Spatial Integration of Groundnut Markets in Zambia: Application of Co-integration and Vector Error Correction Model

Patrick Lupiya\(^1\)*, H. K. Bett\(^1\), E. Kuntashula\(^2\)

\(^1\)Department of Agricultural Economics & Agribusiness Management, Egerton University, P.O Box 536 20115, Nakuru, Kenya.
\(^2\)Department of Agricultural Economics and Extension, University of Zambia, P.O Box 32379, Lusaka, Zambia.

*Correspondence: lupiyapatrick@gmail.com

Available Online: 31\(^{st}\) May, 2018

URL: http://www.journals.adrri.org/

Abstract

In Zambia, there are persistent shortages in the supply of groundnuts in certain regions, despite the major producing areas of Eastern and Northern provinces having significant surpluses. This is an indication for market inefficiency. Thus, this study assessed market integration and price transmission of groundnuts among geographically separated groundnut markets using co-integration and vector error correction model (VECM). It employed monthly retail groundnut price data from January 2001 to March 2017. The Augmented Dickey-Fuller and Kwiatkowski Philips Schmidt Shin tests both showed that Chipata, Chadiza, Petauke and Kasama were non-stationary at level, meaning that the prices in these markets had a unit root process. Lusaka and Kitwe were stationary at level. After the first difference, all the markets were stationary. Johansen test for cointegration confirmed the presence of long-term causal relationship among the six markets, meaning they were cointegrated and significant at 5 percent level. The VECM showed that the highest speed of adjustment towards the long-run equilibrium was from Kitwe to Kasama at 52 percent. The lowest speed of adjustment was between Lusaka and Chadiza at 33 percent. The speed of price transmission among all the market pairs was relatively slow. Therefore, the study recommended that policy makers or development practitioners should consider development and constant use of market infrastructures in order to enhance efficiency in the groundnut markets.

Keywords: market integration, granger causality, vector error correction model
INTRODUCTION

Groundnut is the fifth most widely grown crop in the Sub Saharan Africa (SSA) after maize, sorghum, millet and cassava (FAO, 2010). However, it is the second most widely grown crop after maize by smallholder farmers and constitutes 8% of arable land in Zambia (Mukuka et al., 2013; Chapoto and Chisanga, 2016). The crop thrives well on a vast range of conditions with the majority of smallholder farmers in Zambia and SSA growing exclusively for both consumption and as a cash crop (FAO, 2010). The major groundnut-producing areas in Zambia are Eastern and Northern Provinces in agro-ecological zones I and II, which are suited for its cultivation (MAL, 2012) with smallholder farmers in Eastern province producing 30 percent of national production (CSO, 2011). In the years between 2000 and 2011, land under groundnut production was expanded by 22% with over 18% of the farmers in the country joining the groundnut production. This led to significant increases in groundnut production in the country (Zulu et al., 2014).

As an incentive, farmers need stable and competitive prices for their groundnuts and for agricultural commodities in general. Smallholder farmers, particularly groundnut producers, have challenges to access market information such as the price of the commodity in the local markets (Ross and De Klerk, 2012). This, in turn, affects the producers’ capacity to participate in the informed and profitable trade as well as taking advantage of seasonal and spatial arbitrage. Due to the lack of market price information, smallholder farmers will only negotiate for the price that the buyers provide, hence jeopardizing their marketing decisions.

In an effort to improve market efficiency, the Zambian government saw it befitting to liberalize markets in 1992 (MOA, 2004). Several strategies and policies have been put in place by the government to enhance market access,
market information and market participation by smallholder farmers. Despite the government embarking on these policies, groundnut marketing in Zambia has remained inefficient, with farmers experiencing excessive price volatility, information asymmetry and lack of organized and consistent markets (Ross and Klerk, 2012). These inefficiencies in the market have led to the acute demand of groundnuts in the deficit areas, despite the surpluses in the main groundnut producing areas (Ross and Klerk, 2012; Mukuka et al., 2013).

Economic theory suggests that optimum distribution of resources can be attained if markets and marketing channels are functioning properly. Spatial market integration approach is used to test relationships between markets. Market integration exists when there are co-movements in prices of similar commodities in different markets and if trade occurs across spatial markets. According to Goletti et al. (1995), the study defined spatial integration as a smooth transmission of both information and price signals through across markets. A well-integrated market is cardinal for a well-functioning market economy. Semira (2014) argues that spatial price relationships have often been used to indicate overall market performance. In addition, an understanding of spatial market integration enables policy makers to frame noble economic policies.

When markets are integrated, food commodities flow from excess to deficit regions. Deficit areas are usually associated with high prices, thereby creating a motivation for traders to bring food from surplus regions to deficit regions. Rational traders will join the market and take advantage of these arbitrage opportunities, increasing the demand for the commodity in the surplus area while increasing the supply of the commodity in the deficit areas. This tendency continues until the prices in both markets reach equilibrium level, thus, trade at this point is unprofitable. The price differences that cannot be expounded by
transport and transaction costs show inefficient arbitrage. When markets are not integrated, it reflects the existence of imperfect competition, poor infrastructure, and missing institutions that disturb the efficient flow of commodities (Ahmed and Gjolberg, 2015) and this is the case in most markets for agricultural commodities in Sub-Saharan Africa and developing countries.

In Zambia, there is a persistent shortage in the supply of groundnuts in certain regions, despite the major producing areas of Eastern and Northern regions having significant surpluses. This is a clear indication of market failure to stimulate groundnut production and distribution in addition to excessive price volatility, information asymmetry, and lack of organized and consistent markets. These market inefficiencies not only make it hard for producers to plan for their production and forecast profits, but it also interferes with end users’ consumption patterns.

