AN EVALUATION OF THE TRANSMISSION OF INTERNATIONAL WHEAT PRICES INTO KENYA'S DOMESTIC MARKET

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DECLARATION

This thesis is my original work and has not been presented for examination in any other University.

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DEDICATION

I dedicate this work to my parents my wife and our unborn baby and my siblings for the continuous love and support.

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LIST OF ABEVIATIONS AND ACRONYMS

ADF:	Augmented Dickey-Fuller
AIC:	Akaike Information Criterion
CBK:	Central Bank of Kenya
CGA:	Cereal Growers Association
DF:	Dickey-Fuller
ECM:	Error Correction Model
FAO:	Food and Agriculture Organization of the United Nations
FOB:	Free on Board
GBHL:	Grain Bulk Handlers Limited
GIEWS:	Global Information and Early Warning Systems
HQIC:	Hannan and Quinn Information Criterion
I(d):	Integrated of order d
I(1):	Integrated of order 1
IMC:	Index Market Connection
JML:	Johansen Maximum Likelihood
KNBS:	Kenya National Bureau of Statistics
KSHS:	Kenya shilling
LOP:	Law of one Price
MT:	Metric tonne
NCPB:	National Cereals and Produce Board
OLS:	Ordinary Least Squares
PBM:	Parity Bound Model
PP:	Phillips-Perron
SIC:	Schwarz Information Criterion
SSA:	Sub-Saharan Africa
TAR:	Threshold Autoregressive

VAR: Variance Autoregressive

VECM: Vector Error Correlation Model

USD: United State Dollar

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ABSTRACT

The prices of most food commodities in the international market have increased in the recent past. Thus, there is need to understand, the extent to which the increase in food prices is transmitted to the domestic market from the world market. Little information is available on the degree of transmission of world wheat prices into the domestic market in Kenya. The study seeked to evaluate the transmission of international wheat prices to the Kenyan domestic market. The purpose of the study was to evaluate the transmission of international wheat price into domestic markets in Kenya.

The study employed an Error Correlation Model (ECM) on monthly wholesale prices for the period 2002-2014 to evaluate the transmission of international wheat prices into Kenya's domestic market. The international wheat price data was obtained from FAO GIEWS, while domestic wheat prices in Kenya was collected from the Ministry of Agriculture, Livestock and Fisheries. The study found out that there exist a long-run steady state equilibrium between the Ukrainian and the Kenyan wheat prices. The long-run elasticity of price transmission is estimated at 0.78 to show that 78 percent of the changes in the Ukrainian wheat prices are transmitted to the Kenyan domestic market. The speed of adjustment is estimated at -0.08 which implies that it takes about 13 months for the wheat price changes in Ukraine to be fully transmitted to the Kenyan market.

The Kenyan government should improve infrastructure in the rural areas to allow for easy movement of goods and services. The government should create conducive environment for local production of wheat. It should also promote production of other staple foods to supplement wheat in case of higher prices. The study also recommends that the government should create competition in grain handling in order to reduce cost and time of handling.

CHAPTER 1: INTRODUCTION

1.1 Background information

The 2008/09 food price crisis led to sharp increases in food prices all over the world and depleted food reserves in most developing countries. Real prices of almost all commodities increased substantially all over the world. According to the Food and Agricultural Organization of the United Nations, (FAO, 2008), the food price index increased by 57 per cent between March 2007 and March 2008 as compared to a rise of nine per cent the previous year. On the other hand, the global prices of wheat, maize, and soybeans doubled while rice prices tripled between January 2006 and beginning of 2008 (Minot, 2010).

A number of possible causes of the persistent increase in food prices were identified by several studies including Brahmbhatt and Christiaensen, 2008, Braun 2007, FAO 2008 and World Bank, 2008. The causes included low levels of world cereal stocks due to extreme weather, failure of crops in major exporting countries, an increase in population, increase in urbanization, and an increase in demand for biofuels. Other causes included escalating oil prices which affected fertilizer use, food production, transport and distribution and hence an increase in food prices.

Speculation in food markets was also identified as one of the causes of the rise in food prices. Other factors that caused the food crisis include restrictions of export by main exporting countries, weakening of the US dollar and financial crisis. The crisis mainly affects the net food buyers who resort to cheaper foods and reduce non-food spending budget.

According to Minot (2010) the food crisis was severe in Sub Saharan Africa (SSA) since most countries are net importers of food and agricultural commodities. This leads to trade imbalances in a situation of higher prices. A large number of families are net buyers of staple food crops and hence feel the effect of the high food prices. Most households earn low incomes and as such, a larger share of their budget is taken by food with a range of 50 to 70 percent, (Minot (2010)).

Kenya was mainly affected by the 2007 post-election events, which escalated the crisis and led to further food price increases. As a result of the post-election violence, many households were displaced from the agricultural rich areas. This caused a reduction in the production of food commodities. A reduction in production of the food crops led to an increase in the food prices across the country. According to Emongor (2011), food prices in Kenya have been on the increase since the period 2007-2008. Prices of staple foods, which include wheat, have been on a steady rise and this has led to volatility of the food prices.

The prices of food commodities in Kenya continued to remain considerably high even though the world food prices reduced, (Emongor, 2011). Increase in food prices is caused by different factors classified as demand side factors and supply side factors. The demand side factors include increase in population, rapid urbanization, low incomes, and an increase in demand for food products for biofuel production, (Emongor, 2011). Supply side factors include declining agricultural productivity, high input prices, decline in world food stocks, climate variability, under investment in agriculture and poor infrastructure.

The prices of staple crops increases considerably in the international market. Wheat prices like other staple crops have been increasing globally. According to Mittal (2009), wheat prices increased by 127 percent during the period 2005 to 2008. The prices of wheat in the world almost doubled during the global food crisis. Since Kenya is dependent on imports, the high prices are transmitted to the local market. The domestic prices of wheat in Kenya have continued to increase despite a reduction in the international prices. This shows a poor degree of price transmission from the international market to the domestic market (Emongor, 2011).

According to Nzuma (2013), domestic wheat prices in Kenya increased at a higher rate compared to the international wheat prices and this suggests the existence of protectionist domestic policies. Wheat is the second most essential cereal in Kenya after maize. It is the most important food import in Kenya. According to FAO (2013), wheat in Kenya is the second most vital agricultural commodity both in terms of amount and the calories consumed. The demand for wheat is high in urban areas that mostly depend on it for their diets. According to the KNBS (2015), wheat is a major food import commodity in Kenya. The country imports approximately five times what it produces.

Unlike other food-security related commodities like maize and rice that are imported in significant quantities from other East African countries; wheat is sourced from world markets. According to KNBS (2015), the average annual domestic production of wheat in Kenya in 2014 was 486,000 MT. Imports of wheat in the same year were 1,275,000 MT while exports were negligible with about 7,000 MT, and retention for seed was 11,000 MT.

The total supply; that is domestic production and exports, was an average of 493,000 MT of which domestic production account for about 99 percent. Average national consumption in 2014 was 1,644,000 MT, which included imports. Out of the total consumption, imports accounted for about 78 percent while the remaining 22 percent accounted for processed wheat, and wheat retained for seed. Exports accounted for about 2 percent of the total domestic production.

Imports of unmilled wheat increased in quantity by 18.6 percent from 1,033.1 thousand tonnes in 2013 to 1,275.7 thousand tonnes in 2014 (KNBS, 2015). A continuous increase in the demand of wheat and wheat products has led to the quantity of wheat imports increasing yearly since 2010 except in 2013 when there was a marginal drop in import level. The total domestic production of 486 MT does not meet the domestic demand of 1,644 MT. This deficit in 2014 was met through imports of 1275 MT (KNBS, 2015).

In spite of the continuous increase in wheat production over the last three years, the share of local production in wheat supply has remained below 15 percent (KNBS, 2015). Wheat in Kenya is mainly grown in small, medium and large scale. The Cereal Growers Association (CGA) defines large scale farmers as farmers who own all their farm machinery and implements and cultivate 100 or more acres of wheat while medium scale farmers may own some machinery and cultivate from 20 to 100 acres. Small scale farmers are those who cultivate less than 20 acres and hire machinery. Wheat is grown in areas with an altitude of above 1500 metres above sea level, FAO (2013). These areas include Nakuru, Laikipia, Narok, Uasin Gishu, and Trans Nzoia counties. The average acreage under production of wheat in Kenya increased slightly in 2013 from about 150,000 ha in 2012 to 163,000 ha in 2013, FAO (2013).

Kenya mainly produces soft wheat and imports all of its hard wheat requirements (Nzuma, 2013). Soft wheat has lower protein content than hard wheat and its flour has small particle sizes while that of hard wheat has coarser particle size, (Carter, Galloway, Morris, Weaver, & Carter, 2015). According to FAO (2013), millers blend the imported hard wheat varieties with the soft wheat in 40:60 ratios in order to produce a flour quality that meets Kenyan market demands. The Kenyan soft wheat is of low quality compared to imported wheat and a quality premium is used to reduce the price of imported wheat to make it comparable with the Kenyan wheat (FAO, 2013). The quality premium effectively reduces the reference price to be compared with the Kenyan price.

According to Gitau *et al*, (2011), most of Kenya's wheat import is from Argentina, United States of America, Ukraine and Russia with Argentina being the main source in 2004 and 2005. In 2004 imports averaged about 400,000 MT with Argentina contributing about sixty-four percent of the total import. USA contributed six percent of the total imports while the remaining thirty percent was shared among Russia, Ukraine, and other countries. In 2007 the total imports averaged 600,000 MT with imports from Russia being thirty-two percent of the total imports. Twenty-seven percent of the imports were from Argentina and twenty percent from Ukraine, (Gitau *et al*, 2011).

Russia and Ukraine became important sources of wheat from 2005 with Russia's proportion increasing overtime. Russia imposed an export ban in 2010 and this increased the world prices Gitau *et al*, (2011). The average imports for 2013 were 764,000 MT with 34 percent of the total imports coming from Russia, 25 percent of the total imports from Ukraine, 11 percent from Argentina five percent from Pakistan and four percent from USA (FAO, 2014).

According to Gitonga and Snipes 2014, most of Kenya's imports come from the Black sea region (Russia and Ukraine). In October 2015, the price of the US hard winter wheat was USD 221 per MT while the price in Argentina was USD 224per MT (FAO, 2015). The price in Russia and Ukraine averaged USD 196 per MT. The Kenyan price of wheat in the same period averaged USD 330 per MT. The price of wheat in Kenya is higher than the world prices. According to Gitau *et al,* 2011, the US Gulf CIF price of wheat in July 2010, was USD 221 per ton. The price is then translated to USD 276 per ton after clearance from the port and transported to the warehouse.

Factoring the transport charges and the duty charged on the imports, the world prices and the domestic prices will tend to be equal. This is the basis of the study to assess whether the world prices are transmitted to the domestic market. Since Kenya imports most of its wheat, changes in international prices will have an effect on the prices of the wheat in the domestic market. In March and April 2014, the price of wheat in Ukraine was US $247/MT and US $240/MT respectively. The price of wheat in Mombasa in the same months were US $ 694/MT and US $692/MT. this shows that an increase in price in the international market tend to raise the prices in the domestic market.

