms involved in value addition tend to exhibit oligopolistic and monopolistic types of competition, and

therefore influence the output prices, product and firm differentiation, market concentration, barriers to entry, location and information symmetry creating imperfections in the food marketing system (Kohls and Uhl, 2002; Kotler and Armstrong, 1999). The challenge is how to create a suitable meeting point between unattainable perfect competitive market conditions and the real world of imperfect competition in the food marketing system. Food markets in most developing countries are characterized by poor communication, inadequate storage and transport infrastructure, and poor organization of markets both physically and institutionally (Barrett and Mutambatsere, 2005).

The micro-level realities of food markets in most developing countries are constrained by such factors as those that are linked to weak or inadequate infrastructure (poor/impassable roads, storage and processing infrastructure), market information asymmetry, missing institutions (for example, lack of assurance on quality grades and standards), and incentives to adhere to them (Barrett and Mutambatsere, 2005; Goodwin, Greene and Wohlgenant, 1990).

2.3.1 Analysis of price trends

Price movements over time reflect changes in real prices which could be as a result of supply or demand forces. The time variable in the trend analysis enables measurement of the effects of the variables that influence the prices of agricultural products. The Cobweb theorem explains cycles in agricultural prices and production. The model was based on certain assumptions:

i) Price is determined in an atomistically competitive market environment in which no seller has a market share large enough to influence the price of the commodity on offer.

ii) Current prices are determined, in part, by available supplies which are subject to little or no modification in the immediate period.

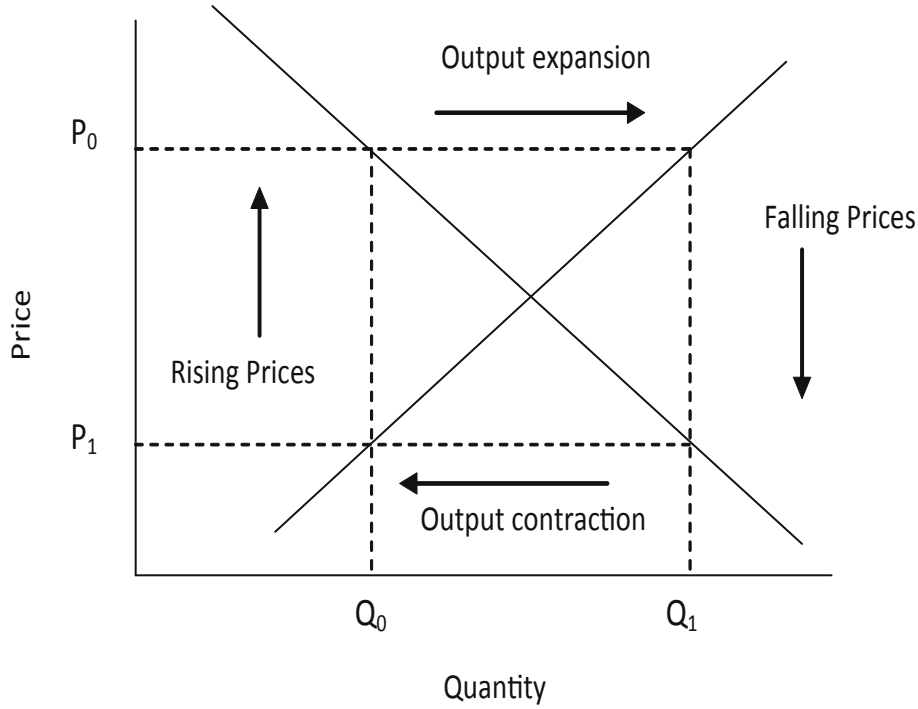
iii) Producers plan production for the next period primarily on the basis of recently observed prices.

iv) There is a lag of at least one production period between the time of a decision's produce and actual availability of the product(s).

v) Demand and supply relationships remain constant (i.e. coefficients that underlie key relationships remain constant).

Except in the short-run, markets for most agricultural products are price elastic (that is, they respond to changes in prices). Agricultural supply functions are of an 'inverted S' type (that is, obey law of diminishing returns). Theoretically, cycles in price and production are inversely related, high prices encourage new producers to begin production and exiting producers to expand output. The length of the

Figure 2.3: Illustration of cobweb agricultural price and output cycle



Source: Kohls and Uhl, 2002; Goodwin, 1994

agricultural price cycles (peak to peak) depends on the biological lags involved in producing the commodity (Figure 2.5).

2.3.2 Importance of price transmission

Price transmission estimates the responsiveness of prices between markets, usually defined as the percentage change in the price of one market given a one per cent change of the price in another market (Meyer and von Cramon-Taubadel, 2004; Kohls and Uhl, 2002; Peltzman, 2000). The markets are assumed to be perfectly competitive. This assumption implies that products are homogeneous (perfect substitutes), meaning there is no variation in quality. Traders are numerous such that none has any overbearing market power, traders have complete information, trading occurs instantly and there are no policy barriers to trade.

