

Testing for Cointegration and Granger Causality: Evidence from Selected Indigenous Egg Markets in Kenya

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Abstract

Despite the increasing consumer demand for indigenous eggs, particularly among the urban rich in Kenya, empirical analysis of spatial market integration has received limited attention. This study is an attempt to analyze the existence of market integration and price transmission among four selected indigenous egg markets. The study uses secondary data obtained on prices of eggs on a weekly basis during the year 2014. Analysis of Cointegration and Granger causality was attained using Johansen cointegration approach. Interestingly, results indicate integration in the indigenous eggs markets in Kenya. While prices of eggs in Kisumu and Eldoret towns Granger-caused each other, there was no evidence to account for price interactions among the rest of the markets. These findings strongly indicate asymmetric price transmission within the markets. Taking advantage of the promising niche provided by indigenous eggs requires policies aimed at unlocking information asymmetry as well as promoting market access among farmers.

Key words: Market integration, Granger causality, indigenous eggs, Kenya

1. Introduction

Poultry sector in Kenya plays a vital role in provision of protein as well as a source of income among livelihoods. According to the United States Agency for International Development (USAID, 2010), the sector offers employment opportunities to approximately three million people. In Kenya, statistics show that livestock sector contributes 7.9 to 10 percent of the Gross Domestic Product (GDP) to the economy. Specifically, poultry sector contributes 1.7 percent of the 25 percent agricultural GDP. Even though exotic (hybrid) poultry is gaining more limelight in Kenya, statistics reveal that indigenous chicken (*Gallus domesticus*) comprise 74 percent of the current 32 million poultry population (GoK, 2001). According to Kingori *et al*. (2010), the population of indigenous chickens in Kenya are approximately 22 million and are mainly kept in rural areas under free-range system. Mapate and Lonny (1998) posit that in developing countries, indigenous chicken dominate despite the introduction of exotic species.

There exists unequivocal evidence that commercial production efforts for indigenous chicken in Kenya are still limited despite their potential in enhancing economic welfare among rural farmers. Amidst other challenges, one key determinant of low productivity of indigenous chicken is financial constraint that is rampant among many smallholder farmers in the rural areas. In addition, other factors that contribute to low productivity in the indigenous poultry sector are genotype, poor nutrition, diseases and management (Kingori *et al*., 2010). This is evident in low input-low-output productivity (Ochieng *et al.*, 2012).

According to Olila (2014), agricultural sector in Kenya is characterised by problems of climate change, production spikes, as well as inadequacy in finances to invest in agriculture as business. Consequently, agricultural transformation agenda has remained elusive over decades. Moreover, inefficient markets, information asymmetry, as well as high transaction costs exacerbate financial constraint. Other empirical studies indicate that a majority of agricultural markets in African countries are inefficient and poorly integrated (Onyuma *et al.*, 2006). Production of indigenous chicken is vital for employment creation as well as enhancing economic growth in Kenya (Kingori et *al.,* 2010). In Particular, egg production for commercial acts as an alternative livelihood strategy. Poultry has great prospects for rural employment and poverty alleviation (USAID, 2010), particularly among traditional poultry systems.

In the recent past, there has been a growing preference for indigenous chicken meat and eggs. Some of the reasons explaining the consumer taste is mainly due to characteristics of indigenous chicken such as leanness, flavor, and presumed organic product (Kingori *et al.,* 2010). Additionally, increasing disposable income among consumers in developing countries, empirical projections indicate that the demand for such products are likely to be inelastic (USAID, 2010); implying that an increase in price has less impact on the quantity demanded. Moreover, consumers perceive indigenous chicken and products as having better health benefits due to their free-range nature. Other reasons are pegged on increasing consumer demand are taste, texture and the colour of traditional eggs (USAID, 2010). Consumer preferences for various attributes of indigenous egg is consistent with the Lancaster characteristics theory of value(Lancaster, 1966). This theory postulates that consumers derive utility from the attributes of the good not the good per *se.* In Kenya, Olila *et al*. (2015) used the theory to value farmers preferences for design of crop insurance in Trans-Nzoia County.

Delgado *et al.* (2001) argue that livestock revolution is enhanced by demand particularly in developing countries where urbanization is taking root. According to Delgado *et al*. (2001), poultry consumption in developing countries is projected to grow at 3.7 percent as compared to the 1.3% annually in developed countries by 2020. The increment in demand is further attributed to increasing population (USAID, 2010). Government, Non-Governmental organizations (NGOs), as well as development partners have injected capital to enhance the production of indigenous eggs.