Therefore, this study investigated the extent of market integration and the speed of adjustment in the retail prices between the deficit and surplus areas among geographically separated groundnut markets in Zambia with the aim of enhancing the flow of market information among groundnut market participants. The study aimed at answering the following questions: To what extent are the deficit and surplus groundnut markets integrated? What is the speed of adjustment in the retail prices between the deficit and surplus areas?

The study focused on certain markets in Eastern and Northern Provinces which are the major producing areas and in Lusaka and Copperbelt Provinces that have traditionally been regarded as the main consumption areas (Chiwele et al., 1998). Hence, to determine the pricing efficiency in the groundnut market the study explored the network of buyers, sellers and other actors that converge to trade in this market.
Despite the importance and benefits of market integration to the economy, no study related to the subject matter has been conducted in Zambia to assess the extent of groundnuts integration between markets. Therefore, providing knowledge of groundnut information does not just end at the point of groundnut production and consumption, but goes beyond to inform policy. Most studies in Zambia have shifted concentration to crops like maize, coffee, beans, tobacco, cotton, cassava, sugar cane and recently horticultural while neglecting vital food crops like groundnuts yet it is the second most important crop grown nationally (Muyatwa, 2000; Chisanga et al., 2015; Sunga, 2017).

The knowledge of market integration would enable the government and stakeholders to come up with sound policies such as price stabilization policies that would protect farmers from price risks. This would, in turn, enhance self-sufficiency among smallholder farmers. Alderman (1993) argued that there was a positive relationship between the ease to implement stabilization policies and the degree to which markets were integrated. In addition, Fackler and Goodwin (2001) rightly argued that the level of market integration was important for designing stabilization policies. Therefore, this study would play a critical role in implementing appropriate policies. Also, Kabbiri et al. (2016) observed that studies on market integration had concentrated a lot on countries like China, Ethiopia, Ghana, India, Malawi, Russia and United States of America (USA). Therefore, this study would make literature available for future references in countries that have not been covered particularly Zambia.

The paper is organized as follows: the second section contains the literature review, the third discusses the research methodology of the study, the fourth presents the results and discussion, and the fifth and final section contains the conclusion and recommendations of the study.
LITERATURE REVIEW

Smallholder groundnut marketing in Zambia

Zambia like many other African countries suffers from poorly developed transport and infrastructural development system (Muyatwa, 2000; Sunga, 2017). Poor market infrastructural system affects the participation of market agents, thereby, reducing the possibilities of spatial market perfection (Kabbiri et al., 2016; Loveridge, 1991; Muyatwa, 2000; Sunga, 2017). Smallholder Groundnut marketing is affected by lack of market information, low and unpredictable prices, thereby jeopardizing their marketing decisions (Ross and Matthew de Klerk, 2012). Therefore, bridging the gap between the market agents would ensure a proper linkage between production and markets (Mtumbuka et al., 2015).

The marketing channel of groundnuts includes producers, middlemen, traders, processors and exporters. Traders are generally categorized into small-scale and large-scale traders. Small-scale traders normally buy groundnuts in small amounts but mostly from some village markets. Large-scale traders on the other hand often have enough money to buy large quantities of groundnut produce from far-flung areas (Mukuka et al., 2013). Groundnut crops have seasonal price variations. Groundnut domestic prices are low at the beginning of the marketing season due to the high supply of the nuts and skyrocket when the planting season begins because of limited supply (Ross and Matthew de Klerk, 2012). In terms of export volumes, Chapoto and Chisanga (2016) noted that the import-export value ratio of groundnuts in Zambia was greater than one, implying that Zambia imports more groundnuts and other groundnut products than it exports. Thus, the local demand for groundnuts is high and still increasing than its supply. In essence, the production of groundnuts has never matched local and export market demand for groundnuts.
Market Integration and Empirical evidence of agricultural commodities

Market Integration has been defined differently by various proponents. According to Barret (2001), market integration is a situation where commodity prices in different markets either move together, trade occurs between them or both. More so, there are different types of market integration which include vertical integration, spatial integration and inter-temporal market integration. Studies on market integration enable policy makers to design appropriate short and long-run policies and help in diagnosing problems that occur in agricultural commodity markets (Rashid et al., 2010).

Barrett and Li (2002) rightly argue that the definition of market integration relates to tradability or contestability. This entails that if two markets are integrated, the supply and demand circumstances in one market would disturb prices or transaction volumes in the other market. Therefore, the actions of spatial arbitrageurs are to ensure that the prices of the homogenous product between markets varied by the cost of moving the good from the lower price area to the area with the higher price (Kibiego et al., 2006).

According to law of one price, price transmission tends to be complete once equilibrium prices of the product being marketed across different markets differs only by the transaction cost. However, if there are shifts in demand and supply in a single market, it affects trade and prices in the other market so as to re-establish equilibrium through spatial arbitrage. Absence of market integration and complete price transmission variations between markets has implications on economic welfare. Incomplete price transmissions emanating from either extreme transaction costs such as transportation costs, co-operation costs and imperfect information, or border policies for example, import quotas, tariff, non-tariff barriers and export subsidies hinder the welfares of arbitrage thus changing the marketing choices of groundnuts producers and dealers. In
such conditions, the law of one price does not hold (Ghafoor and Aslam, 2012; Mtumbuka et al., 2015).