Transaction (including transportation) costs are a major factor in trade, particularly for staple food crops. A low value-to-bulk ratio implies that transportation costs are large, relative to the value of the product. Price transmission is said to be perfect when any price change in one market is quickly reflected in an equivalent change in other markets. In other words, the transmission elasticity would be unity (1.0). In this case, spatial arbitrage would ensure that the price of a commodity is the same in all markets.

If the difference between price in market A ( ) and in market B ( ) is greater than the cost of transportation between the two markets including taxes, risk and profits, then trade is profitable.

If $P_B^{\alpha} - P_A^{\alpha}$ .....(2.1)

Therefore, it will be profitable to move the commodity from A to market B. Trade will reduce the supply and raise the price in the exporting market (market A) and increase the supply and reduce the price in the importing market (market B), thus causing the prices in the two markets (PA and PB) to move towards each other. Spatial equilibrium is reached when

$P_B - P_A = c$, ...(2.2)

implying that traders would chose to be indifferent between trading and not trading. On the other hand, if the difference between the price in market A and in market B is less than the full cost of transportation (including taxes and risk), then it is not profitable to trade between the two regions.

If the direction of trade between the two markets regularly or frequently changes, price transmission will be imperfect. Trade reversals are not uncommon in agricultural markets because the supply of most crops is seasonal, so a region may export a crop during its harvest season and import it during the off-season (Stephen *et al.*, 2012; Minot, 2011; Moser *et al.*, 2009; Negassa and Myers, 2007).

2.3.3 Price transmission between integrated markets

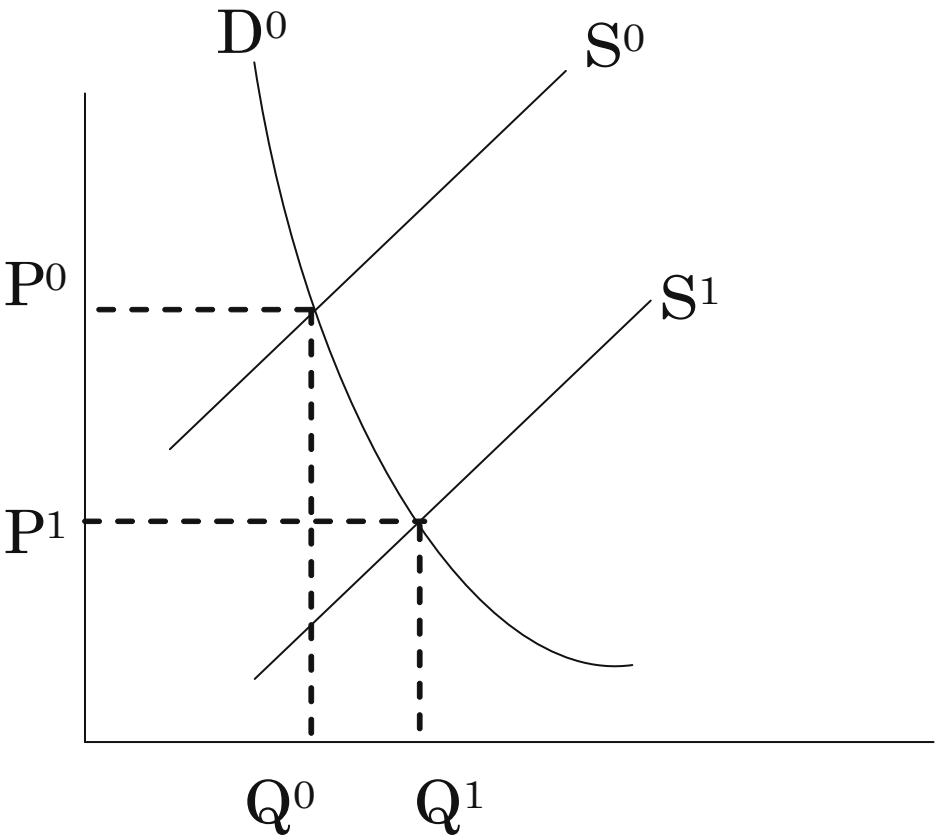
For most developing economies, there have been several constraints in the development of market–oriented food systems. The adoption of market liberalization as a policy reform agenda has exposed both the producers and consumers to considerable price changes (Byerlee, Jayne and Myers, 2006). Kenya has adapted a liberalized market economy, and therefore, it was expected that private food markets should be left to operate. However, during drought/ famine, the government tends to intervene by putting in place policies to protect either the consumers or the producers, often resulting in market failure (Barrett, 1999).

Food security responds to four interrelated dimensions of: (i) availability, (ii) accessibility, (iii) stability (in both availability and accessibility), and (iv) utilization. Providing a space for the growth of private markets is critical to attainment of the various dimensions of food security. For example, inadequate storage sometimes exacerbates the flow of food from informal markets and inhibits orderly flow of food from surplus-producing locations to deficit areas. Sometimes, food is re-distributed back to the surplus areas in a value-added form and this reflects on there being disincentives to investment in storage (Jayne and Tschirley, 2010; United Nations, 2010; Barrett *et al.*, 2005).