Price transmission refers to the co-movement shown by prices of the same good in different locations (Conforti, 2004). According to Fackler, 2002, the basic notion in analysis of price transmission mechanisms is the Law of One Price (LOP) which follows the spatial arbitrage condition where the variance in prices in different places will not exceed the cost of transportation. Real prices may deviate from the spatial arbitrage condition in the short run but the actions of the arbitrageurs are anticipated to make it effective in the long run by moving the price towards the transport cost, (Goodwin and Piggott, 2001). Price transmission occurs when two markets are integrated.

According to Rapsomanikis *et al*, (2003), the notion of price transmission can be better understood based on three main components: co-movement of prices, speed of adjustment, and asymmetry of response. Co-movement of prices means that a change in price in one market is fully transmitted to the other market at all points of time. Speed of adjustment refers to the rate at which the changes in prices are transmitted to the other markets and asymmetry of response means the process in which transmission differs according to whether prices are increasing or decreasing (Prakash, 1999; Balcombe and Morrison, 2002).

According to Rapsomanikis *et. al*, (2003) factors such as trade policy distortions, wide marketing margins due to market power, the quality of the commodity, inadequate trader access to finance and poor road connectivity between markets are impediments to transmission of price signals. This implies that change in price of a commodity in one market may not be transmitted immediately to the other market because of non-trivial transportation and transaction costs, market power, foreign policy impediments, long supply chains and complex contractual arrangements between marketing agents, storage, and transportation delays, processing and price-levelling.

There has been substantial increase in food prices globally over the past few years. Wheat is a staple food in Kenya and the production locally cannot meet the local demand. Kenya imports more than it produces and hence depends on the international market to meets its growing demand. As a result, the local prices are dependent on the international price. A large percentage of families live in the rural areas and are net buyers of staple food crops and hence feel the effect of high food prices. Therefore, it is important to understand how the prices from the world market affect the domestic market.

1.2 Statement of the problem

Kenya imports most of its wheat in order to meet the domestic demand. Local production is not sufficient to meet the local demand. Local prices are thus affected by the world prices. In the past few years, the price of cereals in the world have been increasing and the prices trickle down to the domestic market. In essence, the increase in prices should increase the income of local producers subject to cost of production.

A key issue to try to understand in spite of the increase in food prices is the extent to which the increase in prices is transmitted from the world market to the domestic market. Most of the wheat imported in Kenya is the hard wheat that is mixed with the soft wheat by millers in a 40:60 ratio to produce the flour quality that meet the local demand. The prices of wheat in the domestic market is dependent on the price of wheat in the international market and the extent of the transmission is not quite known. There has been growing trend on analyzing transmission of prices but little is known on the transmission of wheat prices to the domestic market. There is no empirical study done on price transmission of wheat in Kenya and hence the connection between world prices and the domestic prices is not well known.

An understanding of the relationship between world wheat prices and Kenya's wheat prices will shed more light on price transmission trends. It also sheds light on the likely impact of rising world food prices on Kenya's economy. It helps to understand the extent to which the international prices are transmitted to the domestic market. A study of price transmission will help provide important information on how markets are integrated domestically.

1.3 Purpose and objectives of the study

The purpose of this study is to evaluate the transmission of international wheat price into domestic markets in Kenya.

The specific objectives of this study are:

i. To assess the integration of wheat markets in Kenya.
ii. To assess the transmission of world wheat prices to Kenya's domestic wheat markets.

1.4 Hypotheses to be tested

The hypothesis to be tested are; that

i. Kenyan wheat markets are not integrated.
ii. There is no transmission of wheat prices between Kenya and Ukraine.

1.5 Justification of the study

Wheat is the second most important cereal in Kenya after maize, KNBS (2015). Kenya's domestic production does not meet the demand and therefore the country imports in order to meet the excess demand. According to KNBS (2015), sustained demand for wheat and wheat products in Kenya has led to a rising quantity of imports. The share of local production out of the total wheat supply has remained below 15 percent (KNBS, 2015). This study is in line with the Agenda 4 on food security to all Kenyans and an increase in income for all farmers.

An understanding of how price changes in a country is of economic significance since it provides a forecast on how producers and consumers in the local market react to the changes in the external market (Kilima, 2006). The study will give an understanding of the Kenyan wheat market in relations to the world market. This study is in line with Kenya's Agricultural Sector Development Strategy (ASDS, 2010-2020) which targets a nation that is food secure and prosperous with the overall goal of the agricultural sector achieving an average growth rate of 7 per cent per year. The strategy has, among others, target to reduce food insecurity by 30 per cent to surpass the MDGs by the year 2015 (Republic of Kenya, 2010).

It is helpful in identifying the possible reasons for the fluctuating wheat prices in the Kenyan market. It helps to know how shocks from one market affect another and this will help policy makers in understanding the trend in prices and hence guide in policy making. The study will help identify possible actions and policies for support from the government and the actors in the wheat sector. It helps to identify points of intervention that can lead to formulation of pricing policies to help in food security status in Kenya and eliminate extreme poverty and hunger.

CHAPTER 2: LITERATURE REVIEW

This chapter presents the theoretical approaches used to analyze price transmission and reviews some relevant empirical evidence on price transmission analysis.

2.1 Theoretical review

There are various approaches used to analyze price transmission, which could be either linear or non-linear. Linear approaches include the correlation coefficient and regression model, Granger causality, Ravallion model, Co-integration and error correction models. Non-linear models include Parity Bound Model (PBM), Threshold Auto-regressive model.

Simple regression and correlation analysis are the oldest method used in the study of price transmission. According to Hossain and Verbeke (2010), regression analysis approach involves the estimation of a bivariate correlation and regression coefficients of a product which is similar in different markets. This approach is based on the notion that there is a co-movement of prices between markets that are integrated (Ankamah-Yeboah, 2012). According to Nkendah and Nzouessin (2006), regression method entails a static regression approach. The static regression analysis is used to find an equation of best fit in a particular data set.

The method has some advantages and one of it is that it gives information to calculate transmission elasticity that takes into account effects of inflation and seasonality (Nkendah and Nzouessin, 2006). One disadvantage of this approach is that it is believed to give misleading results if the data used is non-stationary.

The correlation coefficient indicates the degree of relationship between two variables, (Abdulai, 2007). The correlation coefficient ranges between 0 and 1, where 1 shows perfect correlation and 0 is no correlation. High correlation shows that the markets are integrated that is it shows co-movement and is a sign of an efficient market. One advantage of this method according to Abdulai, (2007) is that it is easy to calculate and understand since the coefficient of determination, R^2 indicates share of variation in one variable explained by other variables.

The Correlation Coefficient approach has a number of limitations, which could lead to making misleading conclusions. One of the weaknesses according to Cirera and Arndt, (2006) is that correlation does not imply casuality. The co-movement of prices can occur for various reasons other than the integration of markets. The parallel movement could occur due to exogenous trends such as inflation, seasonality, autocorrelation and heteroscedastic residuals in the regression with non-stationary price data (Basu, 2006). Barrett, 1996 asserts that correlation test may overestimate absence of market integration if lag in price response is caused by lags in market information.

Granger causality test is yet another approach used to analyze price transmission. This approach was proposed by Granger, 1969 and improves on the single bivariate correlation and regression tests. According to Granger, 1986, Granger causality shows the relationship between the current value of one value and the past values of others. It provides an indication whether price transmission is taking place between two markets and the direction of flow (Granger, 1969). It refers to the idea of causality in terms of lead and lag relationships: significant coefficients of the lagged prices imply that shocks to price in one market induce significant responses in another after some lags (Granger, 1969).

According to Judge *et. al*, 1988, if there are two price series, P_t^i and P_t^j, P_t^i granger-causes P_t^j if both the current and lagged values of P_t^i improves the accuracy of forecasting P_t^j. This approach has its weaknesses in that Granger causality tests include their sole dependence on the statistical difference of the coefficients of the lagged exogenous variables in the models to deduce the relationship between the concurrent and lagged prices. Fackler and Goodwin, 2001 asserts that there could be a statistically significant relationship that is inconsistent with the conventional ideas of market integration and be mistaken as evidence of market integration.

The Ravallion model has been used to analyze price transmission. Ravallion (1986) formulated a dynamic model of spatial price differentials, which allows distinction between short-run and long-run market integration and market segmentation. According to Rapsomanikis, *et.al*, (2003), the Ravallion model was an improvement compared to the correlation and regression model and the Granger causality since it made provisions for other variables that affect prices. Ravallion's 1986 model specifies a radical framework in which several rural markets are connected to a central market, and his test for market integration shows whether the price of a good in a given rural, producer market is influenced by its price in a central market.

According to Fackler and Goodwin, 2002, this model shows that the price in one market is influenced by current and lagged prices in all the other markets and its own lags. Rapsomanikis, *et al.* (2003) note that various hypotheses can be tested using this model, which includes, the market segmentation, central market, short-run and long-run market integration hypotheses. This model became the standard tool as it provided more comprehensive assessment of markets inter-relationships and resolved many of the shortfalls of the previous approaches.

It also gave rise to a series of extension for instance Timmer in 1987 extended the usefulness of Ravallion's approach through an index of market connection (IMC) that gives an easily comprehensible measure of short-run market integration between two markets. However, the interpretation of the IMC is still ambiguous; because a larger value of IMC, for example, might indicate that markets are not integrated or that markets are integrated but transport costs exhibit a higher degree of persistence. In the same way, a low IMC suggests that markets are not isolated but it is unclear how connected the markets are (Kilima, 2006).

The price in any of the other markets is influenced by the current and lagged values of the price in the first market and its own lagged values only. This approach has a number of limitations. In as much as it mitigates the disadvantages of the simple bivariate correlation model it is still faced with serious problems that can lead to inefficient estimators. One of the major problems is the non-stationarity of the price series and the inappropriate application of transformation on these series (Abdulai, 2000). Barett, 1996 asserts that the assumption of radial market structure does not always hold due to inter-seasonal flow reversals and direct trade links between regional markets.

The problem of non-stationarity in the series data is not addressed even with the constant changes in the models above. Hence the technique of co-integration of time series data was developed by Engel and Granger in 1987. According to Conforti, (2004), co-integration between the price series data shows that even though prices may behave differently in the short run, they converge to a common behaviour in the long-run due to economic forces such as market mechanism and government intervention.

There are two commonly employed approaches in obtaining co-integration vectors and determining existence of market integration. The approaches are the two-step approach of Engel and Granger (1987) used for bivariate models and the Johansen vector autoregressive (VAR) approach. The first step in both approaches is to test that the price series are non-stationary and integrated of the same order. These tests are done using the Dickey-Fuller (DF), Augmented Dickey-Fuller (ADF) and the Phillips-Perron (PP) approaches.

