Full Length Research Paper

Spatial Integration and Price Relationships in Kenyan Sorghum Markets

Brian Omondi Lumumba[*] **and Jonathan Makau Nzuma**

Department of Agricultural Economics, University of Nairobi, P.O. Box 29053- 00625, Nairobi, Kenya.

*Corresponding Author's Email- brianomondi24@gmail.com

Over the past few years, policymakers and researchers in Kenya have implemented different interventions to improve the efficiency of the sorghum subsector. However, marketing barriers persist, while poor market information access remains a major constraint. This study evaluated the integration of sorghum markets in Kenya and tests for causality using bi-monthly data from five markets for the 2011 to 2017 period. Johansen cointegration approach and Granger causality tests were employed to test for market integration and causality respectively, using data from five markets; Kalundu, Kibuye, Homabay Town, Soko Posta and Gikomba as the reference market. The cointegration results revealed that there is existence of a long run relationship between Gikomba and all the other markets. This implied that sorghum prices converge towards equilibrium in the long run. Granger causality tests revealed presence of three unidirectional, one bidirectional and three independent price relationships. The independent relationship implied marketing inefficiencies. The study recommends the strengthening of market information systems as this will enhance market integration.

Keywords: Market integration, Unit roots, Johansen cointegration, Granger causality.

1. INTRODUCTION

The movement of food produce from production to consumption zones largely depends on the availability of effective agricultural markets. Price mechanisms play a critical role in ensuring that markets function properly as they guide economic actors towards efficient allocation of resources. Through market integration, policy makers are able to assess the effectiveness of agricultural markets. Market integration refers to the co-movement of price shocks or other information across markets that are spatially separated (Goletti and Tsigas, 1995). The absence of market integration would result in food scarcities as producers in surplus areas would fail to react to price signals from deficit markets (Stephan von Cramon-Taubadel, 2017).

Additionally, Baulch (1997) argues that lack of food market integration would lead to increased price volatility, as producers would fail to specialize thus limited gains from trade. A key conceptualization of market integration is the tradability aspect, which describes the transfer of excess demand from one market to another. Market integration is a good indicator of the process of market inter-relationships. It can be measured by assessing the existence of one or more price co-movements (Barrett and Li, 2002). Thus, it is essential to understand the degree to which food markets are integrated as this information would help in the designing of effective food marketing policies.

Sorghum is one of the cereal crops grown in Kenya and its importance in eradicating food security continues to be emphasized, although it falls behind other staple crops that include maize, rice and wheat (ASARECA, 2011). It is a drought tolerant crop whose importance continues to grow in the face of climate change. Sorghum production levels in Kenya have increased over the past few years, for instance,

production has increased from 94,955 metric tons in 2010 to 178,000 metric tons in 2016 (KNBS, 2017). However, consumption levels currently stand at 188,000 metric tons, the deficit is met by imports from the COMESA region, particularly Uganda and Tanzania (ASARECA, 2011).

The sorghum subsector contributes to the Kenyan economy through its whole value chain where its value currently stands at Kenya shillings 7.54 billion (MoALF, 2016). The increased production levels in the recent years provide an opportunity for increased trade with deficit regions; this is because variations in production is one of the key tenets for successful market integration (Goletti and Tsigas, 1995). With more emphasis on production, it is also essential to improve the marketing thus completing the whole value chain.

While there have been efforts and intervention measures to improve the sorghum subsector, various marketing barriers persist. One of the key marketing constraints that has been identified is poor price information access (KAPP, 2011). However, very few attempts have been made at evaluating the integration of sorghum markets in Kenya. This is despite the significant price differences that exist between surplus and deficit sorghum markets in Kenya. This study is an attempt to bridge the existing knowledge gap on sorghum market integration in Kenya.

Different approaches have been applied in analysing the integration of food markets in the literature with varying results. Threshold models have established lack of full market integration in sorghum markets in both Nigeria (Blay *et al.*, 2015) and Ethiopia (Tamru, 2013) respectively. While Amassaib *et al.*, (2015) through the application of price correlation model established that sorghum markets in Sudan were integrated with world markets. On the other hand, there has been numerous applications of cointegration models to evaluate sorghum market integration (Abdalla, 2016; Asche, *et al.*, 2012 and Zalkuwi, *et al.*, 2015).