Food crops generally tend to have inelastic demand, therefore, increase in income growth and price change do not effect significant changes in the amount of food demanded. However, productivity growth tends to result in lower producer prices, which are not proportional to increase in demand (Abott, Hurt and Tyner, 2008). Figure 2.6 shows that increase in productivity leads to increase in supply, shifting the curve from S^0 to S^1. The demand for food crops is inelastic, therefore the market is not able to absorb the surplus. Thus, the actual quantity increases marginally from Q^0 to Q^1. In addition, most of the food markets are thin and farmers tend to dispose their produce immediately they harvest due to lack of or inadequate storage technology and facilities and, more importantly, to meet their financial obligations. This is also the case when food producing areas are poorly linked to food deficit, due to lack of adequate market infrastructure.

On the other hand, if there are improvements in crop production (for example, increase farm productivity), storage technology and market infrastructure, supply will increase from S^0 to S^1 (Figure 2.7). If the food producing areas are adequately

Figure 2.4: Illustration of food supply expansion with inelastic demand



Source: Adapted from Kohls and Uhl, 2002

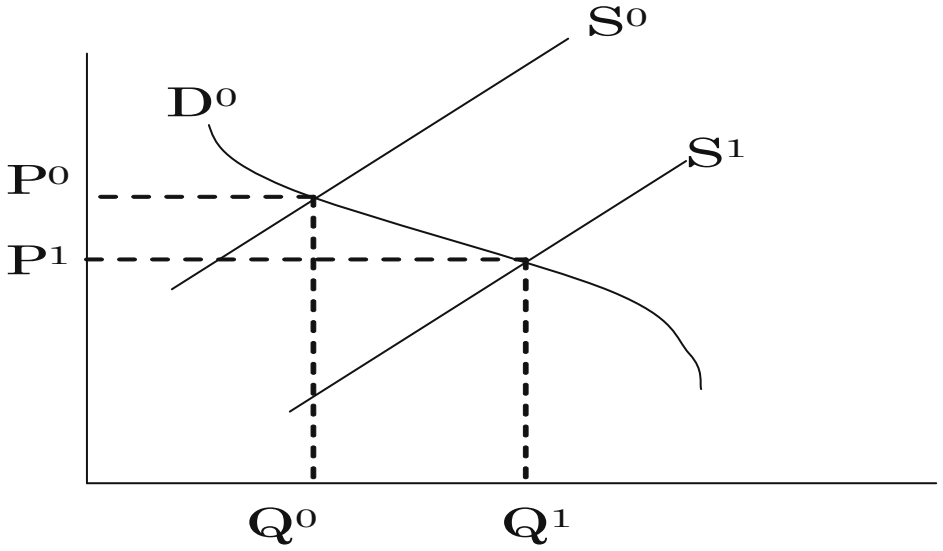
linked to food consumption areas, then the demand for food crops will become relatively more responsive to price changes (that is, elastic). The market would be able to absorb the increase in production Q^o to Q^1, with a minimal effect on the price which will change from P^o to P^1. This scenario will provide incentives for the farmers to produce at a cost that many consumers can afford. The optimistic scenario suggests that consumers tend to maintain their levels of consumptions with regard to price changes and functioning of food markets (United Nations, 2010; Smale and Jayne, 2003; Goodwin, 1994).

2.3.4 Measurement of market integration

The common tests for market integration when using price series data include (i) correlation analysis following the law of one price (Richardson, 1978), (ii) ravallion model (Ravallion, 1986), (iii) cointegration, and (iv) granger causality. One main criticism of the cointegration test is that it ignores transaction costs and assumes a linear relationship between the market prices, and this is not a sufficient condition for market integration implied by the spatial arbitrage conditions. One main cause of price difference between surplus and deficit areas is the transaction cost, which reduces market integration (Jayne and Tschirley, 2010; Baulch, 1997; Barrett, 1996; Faminow *et al*., 1990).

Cointegration focuses on the long-run relationships between bivariate or multivariate price series. Given prices for two (or more) spatial markets, the long-run price relationship can be obtained by running the following regression:

Figure 2.5: Illustration of food supply expansion with elastic demand



Source: Reardon and Timmer, 2005; Smale and Jayne, 2003

$$P_t^i = \alpha + \beta p_t^j + \varepsilon_t \quad \text{.....(2.3)}$$

where ε_t is the error term. These tests including β=1 in equation 2.3, is the test of the law of one price, implying that price changes in one market will be transmitted to other markets. If the price series is non-stationary, then the parameters are not valid since they are likely to be spurious. However, if the price series is stationary, that is, integrated in the same order, then equation 2.3 can be used to test for cointegration using the Johansen vector autoregression (VAR) method (Asche *et al.*, 1999). If the Johansen test indicates that there is a long-run relationship between the two variables, then we estimate the VECM. The model takes the following general form:

$$\Delta P_t = \alpha + \prod P_{t-1} + \sum_{k-1}^{q} \Gamma k \Delta P_{t-k} + \varepsilon_t \quad \text{.....(2.4)}$$

where P_t is an *n x 1* vector of n price variables;

Δ is the difference operator, so $\Delta pt = p_t - p_{t-1}$;

ε_t is an n x 1 vector of error terms;

α is an n x 1 vector of estimated parameters that describe the trend component;

Π is an n x n matrix of estimated parameters that describe the long-term relationship and the error correction adjustment; and

Γk is a set of n x n matrices of estimated parameters that describe the short-run relationship between prices, one for each of *q* lags included in the model.