The Law of One Price is represented as shown below;

\[ P_{jt} = P_{it} + K \]  

(1)

Where \( P_{jt} \) and \( P_{it} \) are prices in two spatially separated markets respectively, and \( K \) represents the transfer cost. If the above relationship holds, the markets in question are integrated and equilibrium exists between the two markets. This indicates that there would be product movement from the \( i^{th} \) to the \( j^{th} \) market, since prices in the latter tend to be higher than those in the former. This therefore, makes the price difference between these markets to be larger than the transportation cost from the \( i^{th} \) to the \( j^{th} \) market. The increased commodity supply in the \( j^{th} \) market will cause its price i.e. \( P_{jt} \) to drop until prices in both markets tend to reach equilibrium. This would eventually stop the benefits and flow of trade.

Various approaches have been used by researchers to analyse the spatial integration and price transmission in agricultural product markets. Wyeth (1992) used correlation analysis, but this method was limited due to population growth and climate patterns. The regression technique has also attempted to study spatial integration (Alexander and Wyeth, 1994). In the last two decades, studies on market integration have taken two approaches; parity bound models (PBM) and threshold autoregressive (TAR) models. Although there have been improvements in the two models over other models that overlooked transaction costs, the PBM and TAR also have limitations. The major criticisms associated with the parity bound models are that their results are sensitive to underlying distributional assumptions and assume that it is static in nature. Whereas the TAR model assumes constant transaction costs and it is difficult to get the
standard errors and confidence intervals (Campenhout, 2007). Also, the TAR models are said to impose non-theoretical restrictions and are associated with calculations challenges.

However, Cramon-Taubadel and Meyer (2002) posited that no uniform method exists in the evaluation of market integration. Kilima (2006) further argued that the degree of price transmission had no single explicit test as a result of market dynamic relationships arising from trade breaks and distortions in arbitrage resulting to non-linearities. Therefore, in this regard, the study adopted co-integration and VECM models to examine spatial market integration and price transmission in the selected groundnuts markets in Zambia. This was because scanty studies have been done on spatial integration of commodity markets generally, and groundnut markets specifically. And also, most studies on marketing in Zambia have concentrated on the staple maize crop (Mason and Myers, 2013).

**METHODOLOGY**

**Study area**

The study focused on four provinces namely Copperbelt (13.0570°S 27.5496°E), Eastern (13.8056°S 31.9928°E), Lusaka (15.3657°S 29.2321°E) and Northern (9.7670°S 30.8958°E) provinces in Zambia (Latitude Longitude Organization, 2017). The four provinces are among the ten provinces of Zambia, Lusaka province being the capital city and the Copperbelt province being the mineral-rich province. The two provinces are perceived to be the consumption areas while Eastern and Northern provinces are the major production areas of groundnuts. Eastern province is the largest producer of groundnuts seconded by Northern Province in the country (CSO, 2011). Markets that studied in eastern province were Chadiza, Chipata and Petauke; while in the Northern Province Kasama market was studied. These markets are the surplus markets
and markets in deficit areas included Kitwe market in Copperbelt and Lusaka market in Lusaka province. Markets in surplus regions were selected based on production and trade volumes.

**Data Sources**

This study aimed at investigating the degree of integration and price transmission among geographically separated groundnut markets in Zambia in order to enhance the flow of market information among groundnut market participants. The study used secondary time series data that was collected from Zambia’s Central Statistics Office (CSO) and the Ministry of Agriculture and Livestock. The monthly price data was deflated and adjusted to cater for inflation during the period of study. The sample data covered the period from January 2001 to March 2017. Six groundnuts markets were carefully chosen for the study based on the surplus and deficit regions and these included, Lusaka, Kitwe, Chipata, Chadiza, Petauke, and Kasama.

**Analytical approaches**

**Stationarity tests**

*(a) Augmented Dickey-Fuller test for stationarity*

ADF test was used to test for the presence of unit root, which is, testing for stationarity. It is very crucial to test for stationarity for any econometric studies involving time series data because non-stationary series could result in spurious regressions and also stationarity or non-stationarity of a series can affect the performance and properties of a series, for instance, the persistence of shocks would be infinite for non-stationary series. In addition, if the variables are non-stationary, this will entail that t-ratios will not follow the t-distribution and, therefore, hypothesis tests about the regression parameters cannot be carried out reliably. The null hypothesis for the stationarity test is that a series has a unit root. Therefore, failure to reject the null hypothesis implies the presence of
unit root. In this case, the data series follows a certain trend (increase or decrease) over time (Dickey and Fuller, 1981).

There exist two types of stationarity, which are covariate stationary and difference stationary. A series is covariate stationary if we reject the null hypothesis that the series is non-stationary in its original form (data). A series is difference stationary if we reject the null hypothesis of the presence of a unit root in the series after differencing the data series. Stationarity tests are important because they help determine the order of integration. Covariate stationary series are integrated of order 0 that is I (0), while series that are I (1) become stationary only after the first difference. This is very important in co-integration analysis. Testing for stationarity is the first step in testing for co-integration.

After taking the natural logs, the Augmented Dickey-Fuller (ADF) test was employed in order to check the order of integration. ADF is based on a linear regression of the form:

\[ \Delta y_t = \beta_1 + \mu_t + \delta \Delta y_{t-1} + \sum_{j=1}^{k} \alpha_j \Delta y_{t-j} + \epsilon_t \]  

(2)

\( y_t \) = Price of groundnuts of a given region in the logarithm form at time period \( t \). \( \Delta y_t \) is the price expressed in first differences with \( k \) number of lags, \( \epsilon_t \) is the white noise error term with a mean of zero and non-varying variance. The coefficients (\( \mu, \beta, \delta, \alpha \)) are parameters to be estimated.