This is evident by their efforts of disseminating management package intervention comprising supplementation, vaccination, brooder, chick rearing, equipment as well as improved housing (Ochieng *et al*., 2012). However, despite these attempts to have a paradigm shift from subsistence to commercialization of the sector, there exists a dearth of empirical information on price transmission in major Kenyan egg markets. In addition, limited information exists of the linkages among indigenous poultry markets. The study is an attempt to fill the knowledge gap by empirically testing for linkages and causality in the indigenous egg markets. Thus, the overall objective of this study is to determine spatial price transmission among selected indigenous egg markets in Kenya. Specifically, the study tests for market integration and further establishes the existence of pairwise Granger Causality.

In the recent past, research on market nexus has drawn a lot of interest among researchers and policy makers across the globe. Some of the underlying reasons include the need to investigate the level of market development and efficiency. Most importantly, market integration is a useful indicator of detecting the success of any market liberalization policy. Generally, government intervention in markets places a need to carry out market integration studies. However, such interventions may cause market failure. In order to alleviate such problems, evidence-based policy research is necessary particularly with respect to markets operating under forces of supply and demand. Such information is significant in *apriori* decision-making.

This study has three important contributions. First, we envisage that the information from this study will be useful in several areas of food policy. For instance monitoring prices of food commodities in the Kenyan markets is important in identification of the chronically food deficit areas. Second, information on market linkages plays an imperative role in forecasting price movements in various markets thus enhancing making *ex-ante* decisions as far as food security is concerned. Finally, the study insight on the behavior of prices within the egg markets is important for understanding the market structure, conduct, and performance.

2. Empirical review

2.1 Overview of market integration

In the recent past, studies on price transmission have gained a lot of interest in both developed and developing countries. According Amikuzuno and Cramon-Taubadel (2012) the interest in development of price transmission studies is attributed to two reasons. First, the need to determine price volatility for agricultural commodities in the international markets are transmitted to domestic markets particularly of developing world where agriculture remains the main source of livelihood. Second, the demand is driven by the existence of advanced empirical methods that unveils policy answers.

Moreover, the advent of market liberalization policies has created the need to determine the impact of such policies on market integration. For instance Sekhar (2012b) argue that agricultural market integration is central to many contemporary debates on trade liberalization, price policy and reform of state trading agencies in advancing economies. Market integration has a long history in empirical literature. For example, according to Sekhar (2012b), conceptualization of market integration is centred around tradability. Tradability implies the ability to transfer excess demand from one market to another either by actual or potential physical flows.

Johnson (2014) posit that spatially separated markets are considered cointegrated when their prices share a common long-run trend. The rationale underlying the theory of market integration is dependent upon the stability of prices exhibiting a linear stable relationship in prices in the long-run. According to Johnson (2014), one of the merits of market integration is the ability to facilitate the movement of goods through transmission of price information.

Furthermore, empirical literature argues that integrated markets are important to producers since they enhance transparency as well as liquidity. Other scholars argue that integrated markets exhibit low spatial and inter-temporal variation in prices. Variability in agricultural commodity prices have resulted in greater variability of consumer food prices around the world (Garc'ıa-Germa'n *et al,* 2016).

2.3 Review of past studies

A plethora of literature exists in the area of price transmission globally. According to Varela *et al.* (2012), the recent wave of high international commodity prices has increased interest in understanding spatial market integration both at the domestic and international markets. Garc´ıa-Germ´an et a*l.* (2016) evaluated price transmission between global agricultural markets and consumer price indices in the European Union (EU). Error correction models were used to determine the extent and speed at which world agricultural commodity price indices affect consumer food prices in the EU member states. Key study finding revealed the existence of long-run relationship between world agricultural commodity and consumer food prices in over half of the member states. In Switzerland, Esposti and Listorti (2014) assessed price transmission from the international market to the domestic Swiss market. A Vector Error Correction Model (VECM) with structural breaks was estimated. The key study finding is the existence of a long-run transmission elasticity of international prices. However, the domestic Swiss food price indicated limited but no null integration with respect to international prices.

Elsewhere in India, Sekhar (2012) studied how agricultural markets are integrated using Gonzalo-Granger model to determine the extent of market integration. Study results revealed that commodity markets do not face inter-state or inter-regional movement restrictions. On the other hand, commodity markets that are subject to restrictions fail to show integration at the National level. Sundaramoorthy *et al.* (2014) analysed price transmission along cotton value chain in India using Johansen's multivariate co-integration and error correction model. Key study findings indicated slow price transmission; however, there existed clear manifestation of price transmission as long as the existence of long-run equilibrium. In the United States of America (USA), Carvalho *et al.* (2015) did a study to comprehend the relationships in the international milk markets using monthly data from the United States, Brazil, Germany, the Netherlands, Russia, South Africa, India, China, and New Zealand. A VECM model revealed that in the US, the International Farm Comparison Network (IFCN) as well as China markets are more relatively independent and their milk prices are not significantly influenced by the international price shocks.