3. Methodology

3.1 Estimating Price Trends in Agricultural Food Markets

Real prices for commodities tend to change and adjust over time and location due to a number of factors such as adaptation of new technologies, inflation, competition and other structural forces. If the trend in real prices is downward, it may imply that the rate of growth in market supply exceeds that of market demand and vice versa.

The price trends of dry maize, green maize and beans are:

i. A descriptive analysis of the price trends over January 1995 to May 2011 uses 197 monthly observation per commodity (dry maize, green maize and beans) in four spatial wholesale markets (Nairobi, Mombasa, Nakuru and Eldoret)

ii. The seasonal index was computed using the ratio-to-moving average

$$SF_t = P_t / CMA_t \quad (3.1)$$

where SF_t is the seasonal factor, P_t is the price, and CMA_t is centred, moving the average of the monthly prices for the different commodities.

3.2 Estimation of Market Integration and Price Transmission

The study used the vector error correction model (VECM) to examine the relationship between the commodity prices and the markets (Minot, 2011; Van Campenhout, 2007). The logarithmic transformation of average monthly prices is used. The following conditions were met:

i. Each variable is non-stationary and integrated to degree 1, written as I(1). This means that the variable follows a random walk, but the first difference (X_t-X_t-1) is stationary, written as I(0).

ii. The variables are cointegrated, meaning that there is a linear combination of the variables that is stationary. We are analyzing two prices at a time, so that the cointegrating equation would take the form of

$$P_1 = \alpha + \beta P_2 + \varepsilon or P_1 - \alpha - \beta P_2 = \varepsilon \quad (3.2)$$

where ε is stationary.

The analysis consists of three steps:

i. Test the price variables individually to see if they are I(1). This is done with the augmented Dickey-Fuller test and the Phillips-Perron test.

ii. Use the Johansen test to determine whether the two series are cointegrated, meaning that each variable is I(1) and a linear combination of the two variables is I(0). In terms of our analysis, this tests whether there is a long-run relationship between the prices in the spatial markets.

iii. If the Johansen test indicates that there is a long-run relationship between the two variables, then we estimate the VECM. The model takes the following general form:

$$\Delta Pt = \alpha + \prod Pt - 1 + \sum_{k-1}^{\alpha} \Gamma_k \Delta P_{t-k} + \varepsilon_{t-1} \quad \text{(3.3)}$$

where P_t is an n x 1 vector of n price variables;

Δ is the difference operator, so $\Delta p_t = p_t - p_{t-1}$;

εt is an nx1 vector of error terms;

α is an nx1 vector of estimated parameters that describe the trend component;

Π is an nxn matrix of estimated parameters that describes the long-term relationship and the error correction adjustment; and

Γk is a set of nxn matrices of estimated parameters that describe the short-run relationship between prices, one for each of q lags included in the model.

The VECM tests for the effect of each variable on each other variable. In the context of this study, the two-variables VECM test the effect of the different commodity prices in the different markets. In addition, the tests indicate that one lagged term is generally sufficient, therefore the interest is one portion of the VECM. This portion can be simplified as follows:

$$\Delta P_t^b = \alpha + \theta(P_{t-1}^a - \beta P_{t-1}^b) + \sigma \Delta P_{t-1}^b + \rho \Delta P_{t-1}^a + \varepsilon_t \quad \text{(3.4)}$$

where p_t^a is the log of market A price;

p_t^b is the log of market B price of the same commodity;

Δ is the difference operator, so $\Delta P_t = P_t - P_{t-1}$;

α, θ, β, δ, and ρ are estimated parameters; and

ε_t is the error term.

3.3 Data and Data Sources

The study uses monthly price series from four spatial wholesale markets, namely; Nairobi, Mombasa, Nakuru and Eldoret, covering the period between January 1995 and May 2011.

4. Results and Discussion

The analytical results are presented and discussed in three sections: (i) descriptive statistics for the dry maize, green maize and beans, (ii) trends in the commodity food prices, and (iii) spatial and cross–commodity price transmission between the domestic markets.