Engel and Granger (1987) proposed that to test for co-integration, one would need to estimate the co-integration between price series by using Ordinary Least Squares (OLS) and then analyze the residuals from the regression. Co-integration of the series means that OLS is a consistent estimator and the residuals are stationary. The approach has a number of limitations which include its inability to factor in more than one co-integrating relationships (Delgado, 1986; Myers, 1994). Stock and Watson, (2003) asserts that the prices can simultaneously influence one another, which lead to the problem of endogeneity.

Even though Abunyuwah, (2007) notes that the Error Correction Model (ECM) presentation has brought about considerable understanding into long-run market relationships price dynamics, Barett and Li, (2002) has criticized the methods. This is because the techniques assume linear relationships between market prices and therefore tends to violate consistent market integration condition.

The above techniques for analyzing price transmission all ignore the importance of transaction costs. This led to introduction of a class of models known as the switching regime models which include threshold autoregressive (TAR) and the parity bound models (PBM). These models both integrate price and transaction costs series and are quite widely used in analysis of agricultural price series (Rapsomanikis *et al*., 2003)

The threshold autoregressive (TAR) model was developed by Balke and Fomby (1997) and Enders and Granger (1998). It addressed the issue of transaction costs and price asymmetry across spatially separated markets. It evidently recognizes the effect of transaction costs met by traders on spatial market integration and account for them (Amikuzuno, 2010). The inter-market price disparities must exceed the threshold bands from transaction costs, before provoking prevailing market equilibrium and triggering price adjustment to guarantee market integration. Regime switch in the threshold models is initiated when a forcing variable meets a predefined threshold between a pair of markets. In addition to transaction costs, TAR models can analyze asymmetries in price adjustment (Enders and Granger, 1998). This method has a number of limitations. According to Barrett, (1996), transaction costs may not be constant in the long-run and may even be non-stationary. This model is mainly limited to longer time series.

The parity bound model (PBM), was introduced by Baulch (1997). To analyze market integration, the PBM explicitly factors in transaction costs and allows trade flow reversals to take place. According to Kilima, (2006), PBM allows for a variety of inter-market price relationships within the range of perfect market integration and complete market segmentation.

Fackler (1996) criticizes this model and asserts that there is no connection between economic theory and the distributional assumptions used in the switching regime models. Another criticism is that this model addresses a small number of markets only. The results obtained may be misleading since the model considers short-run deviations from the equilibrium as inefficiency whereas it may be representing traders' responses to the lags in information and commodity flows. Transaction costs may be difficult to measure due to some unobservable components such as sunk costs, risk premium and variable returns to scale (Barrett, 1996).

2.2 Empirical Review

Several studies have evaluated price transmission in SSA on various cash and food crops. This section reviews past related empirical works that have been undertaken in the subject of price transmission in the recent past.

Abdulahi (2000) analyzed spatial price transmission and asymmetry in the Ghanaian maize market using the threshold co-integration tests on data for the period May 1980 to October 1997. The study found out that major maize markets in Ghana are well integrated. Results show that increases in wholesale maize prices from the central market appears to be passed rapidly to the local markets while reductions in prices take more time to be passed on to the local markets. Both the threshold co-integration and asymmetric error correction models show that wholesale prices of maize in local markets Accra and Bolgatanga respond more swiftly to increase in prices than decreases in prices in central market Techiman prices. Accra prices responded faster than Bolgatanga prices as a result of changes in Techiman market prices.

The study analyzed vertical price transmission in Ghana from the central market to the other markets. The model used assumes constant transaction costs over time. The present study analyzes price transmission of wheat prices from the world market to the domestic Kenyan market using a Vector error correction model.

Babatunde and Labuschagne (2014) analyzed the transmission of world maize price to South African maize market using a threshold co-integration approach. The study adopted a Bayesian approach on maize prices for the period January 2000 to December 2010. The approach allows for comparison of models using the Bayes factor. The study found out that there is non-linearity in price transmission between the South Africa and the rest of the world. Small changes in world prices do not affect the domestic market but only large deviations in the world prices are transmitted.

Large long-run deviations in price are transmitted. Global prices take longer to be transmitted to South African prices when the market is trading at export parity compared to import parity. The model used assumes that the transaction costs are constant over time and this is not the case. The current study uses the Vector Error Correction Model (VECM) to analyze the price transmission of wheat in the Kenyan market.

Tuyishime (2014) analyzed the transmission of international prices into Rwanda’s rice market using a VECM. The study employed monthly time series for the period 2002 to 2012 for four domestic markets; Kigali, Umatara, Ruhengeri and Butare. The study found out that both the Rwandan rice market and the world rice markets are integrated.

It also found out that the international prices are transmitted to the domestic market at a range of between 68 to 82 percent. Butare market takes 4 months to adjust to world prices while Kigali takes 3 and half months. Ruhengeri takes 5 months to adjust to world prices while it takes four months for Umatara market to adjust to world prices. The study analyses price transmission form world prices to four different domestic markets.

The present study uses a similar approach in the analysis of price transmission, but mainly focuses on transmission of world prices to the domestic wheat market in Kenya. The current study mainly focuses on Kenya as a whole. Rwanda is a landlocked country and most of the commodities pass through Kenya.

Tebogo (2015) assessed the transmission of South African maize prices into Botswana market. The study employed cointegration techniques and an error correction model on wholesale monthly price data for the period 2000 to 2013. The study found out that there exist a long-run steady state equilibrium between the South African and Botswana maize prices. A long run elasticity of price transmission of 0.86 was estimated, implying that 86 percent of the changes in the South African maize prices are transmitted to the Botswana market. The price of maize in Botswana takes about 13 months to adjust to the price changes in South Africa.

The current study uses a similar approach of Vector Error Correction Model but differs from the current study since it mainly focuses on wheat as the commodity of study. Transaction costs are likely to differ while in the study under review the transaction costs are deemed constant.

CHAPTER 3: METHODOLOGY

3.1 Theoretical framework

The analysis of spatial price transmission is based on the Law of One Price (LOP) which follows the spatial arbitrage condition that the price of a homogeneous commodity at any two spatially separate markets will differ by the cost of moving the goods from the region of lower price to the region with higher price (Fackler, 2002). A proportional increase in the international price will lead to an equally proportional increase in the domestic price at all points in time assuming markets are perfectly integrated (Mundlak and Larson, 1992).

The spatial arbitrage condition can be expressed following Fackler and Goodwin (2002) as;

$$P_j - P_i \leq R_{ij} \quad \ldots\ldots(3.1)$$

Where P shows the prices in the two locations i and j, which are spatially separated while R_{ij} is the cost of transportation of the good from location i to j.

This is a strong form of LOP which can be expressed as follows;

$$P_j = P_i + R_{ij} \quad \ldots\ldots(3.2)$$

If a relationship such as (3.2) holds, the markets can be said to be integrated and hence price transmission will occur (Rapsomanikis, *et al*. 2003).

According to Fackler and Goodwin (2001), the relationship between two spatially separated markets whose prices are P_t^1 and P_t^2, and allowing for transfer costs c, for transporting the goods from market 1 to market 2 is:

$P_t^1 = P_t^2 + c$………………………………………………………………………………… (3.3)

Where P_t^1 and P_t^2 are prices of two separate markets 1 and 2, and c is the cost of transporting the goods from market 1 to market 2.

Minot (2010) argues that if the cost of transportation c is large it will create a large band within which each price can fluctuate without inducing trade and reconnecting the two prices. The full cost of transportation will be larger in case the distance between the markets is large, the infrastructure is poor, the tariffs and other trade taxes are high, and if trading is particularly risky (Minot, 2010). If the relationship between prices holds as shown in (3.3), the markets can be said to be integrated.

According to Conforti (2004), the LOP is expected to regulate spatial price relations; the premises of full price transmission and market integration correspond to those of the standard competition model. Even though prices may not behave as explained by LOP due to market distortions, they tend to have a co-movement between markets and they might behave differently in the short-run and in the long-run (Conforti, 2004). The LOP can either be weak or strong from of LOP (Fackler and Goodwin 2001). The strong form of LOP is as shown in (3.3) and the weak form of LOP is the spatial arbitrage condition.

This is a situation whereby the prices of a homogeneous good at two different locations will differ by at most the cost of moving the good from the region with the lower price to the region with a higher price (Fackler and Goodwin, 2001). This situation is as illustrated below;

P_t^2 - $P_t^1 \leq c$ …………………………………………………………………………… (3.4)

According to Fackler and Goodwin (2001), the relationship in (3.4) represents an equilibrium condition. Actual prices may diverge from this relationship but the action of arbitrageurs will in a well-functioning market tend to move the price spread toward the transport cost (Fackler and Goodwin, 2001).

3.2 Empirical models

Analysis of price transmission uses price data to measure relationship between prices in two markets. It can be either between world and domestic prices or between local prices of the same commodity in different markets (Food security portal, 2012). According to Minot, (2010), price transmission can be analyzed in two ways; vertical and spatial price transmission. Vertical transmission analysis evaluates the relationship between upstream and downstream markets. On the other hand, spatial transmission analysis evaluates the relationship between prices in geographically separated markets. With efficient markets and no price distortions, price changes for any commodity in the world market should be similarly reflected in the changes in domestic prices. This is called price transmission (Keats *et al*, 2010). Domestic prices may not change as expected due to issues like exchange rates, border costs, transfer costs and product differentiation (Keats *et al*, 2010).

Price transmission analysis proceeds in three steps that includes; tests for data non-stationarity, test for co-integration and estimation of the error correction model.

3.2.1 Unit root tests

According to Gujarati (2003), most empirical work based on time series data assume that the underlying time series is stationary. Time series data is said to be stationary if its mean, variance and covariance are time invariant; that is, they do not change over time, (Gujarati, 2003). If that is not the case, the data is said to be non-stationary. Data non-stationarity implies that; mean variance and covariance are time variant; that is they change over time. The first step in estimation of price transmission is to determine whether the individual price series are non-stationary (integrated of order one).

According to Vavra and Goodwin, (2005), a variable is said to contain a unit root if it is non-stationary. A time series that contains a unit root is known as a random walk. Vavra and Goodwin (2005), define random walk as the process where the current value of a variable is composed of the past value plus an error term which is defined as a white noise (a normal variable with zero mean and a variance of one). The purpose of the unit root tests is to determine whether the series is integrated of order one (I(1)) process with a stochastic trend (Nelson and Plosser, 1982 and Juselius 1993). The most commonly used tests for the presence of unit root tests are the Augmented Dickey-Fuller (ADF) and the Phillips Perron (PP) tests.

Following Gujarati, 2003 the ADF is specified as follows;

$$\Delta Y_t = \beta_1 + \beta_2 t + \delta Y_{t-1} + \sum_{i=1}^{m} \alpha_i \Delta Y_{t-1} + \mathcal{E}_t \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3.5)$$

The ADF test tests for the null hypothesis that a time series is integrated of order one (non-stationary) that is; the time series has unit root, against the alternative that it is integrated of order zero (stationary) that is there is no unit root.

Where Y_t is the time series being tested, t is the time trend variable, m is the number of lags added to the model, Δ denotes the first difference and $\mathcal{E}_t$ is the pure white noise error term with zero mean and constant variance. ADF tests the null hypothesis that $\delta = 0$ meaning that there is a unit root and the time series is non-stationary against the alternative that $\delta < 0$ that is, the time series is stationary.