The rejection of the null hypothesis is based on the MacKinnon critical values. This means that, whenever the probability (\( p \)-value) is smaller than the significance level, the null hypothesis is rejected. In other words, when the estimated coefficient of \( \delta \) is significantly smaller than zero, the null hypothesis can be rejected, implying that there is stationary in the series. Otherwise, the series would be non-stationary (Dickey and Fuller, 1981).

(b) Kwiatkowski, Philips Schmidt and Shin (KPSS) test
The study used KPSS method to confirm the findings of the Augmented Dickey-Fuller test for unit root. This procedure tests the null hypothesis of stationarity against its alternative of non-stationarity. The Kwiatkowski Philips Schmidt and Shin test is a langrange multiplier (LM) procedure for testing $\delta_u^2 = 0$ that is the stationarity hypothesis (Kwiatkowski et al., 1992). The model equation used in the study was as follows:

$$y_t = \xi t + r_t + \epsilon_t$$

(3)

Such that $r_t = r_{t-1} + u_t$

$r_t$ represents a random walk, $u_t$ is independent and identically distributed (iid), $y_t$ is the price series to be tested for stationarity, $\xi$ is a coefficient of $t$, $t$ is the parameter with a deterministic term and $\epsilon_t$ is the error term.

This study adopted Kwiatkowski et al. (1992) approach by using the one-sided langrange multiplier (LM) test statistic in testing the null hypothesis of stationarity given by $H_0: \sigma_u^2 = 0$ against the alternative denoting non-stationarity ($H_0: \sigma_u^2 > 0$). Kwiatkowski (1992) represented the LM test statistics as follows:

$$LM = \sum_{j=1}^{T} \frac{S_j^2}{\hat{\sigma}_e^2}$$

(4)

Where $S_j = \sum_{i=1}^{j} \hat{e}_i$

Here $\hat{\sigma}_e^2$ denotes error variance estimator and $\hat{e}_i$ represents the residual of the regression. The null hypothesis is rejected when the LM Statistic is greater than its critical value. In that case, the conclusion is that the time series variable non-stationary. On the other hand, the series is stationary if we fail to reject the null hypothesis.
Unfortunately, the major disadvantage of KPSS test is that it has a high rate of Type 1 errors. Konya (2004), indicated that KPSS test is characterised by low power limitation. However, for confirmatory purposes, the test was used together with other unit root tests such as PP and ADF and for stationarity testing. When the results from tests statistic (ADF and KPSS) suggest that the series is stationary, then the times series is stationary.

*Test for Co-integration*

The Engle-Grangers Two-Step Estimation method and Johansen’s Co-integration test are used to test the presence of co-integration in time series data. The Johansen’s Co-integration test is method is based on the Maximum Likelihood Method. It uses the Trace Statistic and the Maximum Eigenvalue Statistic to conclude on hypothesis testing. Although the Two Step Estimation Method is easy to run, it requires a larger sample size in order to minimize the likelihood of making estimation errors. This method can only be run on a maximum of two variables (Dolado *et al*., 1991; Charemza *et al*., 1992; Brooks, 2008). Another weakness of Two Step Engle-Granger test is that it restricts testing for co-integrating relationships, unlike Johansen’s method (Books, 2008). However, one drawback of Johansen’s test of co-integration is that it is difficult to interpret results.

Johansen (1988) co-integration test was used to test the presence of a long run relationship. The test was chosen because of its ability to test the association between more than two variables simultaneously. Johansen Co-integration test is typically based on maximum likelihood estimation and two statistics, namely: maximum eigenvalues and a trace-statistics. It stems from the theory and concepts of the rank of a matrix. In this case, the study was interested in the rank of the matrix, which indicates the number of co-integrating relationships among the price variables.
Multivariate Johansen co-integration is derived from the Vector Autoregressive (VAR) model states that: If \( y_t \) is a vector of \( n \) stochastic variables, then a \( p \)-lag vector auto regression exists with Gaussian errors of the following (VAR) form order \( P \) (Johansen and Juselius, 1990) as shown below.

\[
y_t = \mu + \Delta y_{t-1} + \ldots + \Delta y_{t-p} + \epsilon_t
\]  

(5)

Where \( y \) is an \( n \times 1 \) vector of groundnut prices that are integrated of order one, that is, I (1).

According to Johansen and Juselius (1990), determining the number of co-integrating vectors involves the use of two test statistics. The first statistic is trace test which hypothesises (that is the null hypothesis) that co-integrating vectors are less than or equal to \( q \) against the alternative hypothesis \( q = r \). Its Mathematical presentation is as shown below;

\[
\lambda_{trace(r)} = -T \sum_{i=r+1}^{p} \ln(1 - \lambda_i)
\]  

(6)

Where, \( T \) is the number of valid and usable observations, and \( \lambda_i \) are eigenvalues derived or estimated from the matrix. The other statistic, the maximum Eigen value test (max), is computed as follows:

\[
\lambda_{max(r+1)} = -T \ln(1 - \lambda_{r+1})
\]  

(7)

In this test, the null hypothesis that there are \( r \) co-integrating vectors against the alternative that \( r+1 \) co-integrating vectors will be tested.