This study evaluated the integration and causality relationships of sorghum markets in Kenya. The rest of the paper is organized as follows: Section 2 presents the methodology while Section 3 presents a discussion of the results. Finally, conclusions and policy recommendations are drawn in Section 4.

2. MATERIALS AND METHODS

2.1. Data Sources

This study used bimonthly wholesale time series data collected from five major sorghum markets in Kenya for the 2011 to 2017 period. Soko Posta,

Homa bay and Kibuye in the western region; Gikomba in the central region and Kalundu in the eastern region. Soko Posta, Homabay and Kalundu lie in the rural areas and represent the main sorghum producing zones in Kenya, while Kibuye and Gikomba are found in major consumption zones. The price series data were obtained from the Ministry of Agriculture (Marketing Department) and the National Farmers Information Service (NAFIS).

2.2. Theoretical Framework

The law of one price is the main foundation for spatial market integration analysis. The law postulates that the price of a homogenous good in spatially separated markets is equal safe for the transaction or transfer costs (Fackler and Goodwin, 2001). The relationship between two prices can be specified as:

$$P_{1t} = P_{2t} + c\ldots \text{..(1)}$$

Where P_{1t} is the price in market one, P_{2t} is the price in market two and c is the transfer cost. If the relationship in (1) holds, markets one and two are integrated.

2.3. Method of analysis

The study utilized the cointegration model to evaluate the integration of sorghum markets in Kenya. The price series were first transformed into logs and analysis includes constants and trends. The process involves carrying out unit root tests to examine the stationarity nature of the data, cointegration analysis and then granger-causality tests to determine the direction of price causality for markets in the study areas.

2.3.1. Unit Root Tests

The process of testing for cointegration begins with an examination of the price data to examine if it is stationary, that is it has a constant mean and variance over time. The consequence of running non-stationary time series is that it would lead to generation of spurious results (Dickey and Fuller, 1979). The process of examining whether a data set is stationary or not amounts to testing for unit roots.

In this study, Augmented Dickey Fuller (ADF) and Phillips-Peron (PP) tests are employed to examine the unit root properties of the sorghum price data series. The null hypothesis tested is that of a unit root against the alternative of no unit root. The null hypothesis is rejected if the calculated absolute value of (τ) statistic exceeds the DF/Mackinnon critical (τ)

critical value (Dickey and Fuller, 1979). If the null hypothesis is rejected, the conclusion is that the price series is stationary. On differencing, if the series becomes stationary (no unit root) at *d* times, then the series is integrated of order *d*, I (*d*).

2.3.2. Johansen Cointegration Test

Following Johansen and Juselius (1990), the test for cointegration starts with the application of a Vector Autoregressive Model specified as follows:

$$P_t = A_t P_{t-1} + \ldots\ldots\ldots + A_k P_{t-k} + \mu_t \ldots\ldots\ldots\ldots(2)$$

Where P_t denotes an (nx1) vector of I (1) variables which consist of exogenous and endogenous variables, A_t denotes (nxn) matrix of parameters and μ_t denotes (nx1) vector of white noise errors.

This procedure generates two statistics, the trace test statistic and maximum eigenvalue statistic. Based on Johansen and Juselius (1990) the two tests can be specified as:

$$\Lambda_{trace}(r) = -T\Sigma_{tr+1}^{p}\ln(1-\lambda_i)\ldots\ldots\ldots\ldots\ldots\ldots.(3)$$

$$\Lambda_{max}(r, r+1) = -T\ln(1-\lambda_{r+1})\ldots\ldots\ldots\ldots\ldots\ldots \ldots (4)$$

Where λ_i is the maximum Eigen value, T is the number of observations and T represents sample size and $(1-\lambda_{r+1})$ represents max-eigenvalue estimate.