The actual estimation procedure of the ADF test is to difference a variable and regress it on its lagged value e.g. $\Delta Y_t = \delta Y_{t-1} + \mu_t$. Then divide the estimated coefficient of $\Delta Y_{t-1}$by its standard error to compute the *t* (tau) statistic and refer to the Dickey-Fuller (DF) tables. If tau statistic exceeds the DF or MacKinnon critical tau values, the null hypothesis that $\delta = 0$ is rejected. On the other hand, if the computed absolute value of tau does not exceed the critical tau value, we fail to reject the null hypothesis that the time series is non-stationary (Gujarati and Sangetha, 2007). If the unit root null hypothesis is rejected for the first difference of the series but cannot be rejected for the level, then we say that the series contains one unit root and is integrated of order one I(1).

According to Greb *et al*., (2012), before performing ADF stationary tests, it is necessary to include the number of lagged variables. The number of lagged terms is chosen to ensure the errors are uncorrelated. Several selection statistics are available including sequential likelihood ratio tests and the information criteria such as Akaike Information Criteria (AIC), Hannan and Quinn Information Criteria (HQIC) and Schwarz Information Criteria (SIC). According to Ivanov and Kilian (2005), the likelihood ratio tests underperform the information criteria. The performance of the information criteria mostly depends on the frequency and the size of the data. AIC tends to dominate both HQIC and SIC for monthly data as sample size increases. Thus this study will use AIC.

The Phillips and Perron (PP) test use non-parametric statistical methods to take care of the serial correlation in the error terms without adding lagged difference terms, Gujarati, (2003). Phillips and Perron (1988) developed a generalization of the Dickey-Fuller procedure that allows for fairly mild assumptions concerning the distribution of errors. Thus the PP test unlike the ADF test allows the disturbances to be weakly dependent and heterogeneously distributed (Enders, 2004). Phillips and Perron (1988) specified the test for unit root test as follows:

$$X_t = c + \beta\left(t - \frac{T}{2}\right) + \rho X_{t-1} + v_t \quad \ldots\ldots (3.6)$$

Where X_t is the respective time series, T is the sample size, $(t - \frac{T}{2})$ is the time trend and v_t is the white noise error term.

PP tests is similar to the ADF in that it tests the null hypothesis that $\rho = 0$ meaning that there is a unit root and the time series is non-stationary against the alternative that $\rho < 0$ that is, the time series is stationary. The PP tests correct for any serial correlation and heteroskedasticity in the errors v_t of the test regression and directly modifying the test statistics (Sahu, 2015). Under the null hypothesis the test statistics have the same asymptotic distributions as the ADF t-statistic and normalized bias. If the calculated value is greater than the absolute critical value, then we reject the null hypothesis and conclude that the time series is stationary.

One advantage of the PP tests over the ADF tests is that PP tests are more robust to general forms of heteroskedasticity in the error term (Zivot and Wang, 2007). The PP tests are also more powerful than the ADF tests in small samples.

3.2.2 Co-integration tests

If the stationarity tests reveal that the series is integrated of order one, I(1), then the co-integration of the time series is tested. A vector of variables is said to be co-integrated if each variable in the vector has a unit in its univariate representation, but some linear combination of these variables is stationary (Engle and Granger, 1987). According to Gujarati (2003), two variables are said to be co-integrated if they have a long term or equilibrium relationship between them. There are two possible procedures that might be applied on price series to test for co-integration and they include; Engle and Granger (1987) approach and the Johansen Maximum Likelihood (JML) method.

Engle and Granger (1987) developed a simple procedure to test for co-integrations which comprises the static co-integrating regression (using OLS) and applying unit root tests. Engel and Granger (1987) proposed that to test for co-integration one would first need to estimate co-integration between price series by OLS and then analyze the residuals from the regression.

The first step is to estimate the following regression;

$$y_t = \beta x_t + u_t \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3.7)$$

Where y_t and x_t are non-stationary variables and integrated of order one, that is y_t ~ I(1) and x_t~ I(1). According to Dolado *et al*, (1990), if the variables are co-integrated, an OLS regression will give a super-consistent estimator denoted as $\hat{\beta}$ implying that the coefficient β will converge faster to its true value than using OLS on stationary variables, I(0). For y_t and x_t to be co-integrated, the necessary condition is that the estimated residuals from equation 3.5 should be stationary. The analysis involves testing the residuals of the co-integrated regression for unit root using ADF and PP tests.

The null hypothesis for the EG tests is that the estimated residual is non-stationary and the variables are not co-integrated and the alternative hypothesis is that the estimated residual is stationary and the variables are co-integrated. If the null hypothesis is rejected, the variables in the model are co-integrated. If the null hypothesis is not rejected, it means that the variables are not co-integrated.

The second step is estimating a short run model with an ECM by using OLS (Engle and Granger, 1987). If the residuals of the co-integrating regressions are found to be stationary, then co-integration exists. One of the limitations of using OLs in general is that it can only identify one co-integrating vector even when there are many variables in the system (Dolado *et al*., 1991).

The Johansen co-integration test is a means of testing for co-integration in a multivariate context, where there is a possibility of more than one co-integrating vectors, (Johansen and Juselius, 1990). The Johansen method relies on a vector autoregression (VAR) model. A VAR is a model that includes more than one dependent variable. According to Brooks (2008), the simplest form of VAR can be specified as follows;

$$y_t = \beta_1 y_{t-1} + \beta_2 y_{t-2} + \ldots + \beta_k y_{t-k} + \mathcal{E}_t \quad \ldots\ldots \quad (3.8)$$

Where β is the coefficients to be tested, *k* denotes the number of lags included, y_t is a *n*x1 vector of variables that are integrated of order one, t is the time period, and $\mathcal{E}_t$ is the error term.

In the Johansen test, the VAR model is transformed into a Vector Error Correlation Model (VECM) by differentiating;

$$\Delta y_t = \Pi y_{t-1} + \sum_{i=1}^{k-1} \Gamma_1 \Delta y_{t-i} + \mu + \mathcal{E}_t \quad \ldots\ldots \quad (3.9)$$

Where Π is the long run coefficient matrix, Γ_1 is the matrix of short run coefficients and $\mathcal{E}_t$ is the vector of independently normally distributed errors.

The matrix Π contains the co-integrating vectors and a set of loading vectors, which determine the weight of the co-integrating vectors in each single equation. The focus is on the Π matrix where we test the rank (r) of this matrix (Hubana, 2013). The rank is equal to the number of characteristic roots (Eigen values denoted as λ), that are significantly different from zero. That means that the rank (r) will give us the number of cointegrating vectors in a system of variables. According to Enders (2008), two tests are used to test for co-integration and the number of co-integrating vectors, *r* in the Johansen method; the trace test and the maximum Eigen value test. They are specified as follows;

$\lambda_{trace}(\mathrm{r}) = -T\sum_{i=r+1}^{n}\ln(1 - \hat{\lambda}_i)$ ………………………………………………..………..... (3.10)

$\lambda_{max}(\mathrm{r,r+1}) = -T\ln(1 - \hat{\lambda}_i)$ ……………………………………………….……………….. (3.11)

Where T is the number of observations, $\hat{\lambda}_i$ is the estimated eigenvalue of order *i*.

The trace statistic tests the null hypothesis of *r* co-integrating vectors against the alternative hypothesis of *n* co-integrating vectors where *n* is the number of endogenous variables r=0,1,..n-1. The maximum Eigen value tests, tests the null hypothesis of *r* co-integrating vectors against the alternative hypothesis of *r + 1* co-integrating vectors.

The distribution of the two test statistics is not standard and the critical values depend on the value of *(g - r*) and the deterministic terms included (Johansen and Juselius, 1990). If the test statistics is larger than the critical value, the null hypothesis of no co-integration is rejected. The critical values can be found in Johansen and Juselius (1990), and are provided by most econometric software packages. The critical values are provided too by Osterwald-Lenum (1992).

The conclusion about the number of co-integrating relations is derived from the first instance where the null hypothesis cannot be rejected thus giving the rank of the co-integration. Failure to reject the null hypothesis implies that there are no *r* co-integrating vectors while the rejection of the null hypothesis means that there exist *r* co-integrating vectors. This indicates that there is an elastic relationship between the two prices and hence allowing for estimation of price transmission using ECM.

The Johansen approach is faced with some limitations. According to Utkulu (1997), the approach is not useful whenever there is a small sample size since the point estimates obtained for co-integrating vector may not be meaningful as such. Secondly, if there is no unique co-integrating vector, some problems might occur. The Johansen approach has an advantage over the Engle-Granger approach since it has the capacity to deal with models conformed by numerous endogenous variables (Bugueiro, 2010) thus allowing for estimation of multiple co-integrating vectors.

The JML method provides not only the direct estimates of the co-integrating vectors but also enables construction of tests for the rank of co-integration, r (Utkulu, 1994). The JML possess various advantages than the EG method. It is efficient in dealing with multivariate price series obtained from markets in which the direction of causality of price transmission among the markets is unknown (Johansen, 1995). It treats all markets as endogenous and handles the response of the different variables to market shocks simultaneously.

3.2.3 Price transmission analysis

Price transmission is a measure of the effects of price changes in one market on prices in another market, Minot, (2010). If there is a long run relationship between the price series, then an ECM of price transmission can be estimated.

According to Acquah and Owusu (2012), an ECM is an efficient way of combining the long run co-integrating relationship between the levels variables and the short run relationship between the first differences of the variables. The process of differencing results in the loss of valuable long run information in the data so an error correction term is introduced in the theory of co-integration to integrate the short run dynamics of the series with its long run value. The residuals that are obtained from the equation are introduced as explanatory variables into the system of variables in levels.

The error correction term hence captures the adjustment towards long run equilibrium. A Vector Error Correction Model is a type of ECM that is used to distinguish short term from long-term association of variables included in the model. The VECM is an extension of the VAR models which relates the current levels of a set of time series to lagged values of those series (Engle and Granger, 1987)

The VECM takes a general form as shown in equation (3.9) which is an extension of the VAR model.

According to Minot (2010), the VECM model for a small importing country takes the following general form;

$$\Delta p_t = \alpha + \Pi p_{t-1} + \sum_{k=1}^{q} \Gamma_k \Delta p_{t-k} + \varepsilon_t \text{ .... (3.12)}$$

Where;

p_t is the *n*x1 vector of *n* price variables,

Δ is the difference operator,

ε_t is an *n*x1 vector of error terms,

α is an *n*x1 vector of estimated parameters that describe the trend component,

Π is a set of *n*x*n* matrices of estimated parameters that describe the long-term relationship and the error correction adjustment,

Γ_k 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.