By testing market integration for pacific egg markets, Liu and Wang (2003) used Johansen's multivariate cointegartion test to determine the integration of egg markets within six pacific states namely Washington, Idaho, Oregon, California, Nevada and Arizona. Empirical results showed that eggs from these states show substitutability among the markets. In addition, arbitrage possibilities bind egg prices. In West Africa, Adeoti *et al*. (2013) investigated the spatial integration of tomato (*Lycopersicum esculentum)* in Benim and Bukina Faso.

The study used cointegration models based on Johansen and Autoregressive Distributed lag Approach. It was revealed that the integration chain of Contonou was more established as compared to Bohicon and the Melanville chains thus constitute a reference market for tomato wholesalers. Further, Amikuzuno and Cramon-Taubadel (2012) assessed seasonal variation in price transmission in Ghanaian tomato markets. A Vector Error Correction Model (VECM) model employed with seasonally regime-dependent adjustment parameters to wholesale tomato prices. Results showed plausible patterns in the seasonal interplay between the main producer and consumer markets for tomatoes.

Further, it was revealed that failure to account for seasonality leads to hybrid estimates of the parameters that depict price transmission behavior, conflating and obscuring seasonal differences in the way prices and markets interact. In Kenya, Onyuma *et al*. (2006) focused on market integration and efficiency for fresh pineapples using primary data collected for a period of 39 weeks. The study findings revealed that pineapple marketing structure has inter-linkages among farmers, village collectors, retailers, and wholesalers. The key determinant of market integration among pineapple markets is information flow between producing and consuming regions. Johnson (2014) analyzed commodity market integration in Uganda maize market.

The study used weekly egg prize data collected in thirteen regional markets in assessing the degree to which the selected markets are cointegrated. In order to determine whether a symmetric or asymmetric behavior exists, a threshold autoregressive model was used. Study findings revealed that all markets except one was linearly cointegrated with the central market.

Finally, it is important to take note of the fact that cointegration studies have also been applied in other sectors other than agriculture. Some of the studies such as Ai-Ying *et al*. (2011) investigated the relationship between urbanization and economic growth in China. The study applied cointegration theory, error correction model, as well as Granger causality to investigate how Gross Domestic Product (GDP) and urbanization are related. It was revealed that every one percent increment in urbanization led to 4.82 percent growth in the GDP.

3. Methodology

3.1 Study areas

The study was conducted in four different selected markets in Kenya; these include Kisumu City, Nakuru Town, Nairobi City and Eldoret town. Kisumu city is located in 0°6′0″S and 34°45′0″E. The lakeside city is located in close proximity to Lake Victoria and thus acted as a key market in the study. Nairobi is located in 1°16′59.88″S and 36°49′ 0.12″E. It is the capital city of Kenya and most populated with high demand for agricultural products. Nakuru is a major cosmopolitan town in 0.3000° S, 36.0667° E with a relatively high demand for agricultural commodities. It acts as a major source of egg for consumption in Kenya due to its location and accessibility of large scale poultry farms including Tatton farm of Egerton University among others. Eldoret is a principal city in western Kenya located in 0.5167° N, 35.2833° E. It is the capital and largest city in Uasin Gishu County lying south of the Cherengani Hills. A majority of livelihoods in Eldoret town derive their livelihoods from agriculture.

3.2 Sampling, data collection and analysis

In this study, we employ a purposive sampling technique to select four indigenous egg markets namely Kisumu, Uasin Gishu, Nakuru, and Nairobi Counties. Nairobi and Kisumu markets are chosen since they represent main consumption regions while Eldoret and Nakuru present key egg production areas. In addition, Nairobi and Kisumu are Kenya's two major cities where consumer demand for indigenous eggs is relatively high. The markets have a growing population coupled with urbanization. Secondary data was obtained under the courtesy of M-Farm Limited. The objective of M-Farm as an organization is to disseminate agricultural information to various stakeholders such as farmers as well as consumers in Kenya. Average weekly market price data for 53 weeks during the year 2014 is used this study. The aforementioned data is time series in nature. The missing values was filled using imputation method while data analysis using Eviews version 7 statistical software.