**Granger Causality Test**

Granger (1980) causality test gives us the relationship between two-time series variables. This relationship is the direction of causation between the two-time series variables. Apart from showing the association between the two-time series variables, it also determines what causes what between the two-time series variables. Granger causality test is based on the following Vector Autoregressive (VAR) system:
Where, $\varepsilon_{it}$ are white Gaussian random vector. In this case, $x$ and $y$ are the prices that will be tested. This VAR system, if the log of $y$ variable in equation 9 is not significant and log of $x$ in equation 8 is significant; it means that there is a unidirectional causation running from $x$ to $y$. And if the log of $y$ variable in equation 9 is significant while the log of $x$ in equation 8 is not significant, there is also a unidirectional relationship that runs from $y$ to $x$. Bi-directional causational relationship exists when the logs of both variables are significant in the two equations. Finally, if the logs of two variables are not significant, then there is no causation between the two variables.

**Vector Error Correction Model**

After establishing the existence of co-integration between the price series, the vector error correction model was estimated. Since co-integration regression on long-run relationships between the series of variable, the Error Correction Model (ECM) was developed to measure short-run dynamics between the first differences of the time series variables. Ikudayisi and Salman (2014) stated that VECM examined the dynamic adjustment of time series variables towards their equilibrium. If the ECM has a negative and significant coefficient, this suggests that short-term fluctuations eventually culminate into a stable long-run association between the series. The basic error correction term is represented as follows:

$$ e_t = y_t - \beta x_t $$  \hspace{1cm} (10)

Here $e_t$ denotes the error term after regressing $y_t$ on $x_t$, and $\beta$ represents the co-integrating coefficient. Thus the Error Correction Model can be defined as;
\[ \Delta y_t = \alpha e_{t-1} + \gamma \Delta x_t + u_t \]  

(11)

Where \( u_t \) is independent and identically distributed (\( i.i.d \)) and first difference of the dependent variable is explained by the lagged \( e_{t-1} \) and \( \Delta x_t \). \( e_{t-1} \) represents the value of the lagged residuals. For co-integrated time series variables, ECM therefore, measures the adjustment speed of the variables as they move towards long run equilibrium and offers an added independent variable to explain the first difference of \( y_t \).

In this study, the VECM took the following form:

\[ \Delta R_{p_t} = \alpha_0 + \sum_{i=1}^{p} \beta_0 \Delta R_{p_{t-i}} + \sum_{i=1}^{p} \beta_1 \Delta U_{p_{t-i}} - \lambda (R_{p_{t-i}} - U_{p_{t-i}}) + \varepsilon_{1t}, \]  

(12)

\[ \Delta U_{p_t} = \alpha_1 + \sum_{i=1}^{p} \beta_2 \Delta R_{p_{t-i}} + \sum_{i=1}^{p} \beta_3 \Delta U_{p_{t-i}} - \lambda (R_{p_{t-i}} - U_{p_{t-i}}) + \varepsilon_{2t}, \]  

(13)

RESULTS AND DISCUSSIONS

Descriptive statistics of groundnut prices in deficit and surplus areas

Price variability has been at the core of comprehending price behaviour in several markets. It emanates from either natural factors like weather changes or economic factors such as transportation costs, market agents and changes in market structure. From Table 2, Lusaka and Kitwe had the highest nominal mean prices of K12.32 and K8.82 per Kg respectively, while Petauke and Chipata recorded the lowest mean prices of K6.21 and K6.43 respectively. The high prices in both Lusaka and Kitwe were as a result of urban demand of groundnuts that outpaced supply (Mukuka et al., 2013). In addition, the high prices in these districts were also reflecting the high transaction costs incurred by traders during transportation of groundnuts from producing areas to consuming regions (WFP, 2016). The low prices recorded in Chipata, Chadiza and Kasama can be qualified to the fact that the markets are situated in the main groundnut growing regions across the country. In addition, the low
groundnut prices in Chipata were also attributed to the inpouring of groundnuts from neighbouring countries such as Malawi and Mozambique that have recorded significant growth in groundnut production and export in recent years (Mukuka et al., 2013).

Table 1: Nominal monthly groundnuts prices from 2001 to 2017, (K/kg)

<table>
<thead>
<tr>
<th>Markets</th>
<th>Mean</th>
<th>Min</th>
<th>Max</th>
<th>CV (%)</th>
<th>Dev.</th>
<th>Skewness</th>
<th>Kurtosis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lusaka</td>
<td>12.32</td>
<td>2.47</td>
<td>29.59</td>
<td>50.00</td>
<td>6.10</td>
<td>0.91</td>
<td>0.76</td>
</tr>
<tr>
<td>Kitwe</td>
<td>8.82</td>
<td>2.39</td>
<td>24.12</td>
<td>54.00</td>
<td>4.76</td>
<td>1.22</td>
<td>1.35</td>
</tr>
<tr>
<td>Chipata</td>
<td>6.43</td>
<td>1.20</td>
<td>25.00</td>
<td>74.00</td>
<td>4.77</td>
<td>2.00</td>
<td>3.98</td>
</tr>
<tr>
<td>Chadiza</td>
<td>8.36</td>
<td>0.80</td>
<td>31.25</td>
<td>77.00</td>
<td>6.45</td>
<td>1.57</td>
<td>1.94</td>
</tr>
<tr>
<td>Kasama</td>
<td>6.73</td>
<td>1.51</td>
<td>29.01</td>
<td>85.00</td>
<td>5.73</td>
<td>1.94</td>
<td>3.46</td>
</tr>
<tr>
<td>Petauke</td>
<td>6.21</td>
<td>1.00</td>
<td>26.31</td>
<td>79.00</td>
<td>4.92</td>
<td>1.81</td>
<td>3.37</td>
</tr>
</tbody>
</table>

Note: CV denotes the coefficient of variation, Min and Max show the Minimum and Maximum nominal prices. Std. Dev. is the Standard deviation.