According to Minot (2010), the VECM tests for the effect of each variable on the others. It can test for the effect of world prices on the domestic prices and vice versa. However, since most countries in SSA are considered small countries in trade, there is little value in testing the effect of the domestic prices on the international prices. According to Minot (2010) and Greb, *et al*. (2012), the interactions between international or world prices and domestic prices take the following VECM form;

$$\Delta p_t^d = \alpha_1 + \theta_1(p_{t-1}^d - \beta_1 p_{t-1}^w) + \delta_1 \Delta p_{t-1}^w + \rho_1 \Delta p_{t-1}^d + \mathcal{E}_{1t} \text{ .... (3.13)}$$

$$\Delta p_t^w = \alpha_2 + \theta_2(p_{t-1}^d - \beta_1 p_{t-1}^w) + \delta_2 \Delta p_{t-1}^w + \rho_2 \Delta p_{t-1}^d + \mathcal{E}_{2t} \text{ .... (3.14)}$$

Where;

$(p_{t-1}^{d}$ - $\beta_1 p_{t-1}^{w})$ is the error correction term, p_t^d is the domestic price, p_t^w is the world price and α, θ, β, δ and ρ are parameters to be estimated.

The equation can be written in matrix form and allowing for more than one lag of the price difference terms as follows;

$$\begin{bmatrix}\Delta p_t^d \\ \Delta p_t^w\end{bmatrix} = \begin{bmatrix}\alpha_1 \\ \alpha_2\end{bmatrix} + \begin{bmatrix}\theta_1 \\ \theta_2\end{bmatrix} [1\ \beta_1] \begin{bmatrix}p_{t-1}^d \\ p_{t-1}^w\end{bmatrix} + \sum_{i=1}^{k} \begin{bmatrix}\delta_{1i} & \rho_{1i} \\ \delta_{2i} & \rho_{2i}\end{bmatrix} \begin{bmatrix}p_{t-1}^w \\ p_{t-1}^d\end{bmatrix} + \begin{bmatrix}\mathcal{E}_{1t} \\ \mathcal{E}_{2t}\end{bmatrix} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3.15)$$

According to (Minot, 2010) the expected signs and values of the coefficients in the error correction model above can be interpreted as follows; the co-integration factor (β) is the long run elasticity of the domestic price with respect to the international price, that is long run elasticity of price transmission. The expected value for imported commodities is $0 < \beta < 1$. The error correction coefficient (θ) reflects the speed of adjustment and it is expected to fall in the range of $-1 < \theta < 0$. $(p_{t-1}^{d}$ - $\beta_1 p_{t-1}^{w})$ represent the deviation between the prices in the previous period and the long run relationship between the two prices.

If the error is positive (the domestic price is too high given the long term relationship), then the negative value of θ helps correct the error by making it more likely that the Δp_t^d is negative. The larger the θ in absolute terms, the more quickly the domestic price will return to the value consistent with its long run relationship to the world price.

The coefficient on change in the world price, δ, is the short run elasticity of the domestic price relative to the world price. It represents the percentage adjustment of domestic price one period after 1 percent shock in international price and its expected value is $0 < \delta < \beta$. The coefficient on the lagged change in the domestic price, ρ, is the autoregressive term, reflecting the effect of each change in the domestic price on the change in domestic price in the next period and its expected value is $-1 < \rho < 1$.

Following Minot (2010), the study concentrated on testing effect of international price on domestic price since most SSA countries, Kenya included are considered small trading countries in the staple food market, that is the country is a price taker in the international market therefore its actions have no effect on the international commodity prices. Hence, the following model was estimated;

$$\Delta p_t^{Msa} = \alpha + \theta\left(p_{t-1}^{Msa} - \beta p_{t-1}^{Ukr}\right) + \delta \Delta p_{t-1}^{Ukr} + \rho \Delta p_{t-1}^{Msa} + \mathcal{E}_t \quad \text{(3.16)}$$

$$\Delta p_t^{Nkr} = \alpha + \theta\left(p_{t-1}^{Nkr} - \beta p_{t-1}^{Ukr}\right) + \delta \Delta p_{t-1}^{Ukr} + \rho \Delta p_{t-1}^{Nkr} + \mathcal{E}_t \quad \text{(3.17)}$$

$$\Delta p_t^{Eld} = \alpha + \theta\left(p_{t-1}^{Eld} - \beta p_{t-1}^{Ukr}\right) + \delta \Delta p_{t-1}^{Ukr} + \rho \Delta p_{t-1}^{Eld} + \mathcal{E}_t \quad \text{(3.18)}$$

Where;

p_t^{Msa}: is the log of Mombasa price at time t converted to US dollars,

p_t^{Nkr}: is the log of Nakuru price at time t converted to US dollars,

p_t^{Eld}: is the log of Eldoret price at time t converted to US dollars,

p_t^{Ukr}: is the log of Ukraine price at time t in US dollars.

3.3 Data sources

The study employed monthly wholesale price series for the period 2002-2014 for both domestic prices and the international prices. International prices were obtained from the Global Information and Early Warning Systems (GIEWS) of the Food and Agriculture organization of the United Nations (FAO). The international wheat prices that were used are the export Free on Board (FOB) prices for milling wheat in Ukraine. Domestic prices were obtained from the Ministry of Agriculture, KNBS and NCPB for the following markets; Mombasa, Nakuru and Eldoret markets. The domestic prices in Kenya shillings was converted to US dollars. Exchange rate was obtained from the Central Bank of Kenya (CBK).

CHAPTER 4: RESULTS AND DISCUSSIONS

This chapter presents the results of the study. It begins with the presentation of the descriptive results. The presentation of the descriptive is then followed by a discussion of the econometric results generated from the VECM.

4.1 Descriptive results

Table 4.1 represents the descriptive statistics of the wheat price series in Kenya and Ukraine. The prices cover a period of 13 years from January 2002 to December 2014, which corresponds to 156 observations. The prices are quoted in US dollars per metric tonne. The prices used are from three markets in Kenya, which include Mombasa, Nakuru, and Eldoret and prices from Ukraine.

Table 4.1: Monthly wheat prices for the period 2002- 2014 (US$/MT)

Market	Mean	Maximum	Minimum	Standard Deviation	N
Ukraine (US$/MT)	168.59	334.30	72.10	72.51	156
Mombasa (US$/MT)	461.96	786.27	251.16	146.37	156
Nakuru (US$/MT)	398.15	636.26	250.41	87.26	156
Eldoret (US$/MT)	398.97	651.60	221.95	96.24	156

Source: Author's computation

On average, the price of wheat in Kiev, Ukraine was $168.59 per MT while that of Kenya was $461.96, $398.15, and $398.97 in Mombasa, Nakuru, and Eldoret respectively. The maximum price ranges from $334.3 in Ukraine to $786.27 in Mombasa while the minimum price ranges from $72.10 in Ukraine to $221.95 in Eldoret. The prices of Nakuru and Eldoret are higher than in Mombasa since Nakuru and Eldoret are main wheat growing areas in Kenya.

The standard deviation for Kiev, Ukraine is $72.51 while that of Kenya is $146.37, $87.26 and 96.24 for Mombasa, Nakuru, and Eldoret respectively. This shows that there is less variation in the international prices compared to the domestic prices. Eldoret showed a high variability in prices compared to other domestic markets. The domestic prices are highly volatile compared to the international price.

Figure 1 shows some fluctuations in the domestic prices unlike in the international market where prices seem to be constant with little fluctuations. Both markets show an increase in prices in the period 2007-2008. This is the period of the food crisis, but the domestic prices increased sharply. The descriptive analysis provides the pattern of wheat market prices in Kenya compared to international wheat prices. The domestic price is relatively high compared to the international prices.

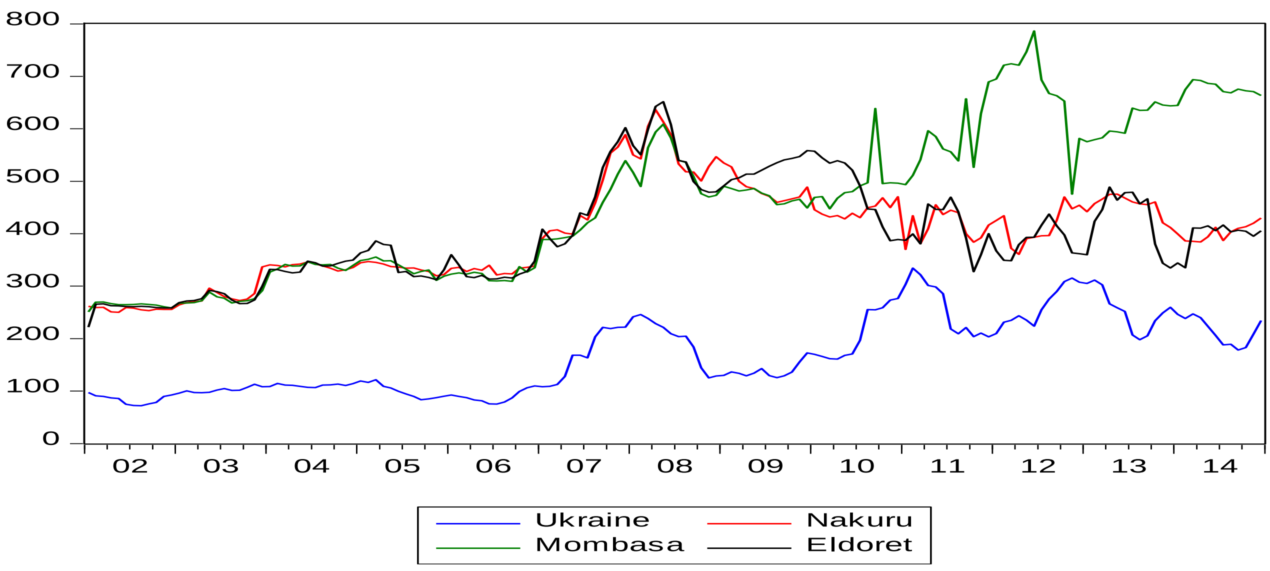

Figure 1: Graph of trend in domestic and international prices

The price of Nakuru and Eldoret are moving in the same direction. This is because both towns are wheat growing regions and the prices are not affected by transport costs. At this stage however, the emerging evidence does not provide a conclusive relationship in the price series. The price fluctuations could be indicative of a non-stationary price series.

4.2 Econometric Results

This section describes the econometric result of the relationship between the Ukraine and Kenyan prices in the three markets

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4.2.1 Unit root tests

Table 4.2 reports the results of the Augmented Dickey Fuller (ADF) and the Phillips Perron (PP) test in level and first difference.

Table 4.2: Unit root tests (ADF and PP) for wheat prices

Series	Level			First difference		I(d)
	ADF	PP	Lags	ADF	PP	
Logarithim of wholesale wheat prices						
Mombasa	-2.78	-2.78	1	-16.48	-16.48	*I*(1)
Nakuru	-1.81	-1.81	1	-13.64	-13.64	*I*(1)
Eldoret	-2.12	-2.11	1	-10.63	-10.63	*I*(1)
Ukraine	-3.38	-1.89	1	-5.33	-8.02	*I*(1)
5% critical values	-3.44	-3.44		-3.44	-3.44	

Source: Author's computations

The ADF t-statistics results for level are -2.78 for Mombasa, -1.81 for Nakuru, -2.12 for Eldoret and -3.38 for Ukraine. The PP t- statistics results at level are -2.78 for Mombasa, -1.81 for Nakuru, -2.11 for Eldoret and -1.89 for Ukraine. These results in levels fail to reject the null hypothesis of non-stationary at five percent level of significance of -3.44 (Table 4.2). This shows that all the four variables are non-stationary at levels. Therefore, it can be concluded that both the ADF and PP tests indicate that all four markets have non-stationary.