3.3 Econometric model

Engle and Granger (1987) argues that an individual economic variable in a time series exhibit the probability of wandering extensively. There is a likelihood of some series not drifting apart. In regard to this, economic theory's objective is to propose the forces that bind such series together. This forms the premise of testing for market integration and consequently Granger causality. Market integration models are concerned with linkages among local, regional, or international markets. The Cointegration approach used by Engle and Granger is the widely technique used in time series analysis.

However, this study uses a Johansen's cointegration approach on times series data on indigenous eggs. According to Adeoti *et al.* (2013), the models have played a significant role in dealing with issues of Non-stationarity in time series data. In addition, Adeoti *et al*. (2013) report that the application of cointegration model has led to the reduction multicollinearity issues in the estimations.

The method formulated by Engle and Granger (1987) comprises of two important steps. First, test the integration in the variables by taking each series separately and testing for the order of econometric integration. The number of times the series are differenced before transforming the data into a stationery series is important. In order to achieve this objective, we employ the Augmented Dickey-Fuller (ADF) test. The second step involves testing stationarity of the residual u_t of the Ordinary Least Square (OLS) regression. Empirical evidence indicates that for the OLS estimation to be valid, the error term must be time invariant (stationery). According to Engle and Granger (1987), OLS is used to estimate the parameters of the model i.e., testing the stationarity in the residuals using the following formulation:

$$y_{1t} = \mu_t + \beta_2 y_{2t} + \beta_3 y_{3t} + ..., \beta_n y_{nt} + \varepsilon_t \quad (1)$$

Where μ_t is the deterministic trend, ε_t is the residual regression (1). The core purpose is to test whether ε_t is stationary or not. In addition, the hypothesis associated with this is coined as $H_0 : \rho = 0$ implying absence of cointegration and $H_0 : \rho \neq 0$ meaning cointegration in the model specified as:

$$\Delta \varepsilon_t = \rho \varepsilon_t + \sum_{t=1}^{k} \gamma_i \Delta \varepsilon_{t-1} + \varepsilon_t \quad (2)$$

The Johansen's model is premised on the maximum likelihood estimates. In particular, the model is uses a Vector Autoregressive Model of order $p(VAR)$ where VAR (p) follows:

$$y_t = \mu + \sum_{t=1}^{p} \Phi_i y_{t-1} + \varepsilon_t \quad (3)$$

Where Φ_t is a matrix on nxn, ε_t is the stochastic error term exhibiting a variance covariance matrix. It is important to note that the aforementioned errors are Independent and Identically Distributed (IID) as per the demands of normality.

According to Granger representation, equation (3) follows a form of error correction model as:

$$\Delta y_t = \mu + \Pi y_{t-1} + \sum_{j=1}^{k} T_j \Delta y_{t-j} + \varepsilon_t \quad (4)$$

With $T_j = -(1 - \Pi_i - \Pi_2 - .... \Pi_j)$

$$\Pi = -(1 - \Pi_1 - ... \Pi_{k+1})$$

The equation is rewritten as follows:

$$\Delta y_t = \mu + a z_{t-1} + \sum_{j=1}^{k} T_j \Delta y_{t-j} + \varepsilon_t \quad (5)$$

Where $z_t = \beta' y_t$ representing the balance error of the system. On the other hand, the integration z_t in (5) results to:

$$\Delta y_t = \mu + a y_{t-1} + \sum_{j=1}^{k} T_j \Delta y_{t-j} + \varepsilon_t \qquad (6)$$

We test this based on a test rank Π . Some of the key explanations of the rank test Π are as follows: First, if the rank $(\Pi) = 0$, it then implies that there are no cointegrating relationships between the variables y_{it} and y_{jt}. Second, if rank $(\Pi) = n$, then unit root does not exist meaning it is and 1(0). Third, if rank $(\Pi) = r$, an (n-r) unit root in the system exists with an r cointegrating relationships in the model.

In this scenario, we decompose Π into $\alpha \beta'$ where α and β are two distinct matrix (nxr). The matrix α is interpreted as a matrix of adjustment coefficient and β the cointegrating vector which verifies the assumption of $\beta' y_t$ is stationary even when y_t is non-stationary.

3.3 Description of variables used in the model

Table 1: Description of variable used in the contegration model

Variable	Description	Unit of measurement	Expected sign
PN_t	Prices of indigenous eggs in Nairobi	Kenya Shillings	+
PK_t	Prices of indigenous eggs in Kisumu	Kenya Shillings	+
PNR_t	Prices of indigenous eggs in Nakuru	Kenya Shillings	+
PE_t	Prices of indigenous eggs in Eldoret	Kenya Shillings	+

The study used for variables namely prices of indigenous eggs in Nairobi (N_t) and Kisumu (K_t) cities, Nakuru (NR_t) and Eldoret (E_t) towns respectively.