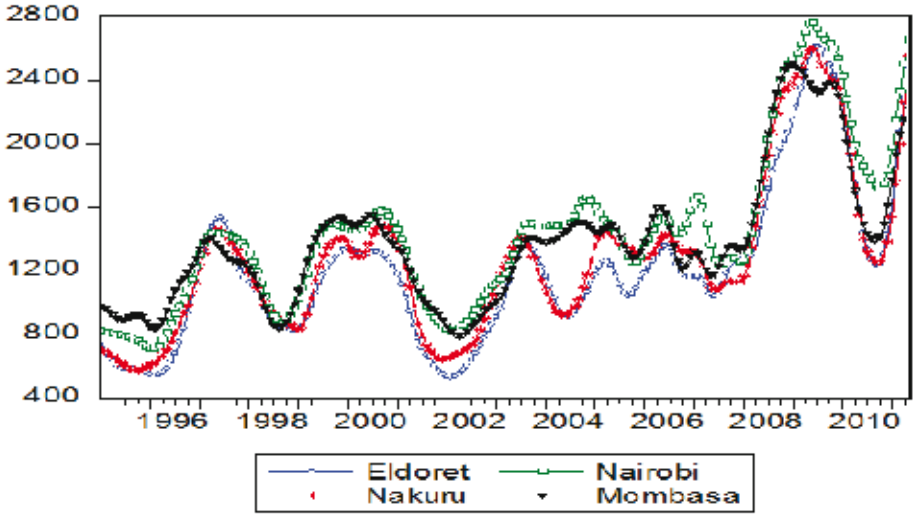
4.1 Descriptive Statistics of the Main Staple Food Commodities

Four staple commodities were used in this study where 196 observations were made per commodity in two consumption markets (Nairobi and Mombasa) and two producing markets (Eldoret and Nakuru).

4.2 Price Patterns for Dry Maize

Figure 4.1 shows the wholesale market prices in the selected agricultural production zones (Nakuru and Eldoret) and consumer markets (Nairobi and Mombasa) between January 1995 and May 2011. It is evident that the trend in the wholesale nominal prices has been on an upward trend. This can be partly attributed to inflation. The average monthly price is highest in Nairobi at Ksh 1,400 followed by Mombasa Ksh 1,300 and is almost the same in Nakuru Ksh 1,200 and Eldoret Ksh 1,200.

Figure 4.1: Wholesale dry maize price trends 1995-2011



Data source: Ministry of Agriculture, 2011

Table 4.1: Seasonality of dry maize production

	Seasonal index (calendar yr)			
	Dry Maize			
	Nairobi	**Mombasa**	**Nakuru**	**Eldoret**
High season	March	March	July	June
Low season	November December	October	December	December

The seasonal cycle for dry maize in the four markets is shown in Table 4.1, whereby the average monthly price of dry maize is highest in March for Nairobi and Mombasa, July for Nakuru and June for the Eldoret market. This is directly correlated to the maize cropping cycle.

4.3 Price Patterns for Green Maize

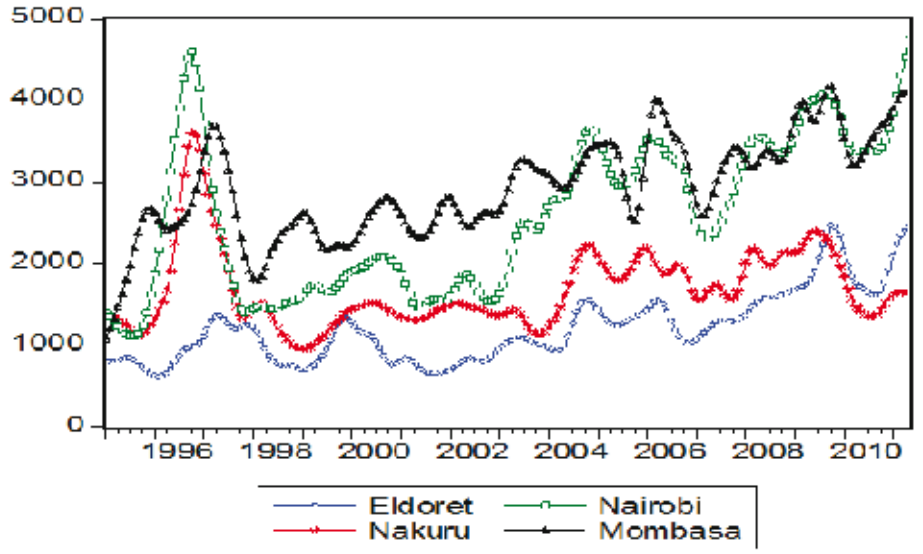
Figure 4.2 shows the wholesale market prices in the production zones of Nakuru and Eldoret and consumer markets of Nairobi and Mombasa between January 1995 and May 2011. It is evident that the trends in the wholesale prices have not varied much over time. The average monthly price is highest in Mombasa Ksh 2,800 followed by Nairobi Ksh 2,500, Nakuru Ksh 1,600 and lowest in Eldoret Ksh 1,200. Unlike dry maize, there is a distinction between prices in producer zones and consumption zones. Second, since 2006, there is a convergence in prices in consumption zones unlike production zones. Third, the transaction costs of green maize versus dry maize are comparably lower because brokers usually collect the green maize at the farm gate. Last, green maize is traded internally/domestic market, while dry maize is subject/affected by international price movements (Stephens *et al.*, 2012; Minot, 2011).

Table 4.2 shows that the price of green maize is highest in the months of May in the Mombasa and Nakuru markets, and April for the Nairobi and Eldoret markets. For the Nairobi market, there is adequate supply of green maize in the months of August, September and October, implying that the city benefits from the supply from the neighbouring towns, whose planting season is mainly in March and April.