In Table 1, Kasama market had the highest price variability (85 percent) while Lusaka recorded the least price variability of 50 percent over the considered period. The difference between the highest and lowest variability of groundnuts prices was 35 percent. This implies that the behaviour across all the markets was significantly different. In general, there was a large price variation among all the markets indicating variability in production. Skewness is a measure of data asymmetry. Groundnut prices in all the markets are positively skewed with insignificant difference between the sizes of the skewness. A study by Otoo (2012) indicated that positive skewness in all the series meant that the series were frequently controlled by periods of high prices which were not offset by periods of low prices of the same magnitude. Lastly, on kurtosis which is a measure of how tailed the data is, Chipata, Kasama and Petauke had values greater than three, meaning the distribution was leptokurtic. This implies that
the distribution of prices tended to be closer to the average price. On the other hand, Lusaka, Kitwe and Chadiza had platykurtic distribution, meaning that the prices are far away from the average.

**Stationarity Test**

The groundnut price data was tested for stationarity before running a co-integration analysis. This was important to avoid spurious regression. In addition, using non-stationary price data leads to unreliable policy-making decisions and is not suitable for long-run predictions (Yusuf and Falusi, 1999). Table 3, shows results for both ADF and KPSS tests on individual variables spanning from January 2001 to March 2017. When prices at all of the six markets were tested for stationarity using ADF test, it was found out that prices at Chadiza, Chipata, Kasama and Petauke were covariate stationary while Kitwe and Lusaka prices were found to be stationary at level. However, after suppressing the constant term, Lusaka and Kitwe were not stationary at level. After differencing once, prices at the six markets were all stationary. Since all variables were stationary after first difference, it means they were integrated of order 1, that is to say, $I(1)$. This is one of the conditions for testing co-integration that depicts the presence of a long-run relationship among the six groundnuts markets. Similarly, Kwiatkowski Philips Schmidt Shin (KPSS) confirmed the results of the ADF tests.

**Table 2: Results for Stationarity test using ADF and KPSS**

<table>
<thead>
<tr>
<th></th>
<th>ADF</th>
<th></th>
<th>KPSS</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Level</td>
<td>First Difference</td>
<td>Level</td>
<td>First Difference</td>
</tr>
<tr>
<td>Chadiza</td>
<td>-2.86</td>
<td>-13.23***</td>
<td>0.80</td>
<td>0.06***</td>
</tr>
<tr>
<td>Chipata</td>
<td>-3.25</td>
<td>-12.84***</td>
<td>0.39</td>
<td>0.32***</td>
</tr>
<tr>
<td>Kasama</td>
<td>-3.43</td>
<td>-20.08***</td>
<td>0.53</td>
<td>0.17***</td>
</tr>
<tr>
<td>Kitwe</td>
<td>-7.29***</td>
<td>-8.39***</td>
<td>0.26***</td>
<td>0.12***</td>
</tr>
</tbody>
</table>
### Lag Selection Criteria

Selection of appropriate lag is regarded as one of the crucial steps that must be done before running Co-integration and Granger Causality Tests. For Lusaka-Chipata market pair AIC and FPE chose the optimum lag of two. In this regard, lag length of two was employed for both Granger Causality and co-integration tests. Similarly, AIC, FPE and LR selected an optimum lag of four for Lusaka-Chadiza market pair. Lusaka-Kasama pair, lag two was chosen as an appropriate lag length. Furthermore, an optimum lag length of three was selected between Lusaka and Petauke market.

For Kitwe-Chipata market pair, Schwarz’s Bayesian Information and Hannan-Quin Information Criterion selected one as an appropriate lag length. Also for Kitwe-Chadiza market pair, Akaike Information criteria and Final Prediction Error chose five as an optimum lag. For the Kitwe-Kasama market pair, the Schwarz’s Bayesian Information Criterion selected lag length of one. Lastly, for Kitwe-Petauke market pair, Akaike Information Criterion, Final Prediction error, Hannan-Quin Information Criterion and Schwarz’s Bayesian Information Criterion chose the lag of three as an optimum lag.

### Co-integration of the Groundnuts Markets

Table 3 shows the results of co-integration analysis using Johansen multivariate analysis. Both statistics, that is the trace statistic and the maximum eigenvalue, reject the null hypothesis of zero co-integrating linear equations among Lusaka-
Chipata, Lusaka-Chadiza, Lusaka-Kasama, Lusaka-Petauke, Kitwe-Chipata, Kitwe-Chadiza, Kitwe-Kasama and Kitwe-Petauke market pairs. This means that there was at most one co-integrating equation among the eight market pairs. It then follows that price signals are transmitted across these markets and, therefore, any shock occurring in one market transmits signals to another, suggesting that there exists a long-run equilibrium relationship among the eight markets pairs. Thus, in the long run, the relationship of these variables was stable and predictable.

In addition, the presence of a long-run association between the market pairs suggested the supply of groundnuts from the surplus areas like Chipata, Chadiza, Kasama and Petauke to deficit areas such as Lusaka and Kitwe. These results are similar to those of Mayaka (2013) who established that there was a long run cointegration between Nairobi-Nakuru, Nairobi-Eldoret, Nairobi-Kitale, Nakuru-Kitale and Eldoret-Kitale market pairs in a study in Kenya. The study also observed co-integration justified the supply of dry beans from surplus to deficit areas. This was the situation during production periods because prices were low. Thus, assemblers had an incentive to transport dry beans to deficit areas expecting higher profit margins. However, these results contradict the findings of Mockshell and Egyir (2010) who found that the groundnut markets were not integrated in either the short or long run, and the groundnut’s distribution channel was large leading to increased transaction cost that was eventually transferred to the final consumer.