4. Results and Discussion

4.1 Variation in indigenous egg prices in four markets

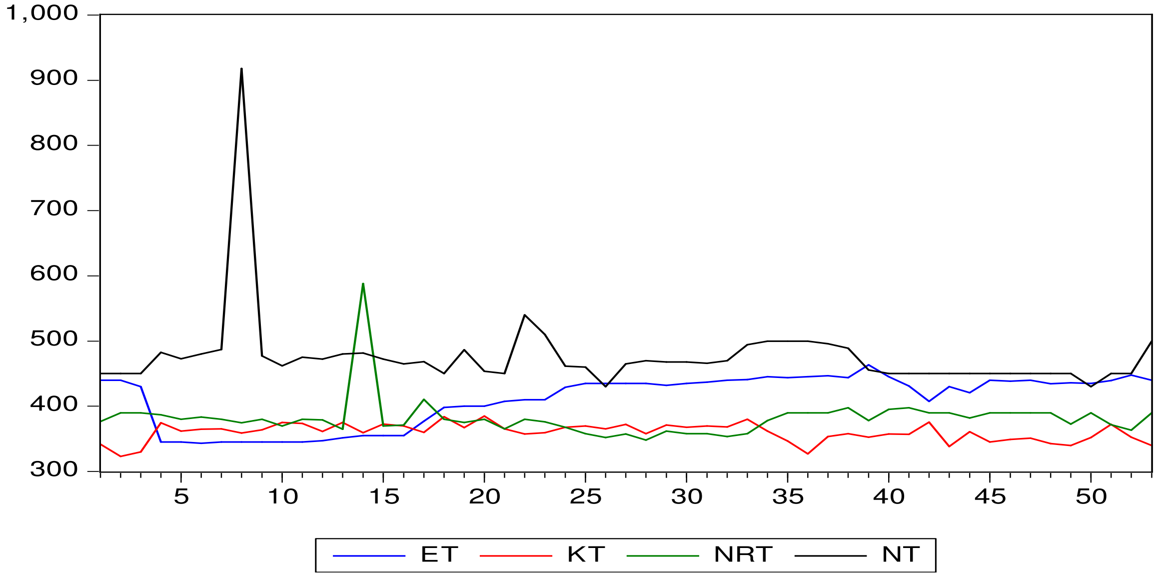

Figure 1: Average weekly egg prices (January-December 2014). Where N_t = Nairobi, K_t = Kisumu, NR_t = Nakuru & E_t = Eldoret.
Source: M-farm Limited

4.2 Unit root test

In order to determine whether prices of indigenous eggs in the four markets exhibited stability or non-stability, we carried out unit root test using ADF test for each market. It is important to note that ADF test may suffer from problems of autocorrelation. However, Dickey Fuller developed a system of equations to eliminate autocorrelation problem in the time series data. These systems of equations are as follows:

$$\Delta y_t = B_1 + ZY_{t-1} + a_i + \varepsilon_t \quad \text{(7)}$$

$$\Delta y_t = B_1 + B_{2t} + ZY_{t-1} + a_i + \varepsilon_t \quad \text{(8)}$$

$$\Delta y_t = ZY_{t-1} + a_i + \varepsilon_t \quad \text{(9)}$$

Equation (7) (denoted as EQI) is estimated with intercept only while equation (8) (denoted by EQII) is estimated with both trend and intercept. Equation (9) (denoted by EQIII) neither has tend nor an intercept. It is important to note that the three equations must be satisfied for a decision of the existence of unit root or otherwise. The null hypothesis is that the price variables are not stationery or exhibits unit root. The results for the ADF test for Eldoret town are as depicted in table 2 below.

Table 2: Results of the unit root test for Eldoret market

			EQ I		EQ II		EQ III	
Eldoret market			t-value	Prob.	t-value	Prob.	t-value	Prob.
Augmented Dickey-Fuller Test Statistic			-1.375	0.588	-3.116	0.113	-0.129	0.635
Test Critical values		1%	-3.563		-4.145		-2.610	
		5%	-2.919		-3.499		-1.947	
		10%	-2.597		-3.179		-1.613	
Equation	Variable	Coefficient	Std. error	t-value	Prob.			
I	ET(-1)	-0.073	0.053	-1.375	0.177			
II	ET(-1)	-0.217	0.070	-3.116	0.003***			
III	ET(-1)	-0.001	0.005	-0.129	0.898			

Notes: Statistical significance levels: ***1%; **5%; *10%

The p-values of equations I, II and III are statistically insignificant (i.e. p-values >5%). This implies that we accept the Null hypothesis that the prices in Eldoret have a unit root (i.e., the prices are non-stationery). In addition, the ADF test statistic (absolute value) compared with the critical values of the test statistic enables the acceptance or rejection of the null hypothesis. In this case, it is evident that the ADF statistics are less than the critical values leading to failure to reject the null hypothesis.