The null hypothesis $r_0 = 0$ is tested against the alternative hypothesis $r_0 > 0$. The calculated absolute values are then compared to the tabulated Osterwald-Lenum (1992) critical values. The null hypothesis is rejected if the trace test statistic and maximum Eigen value statistic values are greater than the Osterwald-Lenum critical values (Johansen and Juselius, 1990). This indicates that there exists a long run relationship between the data series.

2.3.4. Granger Causality Test

The presence of cointegration denotes the existence of causality in at least one direction. Causality refers to the measurement of the predictability of prices (Granger and Lee, 1989). A price series A is said to granger cause price series B if the current and lagged values of A are able to improve prediction of prices of B (Gujarati, 2004). Causality can be determined by carrying out Granger causality tests.

There are three forms of granger causality tests, unidirectional causality indicates that shocks in market A cause prices in market B but there is no reverse effect.

Bi-directional causality implies that there exists a dependent relationship between markets A and B in relation to price information while an independent relationship indicates that none of the markets causes price changes on the other. Following Rashid(2004), pairwise causality tests with Gikomba as the reference market were conducted based on the following specification:

$$P_{1t} = \sum_{i=1}^{n} \alpha i\ P_{1t-1} + \sum_{j=1}^{n} \beta j\ P_{2t-1} + \mu_{1t} \ldots\ldots\ldots\ldots\ldots(5)$$

$$P_{2t} = \sum_{i=1}^{m} \lambda j\ P_{1t-1} + \sum_{j=1}^{m} \beta j\ P_{2t-1} + \mu_{2t} \ldots\ldots\ldots\ldots\ldots(6)$$

Where μ_{1t} and μ_{2t} are uncorrelated. Equation 5denotes that P_{1t} is predicted by lagged variables of P_{1t} and $P_{2t.}$ while equation 6represents the predictability of P_{2t} determined by its lagged values and those of $P_{1t.}$ Granger causality tests are then determined by estimating the lagged coefficients $\sum\alpha_i$ and $\sum\lambda_j$ to test if they are different from zero using F-statistic (Granger C. W., 1969). Essentially it involves testing the null that $\sum\alpha_i = 0$and $\sum\lambda_j = 0$ implying that market 1 does not granger cause market 2 and that market 2 does not granger cause market 1.

3. RESULTS AND DISCUSSIONS

3.1. Unit Root Test Results

Table 1 presents the ADF and PP unit root test results with a constant and a trend variable included for the five market price series. All variables are transformed to logarithms while the prices used are nominal

Table 1: Unit Root Test for Sorghum Market Price Series in Kenya

Series	Level Series		Lags	First Differences		I(d)
	ADF	PP		ADF	PP	
Gikomba	-2.41	-2.69	1	-5.75	-12.40	I(1)
Homabay	-2.60	-2.93	1	-6.05	-11.51	I(1)
Kalundu	-2.75	-3.24	1	-4.04	-12.35	I(1)
Kibuye	-1.67	-2.37	1	-5.45	-11.60	I(1)
Sokoposta	-2.58	-2.83	1	-7.86	-12.65	I(1)
5% Critical	-3.44	-3.44		-3.44	-3.44	

The hypothesis of a unit root in the level series cannot be rejected at the 5 percent significance level for any of the five price series in both models (Table 1). However, the first differenced series rejects non stationarity in all cases (Table 1). These results are consistent with the hypothesis that non-stationarity characterizes sorghum prices in Kenya. Since the sorghum wholesale prices in Kenya are integrated of order one, it is expected that they are jointly determined and might be cointegrated.

3.2. Johansen Cointegration Results

Table 2 presents the Johansen cointegration test results for the five sorghum market price series. Prior to applying the procedure, an unrestricted Vector Autoregressive model was ran and the optimal lag selected using Akaike Information Criteria in E views 7. The null of no cointegrating vector was tested. The model is fitted with one lagged variable in their first differences.