Table 4.2: Seasonality of green maize production

	Seasonal index (calendar yr)			
	Green Maize			
	Nairobi	**Mombasa**	**Nakuru**	**Eldoret**
High season	April	May	May	April
Low season	August September October	September	September	July

Figure 4.2: Wholesale green maize price trends 1995 - 2011



Data source: Ministry of Agriculture, 2011

4.4 Price Patterns for Rosecoco Beans

Figure 4.3 shows the wholesale market prices in the production zones of Nakuru and Eldoret, and consumer markets in Nairobi and Mombasa between January 1995 and May 2011. The trends in the wholesale prices have been on an upward trend over time. The average monthly price is highest in Nairobi, Mombasa and Nakuru (Ksh 3,000) and lower in Eldoret (Ksh 2,800). The price for beans is high in May across all the four markets, and low in August for the three markets (Table 4.3), which can be attributed to the seasonal nature of the cropping cycle.

Figure 4.3: Wholesale rosecoco beans price trends 1995-2011

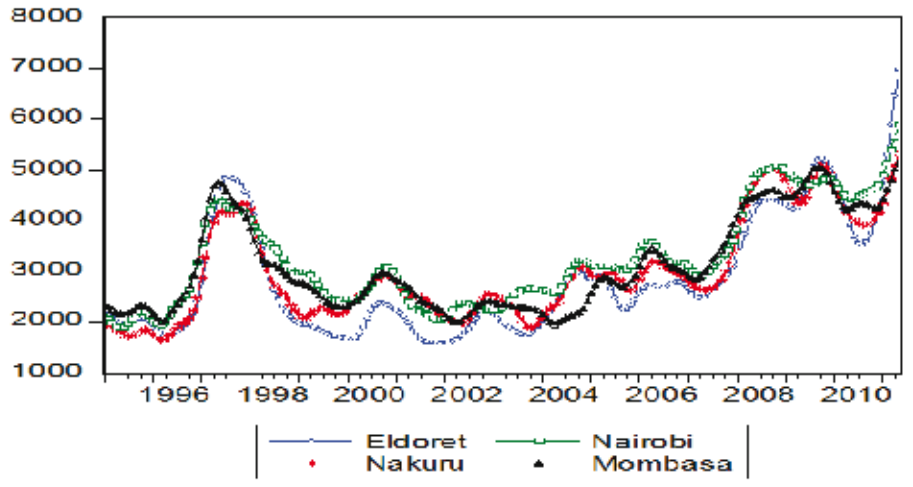


Table 4.3: Seasonality of rosecoco bean production

	Seasonal index (calendar yr)			
	Rosecoco			
	Nairobi	**Mombasa**	**Nakuru**	**Eldoret**
High Season	May	May	May	May
Low Season	August	July September	August	August

4.5 Spatial and Cross–Commodity Price Transmission

Price transmission shows the co-movement of prices in the different markets, thus serves as a proxy for indication of efficient and competitive markets. The first step in the analysis is to test for the presence of unit roots using the Augmented Dickey–fuller unit root test (1979). The series is differenced once to make the data stationary and the unit root shows that null hypothesis can be rejected at 5 per cent for all the price series and the series is integrated of order one I(1) (Appendix Table 1). Second, cointegration was carried out to determine the long run relationships between the markets. Both the trace test and Maximum Eigen value indicated that there were four co-integrating vectors for the following markets: Eldoret, Nakuru, Mombasa and Nairobi for each commodity, that is dry maize, green maize, and beans (Appendix Table 2). Taking to account Nakuru and Eldoret are producing markets, the model-run equation 2.7 with the markets as exogenous variables.

Table 4.4: Transmission of Eldoret prices to Nakuru, Nairobi and Mombasa markets

Location commodity	**Unit root**	**Long run relationship**	**Error correction model**		
	ADF test	Johansen Test	Speed of adjustment	Short run Adjustment	Long run Adjustment
Dry maize					
Nakuru	Yes	Yes	-0.53*	-0.17	0.01*
Nairobi	Yes	Yes	-0.94*	-0.37*	0.16*
Mombasa	Yes	Yes	0.83	-0.29*	-0.55*
Green maize					
Nakuru	Yes	Yes	-0.61*	-0.39	0.01
Nairobi	Yes	Yes	-0.53*	-0.60*	-0.09*
Mombasa	Yes	Yes	1.09	-0.22*	-0.18*
Beans					
Nakuru	Yes	Yes	-0.01*	-0.75*	-0.06*
Nairobi	Yes	Yes	0.06	0.19*	-0.5*
Mombasa	Yes	Yes	-0.28*	-0.60*	-0.22*

* Level of significance is 5 per cent

Table 4.4 shows that Eldoret and Nairobi markets for dry maize have a long run relationship. The speed of adjustment (-0.94) shows that the dry maize prices are transmitted relatively quickly between the two markets. Green maize recorded relatively quick speed of adjustment of the transmitted prices (-0.61 Nakuru), and positive results for Nairobi indicate that the prices in that market were already high (0.53), with a long run transmission proportionate change of 1 per cent and 9 per cent, respectively. Most of the coefficients are significant, suggesting strong relationships between the markets.