Table 3: Results of Johansen Co-integration for Trace and Maximum eigenvalue tests

<table>
<thead>
<tr>
<th>Markets</th>
<th>Test</th>
<th>Test Statistics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lusaka-Chipata</td>
<td>$\tau_{trace} = r = 0$</td>
<td>36.73 **</td>
</tr>
<tr>
<td></td>
<td>$\xi_{max} = r = 0$</td>
<td>36.68 **</td>
</tr>
<tr>
<td></td>
<td>$\tau_{trace} and \xi_{max} = r = 1$</td>
<td>0.05</td>
</tr>
<tr>
<td></td>
<td>ADF residual test</td>
<td>-7.96</td>
</tr>
</tbody>
</table>
Lusaka-Chadiza
\[ \tau_{trace} = r = 0 \]
\[ \xi_{max} = r = 0 \]
\[ \tau_{trace} and \xi_{max} = r = 1 \]
ADF residual test
-6.92

Lusaka-Kasama
\[ \tau_{trace} = r = 0 \]
\[ \xi_{max} = r = 0 \]
\[ \tau_{trace} and \xi_{max} = r = 1 \]
ADF residual test
-6.75

Lusaka-Petauke
\[ \tau_{trace} = r = 0 \]
\[ \xi_{max} = r = 0 \]
\[ \tau_{trace} and \xi_{max} = r = 1 \]
ADF residual test
-7.07

Kitwe-Chipata
\[ \tau_{trace} = r = 0 \]
\[ \xi_{max} = r = 0 \]
\[ \tau_{trace} and \xi_{max} = r = 1 \]
ADF residual test
-7.68

Kitwe-Chadiza
\[ \tau_{trace} = r = 0 \]
\[ \xi_{max} = r = 0 \]
\[ \tau_{trace} and \xi_{max} = r = 1 \]
ADF residual test
-7.62

Kitwe-Kasama
\[ \tau_{trace} = r = 0 \]
\[ \xi_{max} = r = 0 \]
\[ \tau_{trace} and \xi_{max} = r = 1 \]
ADF residual test
-8.49

Kitwe-Petauke
\[ \tau_{trace} = r = 0 \]
\[ \xi_{max} = r = 0 \]
\[ \tau_{trace} and \xi_{max} = r = 1 \]
ADF residual test
-7.63

Note: \( \tau_{trace} \) and \( \xi_{max} \) denotes both the trace and maximum eigenvalue test respectively. \( r \) indicates the number cointegrating equations. The ADF test critical value is -2.876277. Triple, double and single asterisks show statistical significance at 1%, 5% and 10% level respectively.

**Granger Causality of the eight Groundnuts market pairs**

Since Co-integration analysis does not show the direction of the relationship, it is important to run granger causality tests which show the nature of the
relationship among the markets. Moreso, economic theory assures the presence of granger causality in at least a single direction (Order and Fisher, 1993). Goletti and Babu (1994) argued that granger causality denotes the direction of the market relationship as it supplements co-integration analysis. In addition, Mtumbuka et al. (2015) explained that granger causality recognizes the price formation direction between market pairs and the movements of groundnuts to adjust for these price differences. Granger Causality can be either bidirectional or unidirectional causation. Bi-directional causation occurs when shocks between the markets are transmitted in either direction while unidirectional causality occurs especially when shocks are one-way and cannot be reversed between two markets. In this study, granger causality was applied to eight market pairs and out of these market pairs, only one pair (Kitwe-Chadiza) showed bi-directional causation, five market pairs indicated unidirectional causation and the rest of the market pairs showed no causality relationship.

From Table 4, the first null hypothesis is that groundnuts prices at Kitwe market do not granger cause prices at Chadiza groundnuts market. Looking at the p-value (that is 0.01), we reject the null hypothesis that groundnuts prices at Kitwe markets do not granger cause markets at Chadiza market. In this case, any change in prices at Kitwe groundnuts market transmits signals to Chadiza. Chadiza district happens to produce groundnuts more than Kitwe district in Zambia. In Kitwe, people prefer food made of groundnuts such as visashi (vegetables mixed with pounded groundnuts) and packaged groundnuts from supermarkets as such making the demand to be high. That is why any price shock occurring at Kitwe is likely to transmit price signals to Chadiza market. On the other hand, price changes in Chadiza were transmitted to Kitwe. Thus, results in the table showed bidirectional causation between Kitwe and Chadiza market pair. This implies that there is trade between the market pair and price
in Kitwe could be predicted using Chadiza market prices and vice versa. That is, any shock in either market is simultaneously translated to a shock in the other market.

Furthermore, it was observed that Lusaka-Chipata, Lusaka-Chadiza, Lusaka-Petauke, Kitwe-Chipata and Kitwe-Kasama market pairs showed a unidirectional relationship. Any price shock in either Chipata or Chadiza market were transmitted to Lusaka. Similarly, any price shock in Lusaka was transmitted to Petauke.

Finally, Lusaka-Kasama and Kitwe-Petauke market pairs showed no causal relationship between them. This implied that there was the absence of interdependence between these markets. The result is corroborates that of Ani (2015) who found that that there is no interdependence or any other form of causality exiting between these markets. Thus, an increase in price in one market in the short run could not bring about an increase in price in another market. This implied that prices in both markets were inefficiently and slowly transmitted with the interaction of demand and supply that was regulating the prices. However, the study indicated that lack of causality could not mean an absence of price transmission, as in the long-run prices could transmit slowly.