In addition, the coefficients on the variables are negative implying that the model is viable (acceptable). This leads to a conclusion that the three models have unit root in Eldoret market. Table 3 below shows the results of the unit root test for Kisumu city.

Table 3: Results of the unit root test for Kisumu city

			EQ I		EQ II		EQ III	
Kisumu city market			t-value	Prob.	t-value	Prob.	t-value	Prob.
Augmented Dickey-Fuller Test Statistic			-4.513	0.001***	-4.815	0.002***	0.110	0.7131
Test Critical values		1%	-3.563		-4.145		-2.611	
		5%	-2.919		-3.499		-1.947	
		10%	-2.597		-3.179		-1.613	
Equation	Variable	Coefficient	Std. error	t-value	Prob.			
I	KT(-1)	-0.583	0.129	-4.513	0.000***			
II	KT(-1)	-0.623	0.129	-4.815	0.000***			
III	DKT(-1)	-0.403	0.129	-3.117	0.003***			

Notes: Statistical significance levels: ***1%; **5%; *10%

For Kisumu city market (see table 3 above), it is evident that both equations one (EQ1) and two (EQII) show the presence of stationarity in the data. However, equation three (EQIII) depict non-stationarity thus leading to failure to reject the null of unit root.

Table 4 below shows the results of unit root test for Nakuru town.

Table 4: Results of the unit root test for Nakuru town

			EQ I		EQ II		EQ III	
Nakuru town market			t-value	Prob.	t-value	Prob.	t-value	Prob.
Augmented Dickey-Fuller Test Statistic			-7.020	0.000***	-6.977	0.000***	-0.230	0.599
Test Critical values		1%	-3.563		-4.145		-2.612	
		5%	-2.919		-3.499		-1.948	
		10%	-2.597		-3.179		-1.613	
Equation	Variable	Coefficient	Std. error	t-value	Prob.			
I	NRT(-1)	-0.993	0.141	-7.020	0.000***			
II	NRT(-1)	-0.997	0.143	-6.977	0.000***			
III	NRT(-1)	-0.003	0.013	-0.230	0.819			

Notes: Statistical significance levels: ***1%; **5%; *10%

The unit root test for Nakuru market indicates non-stationarity in the data particularly equation three leading to failure to accept the hull hypothesis of unit root. The conclusion is that prices in Nakuru town exhibit unit root. Table 5 below shows the unit root test results for Nairobi city.

Table 5: Results of the unit root test for Nairobi city

			EQ I		EQ II		EQ III	
Nairobi city market			t-value	Prob.	t-value	Prob.	t-value	Prob.
Augmented Dickey-Fuller Test Statistic			-6.466	0.0000***	-6.794	0.000***	-0.579	0.462
Test Critical values		1%	-3.563		-4.145		-2.610	
		5%	-2.919		-3.499		-1.947	
		10%	-2.597		-3.179		-1.613	
Equation	Variable	Coefficient	Std. error	t-value	Prob.			
I	NT(-1)	-0.911	0.141	-6.466	0.000***			
II	NT(-1)	-0.969	0.143	-6.794	0.000***			
III	NT(-1)	-0.015	0.026	-0.579	0.565			

Notes: Statistical significance levels: ***1%; **5%; *10%

The findings show that the prices of indigenous eggs in Nairobi city are non-stationary. The overall conclusion is that the prices of eggs within the four markets are non- stationery. Therefore, the first step is to make the prices stationary by converting them into first difference and use ADF test to establish price stability. The results of ADF test after conversion to the first difference (see Table 6).

Table 6: Results of the 1st difference unit root test for Eldoret town

			EQ I		EQ II		EQ III	
Eldoret market (DET)			t-value	Prob.	t-value	Prob.	t-value	Prob.
Augmented Dickey-Fuller Test			-6.576	0.000***	-6.627	0.000***	-6.643	0.000***
Test Critical values		1%	-3.565		-4.148		-2.611	
		5%	-2.920		-3.500		-1.947	
		10%	-2.598		-3.180		-1.613	
Equation	Variable	Coefficient	Std. error	t-value	Prob.			
I	D(ET(-1))	-0.940	0.143	6.576	0.000***			
II	D(ET(-1))	-0.961	0.145	6.627	0.000***			
III	D(ET(-1))	-0.940	0.142	-6.643	0.000***			

Notes: Statistical significance levels: ***1%; **5%; *10%

The results show that the absolute ADF statistic (6.575) is greater than the test critical value (2.92) at 5% level of statistical significance. On the other hand, the p-vale is also less than the 5% level. This leads to the rejection of the null hypothesis of unit root in equation one. In other words, the prices in Eldoret market are stationary of order (1).