In reference to the speed of adjustment, the negative sign implies that the prices will adjust quickly to a value consistent with its long-run relationship in the long run. While the positive sign shows that dry and green maize in Mombasa are too high and are not transmitted accordingly in the long run; for the short run and long run adjustments, the negative sign implies that the prices are diverging.

Table 4.5 gives a summary of the Nakuru market; the dry maize prices are transmitted to the Nairobi market and cause an 88 per cent proportionate change in the prices in the long run with a short term transmission of about 7 per cent. The short term transmission to the Eldoret and Mombasa causes a 93 per cent and 69 per cent proportionate change respectively, with a long run transmission proportionate change of 16 per cent and 1 per cent, respectively. Green maize prices show an 83 per cent and 61 per cent proportionate change in the Nairobi and Mombasa market respectively in the long run, with the Nairobi market

Table 4.5: Transmission of Nakuru prices to Eldoret Nairobi and Mombasa markets

Location commodity	**Unit root**	**Long run relationship**	**Error correction model**		
	ADF test	Johansen Test	Speed of adjustment	Short run adjustment	Long run adjustment
Dry maize					
Eldoret	Yes	Yes	0.022*	-0.93*	0.16*
Nairobi	Yes	Yes	-0.35*	0.07*	0.88
Mombasa	Yes	Yes	-0.12*	-0.69	0.01*
Green maize					
Eldoret	Yes	Yes	-0.40*	-0.65*	0.08*
Nairobi	Yes	Yes	- 0.17*	-0.62*	0.83
Mombasa	Yes	Yes	0.71	-0.02*	0.61
Beans					
Eldoret	Yes	Yes	0.01	-0.82	0.05
Nairobi	Yes	Yes	-0.14	0.28	0.26
Mombasa	Yes	Yes	0.01	-0.69	0.03

Note= *Significant at 5 per cent

adjusting by 62 per cent in the short run. This can be attributed to the spatial location of the markets.

The coefficients are not significant suggesting a weak relationship between the markets for beans. A 26 per cent proportionate change of the Nakuru bean prices are transmitted to the Nairobi market. The negative sign implies that the prices are diverging.

The speed of adjustment for prices on transmission is fast for green maize in the Eldoret market. The other commodities record fairly slow adjustment speeds, and incomplete adjustment to long run prices for dry maize in Eldoret; green maize and beans in Mombasa.

4.6 Cross-Commodity Price Transmission Elasticities

Table 4.5 shows the cross commodity price transmission, basically an increase in the price of dry maize causes a 71 per cent increase in the price of beans which is a complementary commodity that is used to make the maize and beans mixture. The price of green maize, a supplementary commodity, changes by 50 per cent in the Nairobi market. In the producer market like Nakuru, the effect is the same.

4.7 Synthesis of the Results

The results show that the markets in the country are not efficient, though the markets are integrated and price transmission does occur. The trend results show that there is a general rise in the price of commodities. The possible explanations for this scenario are:

i. Information flow between production and consumption areas is critical for market integration to occur. There is information asymmetry compounded by poor rural road infrastructure. This is a common phenomenon in developing countries, whereby the spatial markets are connected by poor road infrastructure, thus accruing high transport costs (United Nations, 2010).

ii. Co-movement and completeness of adjustment implies that changes in prices in one market are fully transmitted to the other, measured by the speed of

Table 4.5: Cross- commodity price transmission elasticities

	Nairobi market – consumer market	**Nakuru market – producer market**
Dry maize		
Green maize	0.50	0.58
Beans	0.71	0.77

adjustment. Price transmission is incomplete in the short run, but complete in the long run. However, in the markets studied, price transmission is not complete in the long run.

(a) Wholesalers or middlemen have market power in the food marketing chain, hence increasing the transaction costs in the effort to maximize profit; and

(b) The lack of or inadequate infrastructure to facilitate arbitrage.

4.8 Interventions to Mitigate Food Insecurity

The results show, in the long run, the transmission of prices between the markets is slow and not large despite the distinct production cycles that have low and high seasons. There is information asymmetry necessitated by poor infrastructure (physical and virtual). Some of the interventions that could be used to mitigate food insecurity are:

(a) Facilitate and upscale market information sharing;

(b) Invest in increasing storage, physical and virtual infrastructure to facilitate market integration;

(c) Provide incentives to increase food production; and

(d) Provide incentives to encourage private public partnership in the distribution and marketing of food commodities.