Table 2: Johansen Cointegration Test Results for Sorghum Market Integration in Kenya

Hypothesized number of cointegrating equations		Trace Statistic	5 percent critical value	1 percent critical value	Max-Eigen statistic	5 percent critical values	1 percent critical values
None**		145.065	68.52	76.07	67.617	33.46	38.77
At most 1**		77.448	47.21	54.46	36.0234	27.07	32.24
At most 2**		41.424	29.68	35.65	23.544	20.97	25.52
At most 3**		17.879	15.41	20.04	14.941	14.07	18.63
At most 4		2.939	3.76	6.65	2.939	3.76	3.76

Note: The critical values are from tabulated Osterwald-Lenum (1992). *(**) denotes rejection of null hypothesis at the 5 percent and 1 percent level.

The maximum Eigen value test and the trace test reject the null hypothesis of more than three cointegrating vectors at the 5 percent significance level for all five price series, since the computed test results are greater than the critical Osterwald-Lenum (1992) values (Table 2). Both tests suggest the existence of four cointegrating vectors. Based on these test results, it can be concluded that sorghum markets in Kenya have stable long run relationships to which the variables in the system have a tendency to return to and can be interpreted as being integrated.

3.3. Bivariate Cointegration Results

Table 3 presents bivariate cointegration test results which was carried out to explore the relationship between Gikomba as a reference market and the other markets. Gikomba lies in a central location and is also an important market for sorghum consumption point(Kilambya & Witwer, 2013).

Table 3: Bivariate Cointegration Test Results for Sorghum Market Integration in Kenya

Market Pairs	Hypothesis H₀	Trace Statistic	Trace Critical Value	Max Eigen Statistic	Max Eigen Critical Value
Homabay and Gikomba	r=0	20.06**	15.41	16.86*	14.07
	r≤1	3.21	3.76	3.21	3.76
Kalundu and Gikomba	r=0	24.77**	15.41	21.6**	14.07
	r≤1	3.17	3.76	3.17	3.76
Kibuye and Gikomba	r=0	23.86**	15.41	20.49**	14.09
	r≤1	3.36	3.76	3.36	3.76
Sokoposta and Gikomba	r=0	27.77**	15.41	25.19**	14.07
	r≤1	2.57	3.76	2.57	3.76

Note: The critical values are from tabulated Osterwald-Lenum (1992). *(**) denotes rejection of null hypothesis at the 5 percent and 1 percent level.

The trace statistic tests and maximum eigen value tests reject the null hypothesis of no cointegrating vector at the five percent and one percent significance level for Gikomba in relation to Homabay, Kalundu, Kibuye and Sokoposta price series (Table 3). This is because the computed test results are greater than the Osterwald-Lenum (1992) trace and maximumEigen values. Both tests suggest that there is existence of one cointegrating vector between Gikomba market prices and the other sorghum market prices in Kenya. This implies that Gikomba shares a
.

long run equilibrium price relationship with the other market pairs and can be termed as a central market for sorghum in Kenya.

3.4. Pairwise Granger Causality Test Results

Table 4 presents the pairwise granger causality test results. The null hypothesis that Gikomba does not granger cause other markets was tested

Table 4: Pairwise Granger Causality Test Results for the Selected Sorghum Markets

Null hypothesis (H0)	N.	F-Statistic	P-Value	Decision	Type of Causality
Homabay>Gikomba	142	10.045*	4.00E-05	Reject	Uni-directional
Gikomba>Homabay	142	1.709	0.185	Fail to reject	Independent
Kalundu>Gikomba	142	3.712*	0.027	Reject	Bi-directional
Gikomba>Kalundu	142	4.826*	0.009	Reject	Bi-directional
Kibuye>Gikomba	142	8.680*	0.000	Reject	Uni-directional
Gikomba>Kibuye	142	0.981	0.378	Fail to reject	Independent
Sokoposta>Gikomba	142	10.462*	4.00E-05	Reject	Uni-directional
Gikomba>Sokoposta	142	0.087	0.917	Fail to reject	Independent

>denotes "does not granger cause" while * denotes rejection of the null hypothesis at five percent level.