Furthermore, the coefficient of the ADF test equation is negative implying that the model is acceptable (viable). Likewise, the results of Kisumu market (Table 7 next page) indicate stationarity of prices once converted to first difference.

Table 7: Results of the 1st difference unit root test for Kisumu city market

			EQ I		EQ II		EQ III	
Kisumu city market (DKT)			t-value	Prob.	t-value	Prob.	t-value	Prob.
Augmented Dickey-Fuller Test			-10.853	0.000***	-10.966	0.000***	-10.955	0.000***
Test Critical values		1%	-3.565		-4.148		-2.611	
		5%	-2.912		-3.500		-1.947	
		10%	-2.598		-3.180		-1.613	
Equation	Variable	Coefficient	Std. error	t-value	Prob.			
I	D(KT(-1))	-1.403	0.129	-10.852	0.000***			
II	D(KT(-1))	-1.413	0.129	-10.966	0.000***			
III	D(KT(-1))	-1.403	0.128	-10.956	0.000***			

Notes: Statistical significance levels: ***1%; **5%; *10%

Table 8 presents the results of the unit root test for Nakuru market. Findings reveal that prices become stationary once converted to first difference. This condition of stationarity is indeed necessary step towards running the next model.

Table 8: Results of the 1st difference unit root test for Nakuru town

			EQ I		EQ II		EQ III	
Nakuru town market (DNRT)			t-value	Prob.*	t-value	Prob.*	t-value	Prob.*
Augmented Dickey-Fuller Test			-9.802	0.000	-9.695	0.000	-9.905	0.000
Test Critical values		1%	-3.568		-4.153		-2.612	
		5%	-2.921		-3.502		-1.948	
		10%	-2.599		-3.181		-1.6127	
Equation	Variable	Coefficient	Std. error	t-value	Prob.*			
I	D(NRT(1))	-2.225	0.227	-9.802	0.000			
II	D(NRT(1))	-2.224	0.229	-9.695	0.000			
III	D(NRT(1))	-2.224	0.225	-9.905	0.000			

Notes: Statistical significance levels: ***1%; **5%; *10%

Finally, results of Nairobi market confirm further that conversion of prices into first difference indeed makes the prices to exhibit stability as depicted in table 9 (see next page).

Table 9: Results of the 1st difference unit root test for Nairobi city

		EQ I		EQ II		EQ III	
Nakuru town market (DNRT)		t-value	Prob.	t-value	Prob.	t-value	Prob.
Augmented Dickey-Fuller Test		-11.476	0.000***	-11.359	0.000***	-11.592	0.000***
Test Critical values	1%	-3.565		4.148		-2.612	
	5%	-2.920		-3.500		-1.947	
	10%	-2.598		-3.180		-1.613	

Equation	Variable	Coefficient	Std. error	t-value	Prob.
I	D(NT(1))	-1.461	0.128	-11.476	0.000***
II	D(NT(1))	-1.461	0.129	-11.359	0.000***
III	D(NT(1))	-1.461	0.126	-11.592	0.000***

Notes: Statistical significance levels: ***1%; **5%; *10%

We therefore conclude that prices of indigenous eggs in the Kenya's four markets are stable of order I(1). Indeed, this condition is a prerequisite for testing spatial market integration.

4.3 Testing for market Cointegration

Having established the fact that eggs prices exhibit stationarity of order one, the next vital procedure follows testing for cointegration within the markets. A Johansen's cointegration approach enables the establishing long-run relationship among cointegrating variables. The null hypothesis follows no cointegration equations or simply no existence of cointegration among the four markets. The estimation of the cointegration model leads to two important statistics namely *Trace* and *Max-Eigen.* These two statistics are assumed to exhibit a linear deterministic trend. The tests are important since they help in identifying the number of cointegrating vectors in the system. According to Sundaramoorthy *et al.* (2014), the trace statistic gives information on whether r cointegrating vectors exist in the system measured against the alternative hypothesis of stationarity. Table 10 below presents the results of Trace statistics.