5. Implications for Policy

The study showed that there is high variability of price across seasons and between successive market years, therefore, emphasis should be put in stabilizing staple food prices. Food insecurity should be handled in a holistic manner through targeted investments and market-based production policies. There is need to improve the efficiency of food markets through improvement of infrastructure, including storage, transportation, information communication technology (ICT) and market information. Some of the possible interventions that can be put in place include:

i) Use of commodity markets

The commodity markets could be either a cash or spot markets and/or derivates or a futures market. The exchange will serve two purposes: First, it can raise agricultural productivity by ensuring substantial margins for farmers. Second, it can reduce inefficiencies of agricultural marketing by streamlining trading, delivery and payment systems and consequently, reducing transaction costs.

ii) Develop physical market infrastructure

Many markets in the country generally lack adequate basic facilities for storage, cooling, ripening and platforms for display of fresh produce, in addition to lacking proper sanitation (for example, running water, toilets and disposal bins). Investments in this area will go a long way in providing marketing platforms for producer, trades and consumers to access food.

iii) Facilitate/develop warehouse receipt systems

This system will facilitate storage of produce at a fee, thus ensuring that quality produce delivered to the warehouse retains its quality and standard throughout the storage period. Two goals will be achieved through this intervention; one, assured prices which allow for surplus production to continue; and second, the food security needs of the population.

iv) Encourage diversification of staple food diets

Efforts should be made to encourage diversification of staple food diets among the Kenya population through concerted campaigns to promote indigenous and assorted exotic crops grown in different regions in the country.

5.1 Areas for Further Research

The error correction model measures the degree of co-movement in nominal prices regardless of whether the price difference justifies trade between the two

locations. Additional information is required on the "threshold" price difference, below which co-movement ceases. The threshold can be considered a measure of the actual marketing cost between the two markets, including profit and risk premiums.

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Appendix

Table 1: Augmented Dickey Fuller (ADF) unit root test

Variable	Test statistics
Eldoret dry maize	-7.879763 I(1)
Eldoret green maize	-17.80570 I(1)
Eldoret irish potato	-9.932799 I(1)
Eldoret beans	-12.20495 I(1)
Nakuru dry maize	-7.817949 I(1)
Nakuru green maize	-13.81456 I(1)
Nakuru irish potato	-11.07773 I(1)
Nakuru beans	-15.60936 I(1)
Mombasa dry maize	-24.08334 I(1)
Mombasa green maize	-11.09940 I(1)
Mombasa irish potato	-9.058550 I(1)
Mombasa beans	-17.72173 I(1)
Nairobi dry maize	-25.86187 I(1)
Nairobi green maize	-19.77178 I(1)
Nairobi irish potato	-10.97177 I(1)
Nairobi beans	-10.55359 I(1)

The figures in parentheses are the order of integration. The Mackinnon critical values for the Augmented fuller test at 5% significance are -3.46 and -2.98 for first difference

Table 2: Cointegration test–Dry maize (DLELDDMAI DLNKUDMAI DLMBADMAI DLNRBDMAI)

Hypothesized No. of CE(s)	Trace Statistic	0.05 Critical value	Max-Eigen Statistic	0.05 Critical value
None *	253.7106	47.85613	84.34234	27.58434
At most 1 *	169.3683	29.79707	78.82699	21.13162
At most 2 *	90.54130	15.49471	57.18982	14.26460
At most 3 *	33.35147	3.841466	33.35147	3.841466

The trace test and max-eigenvalue test indicate 4 cointegrating eqn(s) at the 0.05 level

* denotes rejection of the hypothesis at the 0.05 level

Table 3: Cointegration test-Green maize (DLELDGMAI DLNKUGMAI DLMBSGMAI DLNRBGMAI)

Hypothesized	**Trace**	**0.05**	**Max-Eigen**	**0.05**
No. of CE(s)	Statistic	Critical Value	Statistic	Critical Value
None *	283.3059	47.85613	92.21878	27.58434
At most 1 *	191.0871	29.79707	80.32317	21.13162
At most 2 *	110.7640	15.49471	73.58730	14.26460
At most 3 *	37.17665	3.841466	37.17665	3.841466

Trace test and max-eigenvalue indicate 4 cointegrating eqn(s) at the 0.05 level

* denotes rejection of the hypothesis at the 0.05 level

Table 4: Cointegration test-Irish potato (DLELDAPO DLNKUAPO DLMBAWPO DLNRBWPO)

Hypothesized	**Trace**	**0.05**	**Max-Eigen**	**0.05**
No. of CE(s)	Statistic	Critical value	Statistic	Critical value
None *	272.6598	47.85613	95.42045	27.58434
At most 1 *	177.2393	29.79707	74.99736	21.13162
At most 2 *	102.2419	15.49471	63.74395	14.26460
At most 3 *	38.49800	3.841466	38.49800	3.841466

Trace test and max-eigenvalue test indicate 4 cointegrating eqn(s) at the 0.05 level

* denotes rejection of the hypothesis at the 0.05 level

Table 5: Cointegration test-Beans (DLELDROSE DLNKUROSE DLMBSAROSE DLNRBROSE)

Hypothesized	**Trace**	**0.05**	**Max-Eigen**	**0.05**
No. of CE(s)	Statistic	Critical value	Statistic	Critical value
None *	263.0075	47.85613	101.2434	27.58434
At most 1 *	161.7641	29.79707	79.69892	21.13162
At most 2 *	82.06518	15.49471	48.50214	14.26460
At most 3 *	33.56304	3.841466	33.56304	3.841466

Trace test indicates 4 cointegrating eqn(s) at the 0.05 level

* denotes rejection of the hypothesis at the 0.05 level

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