When the price series is differenced once, the ADF statistic becomes -16.48 for Mombasa, -13.64 for Nakuru, -10.63 for Eldoret, and -5.33 for Ukraine (Table 4.2). The PP statistic on the other hand became -16.48 for Mombasa, -13.64 for Nakuru, -10.63 for Eldoret and -8.02 for Ukraine. Both ADF and PP tests statistic reject the null hypothesis of non-stationary at five percent level of significance of -3.44 (Table 4.2).

The series is integrated of order one since the null hypothesis of the unit root cannot be rejected when the series are in level but can be rejected at first difference. This implies that each variable has a random walk and integrated of the same order I (1). This is a necessary but not sufficient condition for co-integration. In the next step co-integration analyses of the price variables are undertaken.

4.2.2 Co- integration Analysis (Johansen Maximum Likelihood)

Table 4.3 presents the results for the Johansen Maximum Likelihood estimates for the co-integration test.

Table 4.3: Johansen's maximum Eigen value and trace test statistic for the number of co-integrating vectors. January 2002 to December 2014

Mombasa, Nakuru and Eldoret wheat markets

H_0	Trace statistic	Trace (95%)	Maximum eigen value	Maximum eigen value (95%)
r=0**	39.26	29.68	32.92	20.97
r≤1	6.34	15.41	4.30	14.07
r≤2	2.04	3.76	2.04	3.76

Note: the critical values are taken from Osterwald- Lenum. (1992). * (**) denotes rejection of the null at the 5% and 1% level, **Source: Authors computation**.

The domestic prices co-integration results for the null on no co-integrating vector are 39.26 and 32.92 for Trace and Maximum Eigen value tests respectively. The critical value for Trace is 29.68 and 20.97 for Maximum Eigen value. In both cases, the statistic is greater than the critical value; the null of no co-integrating vector against the alternative of at least one co-integrating vector is rejected. The process proceeds to test the null of one or two co-integrating vectors. In both cases, the statistic is less than the critical value for both Trace and Maximum Eigen value tests. This implies that the null of a presence of two co-integrating equations among domestic markets against the alternative hypothesis of the presence of three co-integrating equations cannot be rejected.

This is because both Trace and Maximum Eigen tests of 2.04 is less than the critical value of 3.76. It can be concluded based on the co-integrations tests that wheat prices of Kenyan wheat markets namely Mombasa, Nakuru, and Eldoret are co-integrated with at least one co-integrating vector.

Table 4.4: Johansen's maximum Eigen value and trace test statistic for the number of co-integrating vectors (Bivariate test). January 2002 to December 2014

Hypothesized No. of CE(s)	Trace Statistic	Trace 0.05 Critical Value	λmax Statistic	λmax 0.05 Critical
1. Mombasa and Ukraine prices				
r=**0***	16.65	15.41	15.27	14.07
r≤1	1.38	3.76	1.38	3.76
2. Nakuru and Ukraine prices				
r=0	7.54	15.41	4.63	14.07
r≤1	2.92	3.76	2.92	3.76
3. Eldoret and Ukraine prices				
r=0	8.56	15.41	5.32	14.07
r≤1	3.25	3.76	3.25	3.76

Note: the critical values are taken from Osterwald- Lenum. (1992). * denotes rejection of the hypothesis of no co-integration at the 5% (1%) level.

Source: Author's computation

The co-integration results for the null of no co-integrating vector for Mombasa and Ukraine wheat prices are 16.65 for Trace test and 15.27 for Maximum Eigen value.

Since the Trace and Maximum Eigen statistics are greater than the critical values of 15.41 and 14.07 for Trace and Maximum Eigen test respectively, the null of no co-integrating vector against the alternative of existence of at least one co-integrating vector is rejected. The null of one co-integrating vector is also tested. The test fails to reject the null hypothesis since the trace statistic and Maximum Eigen statistic of 1.38 is less than the critical value of 3.76. Since the rank is equal to one, then we can say the prices of Mombasa and Ukraine are co-integrated.

The Nakuru and Ukraine wheat prices co-integration results are 7.54 and 4.63 for the Trace statistic and the Maximum Eigen value respectively. The critical value is 15.41 and 14.07 for Trace and Maximum Eigen test. Since the Trace and Max statistic is less than the critical value, we fail to reject the null hypothesis of no co-integrating vector. This implies that there is no long-run relationship between the wheat prices of Nakuru and Ukraine. Eldoret and Ukraine wheat prices co-integration results are 8.56 for Trace statistic and 5.32 for Maximum Eigen value. The statistic is less than the critical value of 15.41 for Trace test and 14.07 for Maximum test. We then fail to reject the null hypothesis of no co-integrating vector on this basis. This implies that there is no long run relationship between the wheat prices of Eldoret and Ukraine.

The prices of wheat in Kenya are co-integrated with the prices of Ukraine. The price of wheat in Mombasa is co-integrated with the price of wheat in Ukraine unlike the prices in Nakuru and Eldoret. The integration between the international prices and the prices in Mombasa is possible because Mombasa is the port of entry. There is a long-run equilibrium between Ukraine and Mombasa.

The prices of Nakuru and Eldoret are not integrated since the two towns are wheat growing areas and the prices reflect the prices of wheat that is harvested and sold in the wholesale market. The wheat harvested, which is soft wheat, is the main type of wheat that is sold in the market. Imported wheat is mainly sold to millers who mix the wheat with the once produced locally.

The presence of only one co-integrating vector suggest that though Kenyan wheat prices are integrated to international prices, the integration is weak. This leads to the estimation of the VECM to quantify how these process is related. The next section estimates the VECM model.

4.2.3 Transmission of international prices into the Kenyan wheat market

Since the domestic prices and the international prices are co-integrated, the long-run and short-run dynamics between international and domestic wheat prices is estimated using the VECM. The long run relationship between Kenyan wheat market in Mombasa and the world reference wheat prices in Ukraine for the period 2002 to 2014 is shown in table 4.5.

Table 4.5 Vector Error Correction Model results for Mombasa and Ukraine wheat prices (2002-2014)

	$\boldsymbol{\beta_i}$	$\boldsymbol{\theta_i}$	$\boldsymbol{\delta_i}$	**Adj $\boldsymbol{R^2}$**	**FStatistic**	**AIC**
Mombasa_Ukraine	0.78(-7.97)	-0.078(-2.48)	0.13(1.39)	0.18	7.81	-2.52

The β_i, θ_i and $\delta_i$are the long-run elasticity of price transmission, the price adjustment, and short-run elasticity of price transmission parameters respectively. The figures in parenthesis are the t-statistic. **Source: Author's computation**

The VECM results shows that the wheat prices from Ukraine are transmitted to the Kenyan domestic market in the long-run and not in the short run (Table 4.5). The price of wheat in Mombasa is linked to world wheat markets. The coefficient of the long run co-integrating equation is statistically significant which indicates that there is a long-run equilibrium relationship between international and domestic prices. The variation in world prices transmitted to the domestic prices is about 78 percent.

The variation can also be interpreted as the long-run elasticities of price transmission (β) since the estimation is done in logarithms. The elasticity suggests that a one percent increase in the price of wheat in the international market, will lead to an increase in the domestic market by 78 percent. The elasticity of price transmission of 0.78 is high but is expected since Kenya is a net importer of wheat.

The high elasticity of price transmission can also be attributed to the fact that Kenya's domestic production does not meet the demand and therefore most of the wheat is imported. Wheat imports into Kenya attracts a number of tariffs. A harmonized rate of 25 percent is charged under the COMESA for member states. The East African Community (EAC) harmonized these rates at 25 percent too in its agreement on a common external tariff (CET). Imports into Kenya by registered millers is charged a 10 percent ad valorem tax. The tax is done through a duty remission scheme where the importers pay the 35 percent tax initially and then apply for remission (FAO 2013).

The coefficient of the speed of adjustment (θ) is negative for Mombasa market and is statistically significant and this confirms the validity of the model. This shows that domestic wheat prices adjust to disequilibrium towards the long-run equilibrium state. The result indicates that it takes 13 months for the price in Mombasa to adjust to the international prices, which is price in Ukraine. This shows that the speed of adjustment is rather slow. This could be due to the distance from the source market to the Kenyan port. It takes a long time for the domestic prices to adjust back to the equilibrium state when a price change occurs in the Ukraine wheat prices.

The slow speed of adjustment may be because of fluctuating domestic supply since Kenya mainly relies on rain-fed agriculture and therefore weather shocks and poor infrastructure are causes of price volatility. Estimates of the total supply are made by the government but could lead to false estimation of expected supply, and the government may not act quickly in response to grain shortage. This may lead to a prolonged return to the equilibrium state. The slow speed of adjustment is also attributed to factors such as storage.

The results from this study tends to agree with findings from other previous studies. According to Iregui and Otero (2013), transportation cost caused by distance, is a factor that helps explain the speed at which prices adjust to the shocks in other markets. Transport costs plays a key role in the speed of adjustment. Even though the two markets are integrated, the slow speed of adjustment depicts an inefficient market structure.

Conforti, (2004) and Minot (2010) talk of other factors such as exchange rates, border, information asymmetry, market power, product differentiation and homogeneity and domestic policies. Rapsomanikis *et. al*, (2003) says that changes in price in one market may need some time to be transmitted to other markets for various reasons such as policies, the number of stages in marketing and the corresponding contractual arrangements between economic agents, storage and inventory holding, delays caused in transportation or processing.

The coefficient of short run adjustments (δ) is not significant in the short-run and this shows that the prices of Ukraine has no effect on the price of the Kenyan wheat in the short-run. The international price does not have any significant influence on the domestic prices.

CHAPTER 5: SUMMARY CONCLUSIONS AND RECOMMENDATIONS

This chapter provides a summary of the study, the conclusions drawn and the recommendations.

5.1 Summary of Main findings

This study evaluated the transmission of Ukraine wheat prices into the Kenyan market. The study used monthly wheat price data for the markets under review. The Ukraine FOB prices for hard wheat were used as the international wheat reference prices. The data was obtained from FAO GIEWS Food Price Data Analysis Tool website for the Ukraine wheat prices. The quality of the Kenyan wheat is of low and therefore a quality premium was used to make it comparable to the international prices. The quality premium is the price ratio of the US No. 2, soft red winter wheat, to hard red winter wheat prices. Domestic prices were obtained from the Ministry of agriculture, Agribusiness Department. The data covered the period 2002 to 2014.

The study employed the Vector Error Correction Model (VECM) to analyze the transmission of Ukraine wheat prices into the Kenyan market. Mombasa prices was used as the domestic reference prices while Ukraine prices was used as the international reference price. First descriptive statistics was done to establish the trend of wheat prices between the two countries. The descriptive involved generation of minimum, maximum, mean and graph analysis of price series. Econometric analysis was then done to evaluate price transmission. This involved three steps namely; the unit root test, co-integration test, and the estimation of VECM.