**Table 4: Results for pairwise granger causality**

<table>
<thead>
<tr>
<th>Market Pairs</th>
<th>F</th>
<th>df</th>
<th>Prob&gt;F</th>
<th>F</th>
<th>Prob&gt;F</th>
<th>Direction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lusaka-Chipata</td>
<td>1.62</td>
<td>2</td>
<td>0.20</td>
<td>6.47</td>
<td>0.00***</td>
<td>Unidirectional</td>
</tr>
<tr>
<td>Lusaka-Chadiza</td>
<td>0.67</td>
<td>4</td>
<td>0.62</td>
<td>2.03</td>
<td>0.09*</td>
<td>Unidirectional</td>
</tr>
<tr>
<td>Lusaka-Kasama</td>
<td>1.60</td>
<td>2</td>
<td>0.21</td>
<td>1.55</td>
<td>0.22</td>
<td>Independent</td>
</tr>
<tr>
<td>Lusaka-Petauke</td>
<td>3.52</td>
<td>3</td>
<td>0.02**</td>
<td>2.00</td>
<td>0.12</td>
<td>Unidirectional</td>
</tr>
</tbody>
</table>
The bi-directional causality between Kitwe and Chadiza suggested that there was efficiency and market information among the market participants. On the other hand, the existence of independent causation among Lusaka-Kasama and Kitwe-Petauke market pairs meant lack of market information and lack of efficiency. Bannor and Sharma (2015) found that bi-directional causality in Rajasthan was because farmers sold their groundnuts through the channel of producers, wholesalers and processors.

Since the results for Johansen cointegration show the presence of a long-run relationship, it is necessary to test whether there are any short-run dynamics between the market pairs. Therefore, to ascertain any short-run relationship, the study used the vector error correction model (VECM). The table below shows the results of the estimated VECM.

### Table 5: Results from the Vector Error Correction Model

<table>
<thead>
<tr>
<th>Market Pairs</th>
<th>ECM Coefficient</th>
<th>t-stat</th>
<th>Lag</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lusaka-Chipata</td>
<td>-0.44</td>
<td>-6.55***</td>
<td>2</td>
</tr>
<tr>
<td>Lusaka-Chadiza</td>
<td>-0.33</td>
<td>-4.71***</td>
<td>4</td>
</tr>
<tr>
<td>Lusaka-Petauke</td>
<td>-0.39</td>
<td>-5.69***</td>
<td>3</td>
</tr>
<tr>
<td>Lusaka-Kasama</td>
<td>-0.36</td>
<td>-5.92***</td>
<td>2</td>
</tr>
</tbody>
</table>
The results show that the estimated adjustment coefficients has a negative sign, as expected and is significant at 1%, as indicated in Table 5. The highest speed of adjustment towards the long-run equilibrium was from Kitwe to Kasama at the rate of 52%. The lowest speed of adjustment was observed between Lusaka and Chadiza at the rate of 33%. These results corroborate with the findings of Habte (2017) who found that there were short-run relationships among the papaya markets in Ethiopia and also, the study noted that the differences in the speed of adjustment in different markets had implications on how equitable and efficient a marketing system can be. Contrary to these findings, Mockshell and Egyir (2010) found the groundnut market in Ghana was not integrated both in the short and in long run.

CONCLUSIONS AND RECOMMENDATIONS

This paper investigated the spatial market integration and price transmission of groundnut markets using cointegration, VECM and Granger causality. Johansen’s trace and maximum eigenvalue tests indicated the presence of long-run co-integration among the eight groundnut market pairs. For the VECM, the highest speed of adjustment towards the long-run equilibrium was from Kitwe to Kasama at the rate of 52%, meaning that 52 percent of the disequilibrium was corrected after an exogenous shock. The lowest speed of adjustment was running between Lusaka and Chadiza at the rate of 33%. The speed of price transmission among all the market pairs was slow. This may be attributed to different reasons such as high transportation cost, poor government policies, lack of adequate price information, poor infrastructure and institutions.
The government and other relevant stakeholders must continue with their efforts in enhancing the flow of information, which plays a crucial role in spatial integration among the markets. Since long distances mostly separate these markets, it is necessary to ensure development and constant use of market information centres. This is very important because market information centres tend to reduce information asymmetries between the market participants, thereby making these markets more efficient. The efforts in promoting online trading platform like EMsika in Zambia is a move in the correct direction. However, these innovations should be made available in all the provinces so that the farmers to fully benefit from them.

The study recommends for provision of quality infrastructure and road network in rural markets in order to reduce the fluctuations of groundnut prices. Also, investing more in the groundnut production and development of market infrastructures such as modern stores, warehouse receipt systems and groundnut factories between the urban markets and rural markets. This would ensure protection of stored produce from the vagaries of bad weather, pests and rodents, prevent quantity and quality losses, regulation of price levels through the control of groundnuts supply and demand, and finally, offering price, demand and supply information to market participants for the development of effective and profitable strategies. Thus, encouraging farmers to produce more groundnuts and participate in groundnuts marketing, hence, enabling farmers to determine the movement of groundnut prices.

The Market Support Services under the Ministry of Agriculture and Co-operatives should consistently collect price information on weekly and monthly basis and this information should be available to the farmers. This would motivate farmers to produce more groundnuts as well as plan their production.
REFERENCES


Sure are we that economic time series have a unit root? *Journal of Econometrics*, 54(1-3):159-178.