Unidirectional causal relationships were established in Homabay-Gikomba, Kibuye-Gikomba and Soko-Posta markets while bi-directional causal relationship was established in Gikomba-Kalundu market pair (Table 4). The presence of bidirectional causality between Kalundu and Gikomba indicates that there is efficiency in market information exchange of sorghum prices. In essence, Gikomba relied on the other sorghum markets to set its price and only had an influence on prices in Kalundu.

Out of the eights pairs tested, three failed to reject the null hypothesis of causality and therefore showed independent causality. These markets were Gikomba-Homabay, Gikomba-Kibuye and Gikomba-Soko Posta (Table 4). This implies that these markets failed to respond to price shocks from Gikomba market indicating marketing inefficiencies. The main implication of this finding is that despite the integration of sorghum markets in Kenya, the price relationships between these markets are not strong and thus shocks are not effectively transmitted.

4. CONCLUSION AND RECOMMENDATIONS

This study evaluated the integration of sorghum markets in Kenya, and causality between Gikomba in Nairobi and other spatially separated sorghum markets during the period March 2011 to March 2017. The cointegration test results indicate the

presence of long run price relationships which implies that sorghum markets in Kenya are integrated.

Bivariate cointegration tests further confirmed this finding as Gikomba shares a long run equilibrium relationship with the other market pairs implying presence of integration between market pairs. Pairwise granger causality tests revealed the presence of three unidirectional relationships and one bidirectional relationship in the Gikomba-Kalundu market pair.

The price relationships indicate efficiency in market information passage in that price changes in any pair can predict adjustments in the other.Conversely, three market pairs failed to reject the null of no granger causality. This is an indication that despite sharing a long run equilibrium, there are inefficiencies in market information access from Gikomba to Kibuye, Homabay town and Soko-Posta markets.

Based on the above findings, a viable option would be to develop and strengthen efficient market information systems. This would in turn lead to increased transmission of prices thus enhancing sorghum market integration.

5. ACKNOWLEDGEMENTS

REFERENCES

ASARECA (2011). Increasing Sorghum Utilization and Marketability Through Product Diversification. Nairobi: KIRDI.

Barrett C (1996). Market analysis methods: are our enriched toolkits well suited to enlivened markets? American Journal of Agricultural Economics, 78, 825-9.

Barrett CB, Li JR (2002). Distinguishing Between Equilbrium and Integration in Spatial Price Analysis. American Journal of Agricultural Economics, 84, 292-307. Retrieved from https://doi.org/10.1111/1467-8276.00298

Baulch B (1997). Transfer Costs, Spatial Arbitrage and Testing Food Market Integration. American Journal of Agricultural Economics, 79(2), 477-487. doi:10.1080/00220389708422479

Engle RF, Granger CJ (1987). Cointegration and error correction: Representation, estimation and testing. Econometrica, 2(251-280), 55.

Granger CW (1969). Investigating Causal Relations by Econometric Models and Cross-Spectral Models. Econometrica, 37, 424-434.

Gujarati D, Sangetha (2007). Basic Econometrics (4 ed.). Tata: McGraw Hill.

Gujarati DN (2004). Basic Econometrics (International Edition ed.). McGraw-Hill Higher Education.

KAPP (2011). Sorghum marketing baseline survey for Nakuru and Makueni Counties for the KAPAP project Technical Report. Nairobi: KAPP.

Kilambya D, Witwer M (2013). Analysis of incentives and disincentives for sorghum in Kenya. Technical series. Rome: FAO.

.

KNBS (2017). Economic Survey 2017. Nairobi: KNBS Press.

MoALF (2016). Economic Review of Agriculture. Nairobi: MOA.

Rashid S (2004). Spatial Integration of maize markets in post-liberalized Uganda. Journal of African Economics, 13(1), 102-133.

Stephan von Cramon-Taubadel (2017). The analysis of market integration and price transmission-results and implications in an African context. Agrekon, 83-96. Retrieved from https://doi.org/10.1080/03031853.2017.1295655

Tamru S (2013). Spatial Integration of Cereal Markets in Ethiopia. Ethiopia Strategy Support Program, IFPRI