The unit root test was used to test for stationarity of the series and the Augmented Dickey Fuller (ADF) and Phillip Perron (PP) tests were used for this. The unit root test result showed that the price series were integrated of order one I(1). The results from ADF and PP both showed that price variables estimated in levels were non-stationary and those estimated in first difference are stationary. This results show that the average price of wheat in Kenya varies over time and their mean and variance are not constant.

Since the price series were I(1), the JML procedure was then used to establish whether a stable long-run relationship exists between the variables. The results indicated that there existed no long-run relationship between the prices in Ukraine and Nakuru, and Eldoret. This is because Nakuru and Eldoret are wheat-growing areas. The prices of Mombasa and Ukraine showed the presence of a long run relationship. This leads to the conclusion that there is a long-run steady state of equilibrium between wheat prices in Ukraine and Kenya.

The VECM results shows that 78 percent of price changes in the Ukraine market prices are transmitted to the Kenyan market and the prices take about 13 months for the domestic prices to fully adjust to the Ukraine prices. The short run coefficient is not significant and this implies that in the short run, the changes in the price of wheat in Ukraine do not have any significant effect on the price of wheat in Kenya.

5.2 Conclusion and policy recommendations

The study found out that the Kenyan domestic markets are integrated among themselves. There exist one co-integrating vectors though there is room for improvement and make the markets more efficient. The Kenyan markets; Nakuru Mombasa and Eldoret are integrated with one co-integrating vector existing. Therefore, rural infrastructure should be improved in all areas to allow easy movement of goods and services. Market information systems should be made easily accessible to producers, traders and consumers for them to make rational decisions on whether to purchase or sell.

The study found out that the elasticity of price transmission is at 78 percent. This shows a high degree of price signals from the Ukrainian wheat market into the domestic market. It could therefore be recommended that the government of Kenya should promote domestic production in order to be able to meet the domestic demand. The government should provide a conducive environment for domestic production. The government should also promote production of other staple foods such as maize to substitute wheat imports in order to avoid food insecurity when wheat prices increases.

The speed of adjustment of the Kenyan prices to the long-run equilibrium was found to be very slow taking about 13 months for the changes in Ukrainian market to be reflected to the Kenyan market. The government should also allow more individuals and companies to operate grain bulk handling. This will create competition and therefore reduce the handling cost and time.

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APPENDICES

Appendix 1: Ukraine wheat wholesale price US$/MT

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2002	97.11	91.12	89.79	86.94	85.80	74.83	72.52	72.10	75.64	78.36	89.64	92.58
2003	96.00	100.26	97.37	96.88	97.84	102.01	104.91	101.14	101.74	107.07	113.01	108.20
2004	108.65	114.56	111.44	111.13	109.06	107.16	106.74	111.46	111.71	113.29	110.74	114.29
2005	119.36	116.74	121.59	109.12	105.80	99.70	94.62	89.65	83.65	85.08	87.40	90.17
2006	92.43	89.68	87.28	83.12	81.56	75.50	75.24	79.26	87.11	99.22	106.20	109.81
2007	108.15	109.21	112.64	128.14	168.47	168.59	163.34	203.41	221.52	218.97	221.62	221.82
2008	241.65	245.97	238.43	228.57	221.46	209.30	203.95	204.77	184.21	144.44	125.34	128.94
2009	130.09	136.62	133.66	128.99	134.26	142.75	129.49	125.52	128.94	136.37	155.65	172.79
2010	169.84	166.05	161.73	160.81	168.24	170.90	196.84	255.30	255.00	258.75	273.38	276.53
2011	303.46	334.30	321.66	301.27	298.77	285.67	218.47	209.36	221.25	203.88	210.49	203.51
2012	209.83	231.19	234.95	243.58	235.34	223.72	254.93	275.57	289.88	308.63	315.37	307.43
2013	305.17	311.46	302.35	266.37	258.68	251.73	206.80	198.11	205.49	234.12	249.20	259.79
2014	246.41	238.32	246.88	239.87	223.58	206.33	187.98	189.28	178.44	182.82	208.36	234.48

Source: FAO, GIEWS Food Price Data Analysis Tool.

Appendix 2: Mombasa wheat wholesale price US$/MT

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2002	251.16	269.32	269.98	266.87	264.84	264.61	265.10	266.32	265.06	263.80	260.68	258.45
2003	267.35	267.99	268.89	272.19	288.61	279.83	276.98	267.93	271.23	272.19	276.07	291.35
2004	326.70	332.60	341.31	338.47	338.85	346.68	341.24	340.47	341.37	334.33	330.22	339.38
2005	348.84	351.41	355.50	348.26	348.57	340.52	332.31	323.55	328.18	330.63	311.21	319.17
2006	323.11	325.47	322.81	326.46	324.24	310.56	310.00	310.80	309.29	337.12	327.01	335.12
2007	389.00	388.91	390.05	392.50	395.09	407.09	420.66	430.14	459.90	484.54	513.79	539.00
2008	516.81	490.08	564.05	593.87	608.67	582.41	540.11	535.89	509.07	476.27	469.97	473.29
2009	490.58	486.29	481.30	483.39	486.03	477.53	472.31	455.62	456.81	462.45	465.57	449.15
2010	469.16	470.63	447.64	467.43	478.16	480.00	491.24	497.27	638.55	495.58	497.14	496.48
2011	493.65	511.42	541.00	596.02	585.25	561.49	556.19	538.87	657.28	526.64	628.64	689.26
2012	694.90	721.36	723.79	721.26	746.59	786.27	693.29	667.39	663.15	652.73	475.31	581.44
2013	575.37	579.41	582.63	595.88	594.21	591.38	639.61	634.97	635.55	651.22	645.22	643.68
2014	644.39	674.82	693.73	691.91	686.40	684.84	670.92	668.39	675.40	672.44	671.02	663.39

Source: Ministry of Agriculture, Livestock and Fisheries (MOALF)

Appendix 3: Eldoret wheat wholesale price US$/MT

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2002	221.95	265.53	266.19	262.61	262.47	261.31	260.87	261.61	260.83	259.13	258.35	258.45
2003	268.78	271.85	272.76	276.10	291.72	289.38	285.41	273.54	266.71	267.19	273.66	299.63
2004	332.04	331.63	327.89	325.16	326.70	347.62	344.48	338.18	338.61	343.45	347.55	349.60
2005	363.57	368.26	386.20	379.39	378.14	326.03	327.94	318.05	319.38	316.56	312.20	331.33
2006	360.04	340.43	318.20	316.33	320.49	313.33	313.77	317.16	315.65	322.78	328.05	347.89
2007	408.61	391.03	375.22	380.76	396.88	439.77	434.88	470.53	526.35	556.84	575.15	602.04
2008	567.95	550.65	598.99	642.51	651.60	607.96	539.70	536.85	499.47	484.12	478.98	479.81
2009	491.17	502.94	506.68	513.51	513.74	520.94	528.40	535.39	540.82	543.42	547.09	558.27
2010	557.12	544.48	534.28	539.35	534.75	521.15	491.24	447.12	446.16	412.98	386.67	389.18
2011	387.24	399.59	380.55	456.68	446.48	446.07	469.42	441.64	391.60	327.84	359.99	400.02
2012	367.40	349.33	348.49	379.33	392.78	393.13	415.97	437.44	414.96	397.52	363.32	361.78
2013	360.06	423.75	445.90	488.98	464.27	478.30	478.94	457.18	466.50	380.31	343.90	334.71
2014	344.36	334.96	411.10	410.79	415.02	405.83	416.48	403.55	406.49	404.71	395.22	405.41

Source: Ministry of Agriculture, Livestock and Fisheries (MOALF)

Appendix 4: Nakuru wheat wholesale price US$/MT

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2002	261.53	259.14	259.78	250.90	250.41	259.19	258.05	254.89	253.43	255.98	255.56	255.66
2003	264.49	268.59	270.22	271.70	296.37	287.87	280.20	275.73	272.77	275.40	285.97	336.90
2004	340.78	339.63	336.88	340.85	342.13	346.21	342.75	338.52	334.49	328.74	331.13	335.67
2005	344.68	346.96	345.35	342.18	337.42	336.17	334.50	334.91	330.62	327.87	319.64	322.21
2006	333.88	335.79	328.19	333.47	330.56	339.82	321.31	324.02	323.27	334.31	335.86	338.31
2007	391.12	405.40	407.29	401.01	399.36	434.76	426.32	458.63	502.31	553.52	564.97	588.88
2008	550.00	542.78	604.98	636.26	613.01	588.80	533.03	517.97	517.36	500.79	528.01	546.73
2009	534.80	527.38	499.76	489.79	485.91	476.69	471.22	459.74	462.93	466.63	469.78	489.04
2010	445.70	437.32	431.90	434.79	428.37	438.86	430.66	449.61	452.76	468.32	449.91	470.27
2011	370.24	434.09	381.08	409.40	455.20	436.71	444.95	440.08	400.13	384.01	392.01	416.68
2012	425.31	434.15	371.95	360.63	390.54	393.13	396.17	396.47	425.47	469.97	447.67	454.17
2013	441.89	457.43	466.10	475.12	475.36	467.90	460.52	457.18	455.44	460.54	420.68	411.96
2014	399.52	386.35	385.41	384.40	394.05	412.17	386.86	403.55	410.24	413.43	419.93	429.98

Source: Ministry of Agriculture, Livestock and Fisheries (MOALF)

Appendix 5: Unit root tests for the series

A5.1: Augmented Dickey Fuller test at level for Eldoret Price series

Null Hypothesis: LELDORET has a unit root
Exogenous: Constant, Linear Trend
Lag Length: 1 (Automatic - based on AIC, maxlag=13)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-2.115465	0.5327
Test critical values:	1% level	-4.018748	
	5% level	-3.439267	
	10% level	-3.143999	

*MacKinnon (1996) one-sided p-values.

A5.2: Augmented Dickey Fuller test at 1st difference for Eldoret Price series

Null Hypothesis: D(LELDORET) has a unit root
Exogenous: Constant, Linear Trend
Lag Length: 0 (Automatic - based on AIC, maxlag=13)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-10.63360	0.0000
Test critical values:	1% level	-4.018748	
	5% level	-3.439267	
	10% level	-3.143999	

*MacKinnon (1996) one-sided p-values.

A5.3: Phillips-Perron test at level for Eldoret Price series

Null Hypothesis: LELDORET has a unit root
Exogenous: Constant, Linear Trend
Bandwidth: 0 (Newey-West automatic) using Bartlett kernel

		Adj. t-Stat	Prob.*
Phillips-Perron test statistic		-2.106860	0.5376
Test critical values:	1% level	-4.018349	
	5% level	-3.439075	
	10% level	-3.143887	

*MacKinnon (1996) one-sided p-values.

A5.4: Phillips-Perron test at 1st difference for Eldoret Price series

Null Hypothesis: D(LELDORET) has a unit root
Exogenous: Constant, Linear Trend
Bandwidth: 4 (Newey-West automatic) using Bartlett kernel

		Adj. t-Stat	Prob.*
Phillips-Perron test statistic		-10.60433	0.0000
Test critical values:	1% level	-4.018748	
	5% level	-3.439267	
	10% level	-3.143999	

*MacKinnon (1996) one-sided p-values.

A5.5: Augmented Dickey Fuller test at level for Mombasa Price series

Null Hypothesis: LMOMBASA has a unit root
Exogenous: Constant, Linear Trend
Lag Length: 1 (Automatic - based on AIC, maxlag=13)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-2.649943	0.2591
Test critical values:	1% level	-4.018748	
	5% level	-3.439267	
	10% level	-3.143999	

*MacKinnon (1996) one-sided p-values.

A5.6: Augmented Dickey Fuller test at 1st difference for Mombasa Price series

Null Hypothesis: D(LMOMBASA) has a unit root
Exogenous: Constant, Linear Trend
Lag Length: 0 (Automatic - based on AIC, maxlag=13)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-16.47672	0.0000
Test critical values:	1% level	-4.018748	
	5% level	-3.439267	
	10% level	-3.143999	

*MacKinnon (1996) one-sided p-values.

A5.7: Phillips-Perron test at level for Mombasa Price series

Null Hypothesis: D(LMOMBASA) has a unit root
Exogenous: Constant
Bandwidth: 4 (Newey-West automatic) using Bartlett kernel

		Adj. t-Stat	Prob.*
Phillips-Perron test statistic		-16.47959	0.0000
Test critical values:	1% level	-3.473096	
	5% level	-2.880211	
	10% level	-2.576805	

*MacKinnon (1996) one-sided p-values.

A5.8: Augmented Dickey Fuller test at level for Nakuru Price series

Null Hypothesis: LNAKURU has a unit root
Exogenous: Constant, Linear Trend
Lag Length: 0 (Automatic - based on AIC, maxlag=13)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-1.814537	0.6931
Test critical values:	1% level	-4.018349	
	5% level	-3.439075	
	10% level	-3.143887	

*MacKinnon (1996) one-sided p-values.

A5.9: Augmented Dickey Fuller test at 1st difference for Nakuru Price series

Null Hypothesis: D(LNAKURU) has a unit root
Exogenous: Constant, Linear Trend
Lag Length: 0 (Automatic - based on AIC, maxlag=13)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-13.63974	0.0000
Test critical values:	1% level	-4.018748	
	5% level	-3.439267	
	10% level	-3.143999	

*MacKinnon (1996) one-sided p-values.

A5.10: Phillips-Perron test at level for Nakuru Price series

Null Hypothesis: LNAKURU has a unit root
Exogenous: Constant, Linear Trend
Bandwidth: 7 (Newey-West automatic) using Bartlett kernel

		Adj. t-Stat	Prob.*
Phillips-Perron test statistic		-1.814537	0.7309
Test critical values:	1% level	-4.018349	
	5% level	-3.439075	
	10% level	-3.143887	

*MacKinnon (1996) one-sided p-values.

A5.11: Phillips-Perron test at 1st difference for Nakuru Price series

Null Hypothesis: D(LNAKURU) has a unit root
Exogenous: Constant, Linear Trend
Bandwidth: 9 (Newey-West automatic) using Bartlett kernel

		Adj. t-Stat	Prob.*
Phillips-Perron test statistic		-13.64379	0.0000
Test critical values:	1% level	-4.018748	
	5% level	-3.439267	
	10% level	-3.143999	

*MacKinnon (1996) one-sided p-values.

A5.12: Augmented Dickey Fuller test at level for Ukraine Price series

Null Hypothesis: LUKRAINE has a unit root
Exogenous: Constant, Linear Trend
Lag Length: 5 (Automatic - based on AIC, maxlag=13)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-3.375929	0.0586
Test critical values:	1% level	-4.020396	
	5% level	-3.440059	
	10% level	-3.144465	

*MacKinnon (1996) one-sided p-values.

A5.13: Augmented Dickey Fuller test at 1st difference for Ukraine Price series

Null Hypothesis: D(LUKRAINE) has a unit root
Exogenous: Constant, Linear Trend
Lag Length: 3 (Automatic - based on AIC, maxlag=13)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-5.328321	0.0001
Test critical values:	1% level	-4.019975	
	5% level	-3.439857	
	10% level	-3.144346	

*MacKinnon (1996) one-sided p-values.

A5.14: Phillips-Perron test at level for Ukraine Price series

Null Hypothesis: LUKRAINE has a unit root
Exogenous: Constant, Linear Trend
Bandwidth: 6 (Newey-West automatic) using Bartlett kernel

		Adj. t-Stat	Prob.*
Phillips-Perron test statistic		-1.888989	0.2385
Test critical values:	1% level	-4.018349	
	5% level	-3.439075	
	10% level	-3.143887	

*MacKinnon (1996) one-sided p-values.

A5.15: Phillips-Perron test at 1st difference for Ukraine Price series

Null Hypothesis: D(LUKRAINE) has a unit root
Exogenous: Constant, Linear Trend
Bandwidth: 1 (Newey-West automatic) using Bartlett kernel

		Adj. t-Stat	Prob.*
Phillips-Perron test statistic		-8.092147	0.0000
Test critical values:	1% level	-4.018748	
	5% level	-3.439267	
	10% level	-3.143999	

*MacKinnon (1996) one-sided p-values.

Appendix 6: Johansen Co-integration Test

A6.1 Johansen's maximum Eigen value and trace test statistic for the number of co-integrating vectors for Mombasa, Nakuru and Eldoret

Sample (adjusted): 2002M06 2014M12
Included observations: 151 after adjustments
Trend assumption: Linear deterministic trend
Series: LELDORET LMOMBASA LNAKURU
Lags interval (in first differences): 1 to 4

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	5 Percent Critical Value	1 Percent Critical Value
None **	0.195906	39.26621	29.68	35.65
At most 1	0.028074	6.342244	15.41	20.04
At most 2	0.013435	2.042493	3.76	6.65

Trace test indicates 1 cointegrating equation(s) at both 5% and 1% levels
*(**) denotes rejection of the hypothesis at the 5%(1%) level

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	5 Percent Critical Value	1 Percent Critical Value
None **	0.195906	32.92396	20.97	25.52
At most 1	0.028074	4.299751	14.07	18.63
At most 2	0.013435	2.042493	3.76	6.65

Max-eigenvalue test indicates 1 cointegrating equation(s) at both 5% and 1% levels
*(**) denotes rejection of the hypothesis at the 5%(1%) level

A6.2 Johansen's maximum Eigen value and trace test statistic for the number of co-integrating vectors for Eldoret and Ukraine

Sample (adjusted): 2002M06 2014M12
Included observations: 151 after adjustments
Trend assumption: Linear deterministic trend
Series: LELDORET LUKRAINE
Lags interval (in first differences): 1 to 4

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	5 Percent Critical Value	1 Percent Critical Value
None	0.034595	8.564606	15.41	20.04
At most 1	0.021282	3.248253	3.76	6.65

Trace test indicates no cointegration at both 5% and 1% levels
*(**) denotes rejection of the hypothesis at the 5%(1%) level

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	5 Percent Critical Value	1 Percent Critical Value
None	0.034595	5.316352	14.07	18.63
At most 1	0.021282	3.248253	3.76	6.65

Max-eigenvalue test indicates no cointegration at both 5% and 1% levels
*(**) denotes rejection of the hypothesis at the 5%(1%) level

A6.3 Johansen's maximum Eigen value and trace test statistic for the number of co-integrating vectors for Mombasa and Ukraine

Sample (adjusted): 2002M06 2014M12
Included observations: 151 after adjustments
Trend assumption: Linear deterministic trend
Series: LMOMBASA LUKRAINE
Lags interval (in first differences): 1 to 4

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	5 Percent Critical Value	1 Percent Critical Value
None *	0.096206	16.65127	15.41	20.04
At most 1	0.009078	1.377025	3.76	6.65

Trace test indicates 1 cointegrating equation(s) at the 5% level
Trace test indicates no cointegration at the 1% level
*(**) denotes rejection of the hypothesis at the 5%(1%) level

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	5 Percent Critical Value	1 Percent Critical Value
None *	0.096206	15.27424	14.07	18.63
At most 1	0.009078	1.377025	3.76	6.65

Max-eigenvalue test indicates 1 cointegrating equation(s) at the 5% level
Max-eigenvalue test indicates no cointegration at the 1% level
*(**) denotes rejection of the hypothesis at the 5%(1%) level

A6.4 Johansen's maximum Eigen value and trace test statistic for the number of co-integrating vectors for Nakuru and Ukraine

Sample (adjusted): 2002M06 2014M12
Included observations: 151 after adjustments
Trend assumption: Linear deterministic trend
Series: LNAKURU LUKRAINE
Lags interval (in first differences): 1 to 4

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	5 Percent Critical Value	1 Percent Critical Value
None	0.030180	7.543091	15.41	20.04
At most 1	0.019124	2.915725	3.76	6.65

Trace test indicates no cointegration at both 5% and 1% levels
*(**) denotes rejection of the hypothesis at the 5%(1%) level

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	5 Percent Critical Value	1 Percent Critical Value
None	0.030180	4.627366	14.07	18.63
At most 1	0.019124	2.915725	3.76	6.65

Max-eigenvalue test indicates no cointegration at both 5% and 1% levels
*(**) denotes rejection of the hypothesis at the 5%(1%) level

Appendix 7: Vector Error Correction Model

Vector Error Correction Estimates
Sample (adjusted): 2002M04 2014M12
Included observations: 153 after adjustments
Standard errors in ( ) & t-statistics in [ ]

Cointegrating Eq:	CointEq1	
LMOMBASA(-1)	1.000000	
LUKRAINE(-1)	-0.784771	
	(0.09850)	
	[-7.96758]	
C	-2.135221	
Error Correction:	**D(LMOMBASA)**	**D(LUKRAINE)**
CointEq1	-0.077800	0.086387
	(0.03139)	(0.03618)
	[-2.47850]	[2.38782]
D(LMOMBASA(-1))	-0.270431	0.034867
	(0.08205)	(0.09457)
	[-3.29585]	[0.36869]
D(LMOMBASA(-2))	-0.046105	0.128066
	(0.08011)	(0.09232)
	[-0.57555]	[1.38713]
D(LUKRAINE(-1))	0.077055	0.461671
	(0.07007)	(0.08075)
	[1.09976]	[5.71702]
D(LUKRAINE(-2))	-0.038788	-0.053871
	(0.07402)	(0.08531)
	[-0.52402]	[-0.63145]
C	0.007530	0.002968
	(0.00480)	(0.00553)
	[1.56820]	[0.53634]
R-squared	0.135267	0.209884
Adj. R-squared	0.105854	0.183009
Sum sq. resids	0.502320	0.667263
S.E. equation	0.058456	0.067374
F-statistic	4.598918	7.809727
Log likelihood	220.4025	198.6806
Akaike AIC	-2.802648	-2.518700
Schwarz SC	-2.683807	-2.399860