Table 10: Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE's	Eigen value	Max-Eigen Statistic	0.05 Critical value	P-value
None	0.478608	74.63737	47.85613	0.0000***
At most 1	0.353194	41.42343	29.79707	0.0015***
At most 2	0.274706	19.20227	15.49471	0.0132*
At most 3	0.053834	2.822198	3.841466	0.0930*

Notes: Statistical significance levels: ***1%; **5%; *10%

The empirical results (Table 10 above) indicate that the four indigenous egg markets in Kenya are cointegrated. Generally, a pair of price series x_t and y_t is said to be cointegrated if the series are follow same economic order with existence of a linear combination of the series. Sundaramoorthy *et al.* (2014) argue that the core aim of the maximum eigenvalue is the provision of information whether the rank is (r) against the alternative hypothesis that the rank is $(r+1)$.

Table 11: Unrestricted Cointegration Rank Test (Maximum Eigen value)

Hypothesized No. of CE's	Eigen value	Max-Eigen Statistic	0.05 Critical value	P-value
None	0.478608	33.21394	27.58434	0.0085***
At most 1	0.353194	22.22116	21.13162	0.0350**
At most 2	0.274706	16.38007	14.26460	0.0228**
At most 3	0.053834	2.822198	3.841466	0.0930*

Notes: Statistical significance levels: ***1%; **5%; *10%

Following the results of Trace and Maximum Eigen statistics as illustrated on tables 10 & 11, it is evident that the indigenous egg markets are cointegrated. This leads to the rejection of the null hypothesis of no cointegrating equations (CE's). The p-values are statistically significant implying that there exists a long-run relationship among the markets. In conclusion, both the Trace and Eigen Statistics show that the prices of indigenous eggs in the four markets are cointegrated.

4.3 Post-estimation tests

Nevertheless, we carry out post-estimation tests with an aim of validating the empirical results. As indicated in table 12, the Pseudo- R^2 indicates that the data fitted the models appropriately. In addition, both the normality test did indicate non-existence of serial correlation. This implies that the results met the necessary conditions in time series analysis.

Table 12 below shows the results of post-estimation tests.

Table 12: Model diagnostic tests

	Model 1	Model 2	Model 3	Model 4
R^2	0.249	0.483	0.564	0.53
F-Statistic	1.143	3.231	4.471	3.888
P-value	0.357	0.003***	0.0002***	0.0008***

Notes: Statistical significance levels: ***1%; **5%; *10%

4.4 Granger causality test

4.4.1 Model specification

Having established the existence of cointegration in the indigenous egg markets, we extend the analysis to investigate the existence of any causal relationships. This is important because of the likelihood of causality (contribution to predictability) running from one market to another. This relationship usually holds with the existence of LOP. The key assumption is non-correlation in the residuals with the null hypothesis being no Granger causality in prices within the four indigenous markets. According to Stern (2011), a variable x is said to Granger cause another variable y if the preceding values of x helps forecast the current value of y assuming availability of appropriate information.

The equations of Granger causality following Stern (2011) are formulated as:

$$y_t = \beta_{1,0} + \sum_{i=1}^{p} \beta_{1,i} y_{t-i} + \sum_{j=1}^{p} \beta_{1,p+j} x_{t-j} + \varepsilon_{1t} \qquad (10)$$

$$x_t = \beta_{2,0} + \sum_{i=1}^{p} \beta_{2,i} y_{t-i} + \sum_{j=1}^{p} \beta_{2,p+j} x_{t-j} + \varepsilon_{1t} \quad \text{............} (11)$$

Where p is the number of lags modelling the dynamic structure while ε is the stochastic error term. Stern (2011) refers to this error term as a white noise. The error term must exhibit the following three properties: identical, independent, and mean zero distribution. It is important to note that if the p parameters $\beta_{1,p+j}$ are jointly significant, then the null hypothesis that x does not Granger cause y is rejected. Likewise, if p parameters $\beta_{2,i}$ are jointly statistically significant then the null that y does not Granger cause x is rejected. The test for $H_0 : c_i = 0$ is carried out with an F-test.

4.4.2 Results of Granger Causality Test

This section presents the results of Granger causality (see Table 13 below). Considering the null hypothesis of non-existence of pairwise granger causality within indigenous egg markets, it is interesting to note that Granger causality exists between Kisumu and Eldoret markets. This could be attributed to the proximity of two markets in terms of a shorter distance as well as better physical infrastructure. Moreover, there is evidence of causality between Eldoret and Nakuru market even though prices in Nakuru town do not Granger cause prices in Eldoret town. The other markets did not show any causality in prices implying existence of asymmetric price transmission consequently defying the LOP. The fact that a majority of indigenous egg markets fail to Granger cause each other is attributed to by many factors such as inadequacy in credit, poor market information among others.

Table 13: Results of Granger causality tests

Null hypothesis	F-Statistic	P-value
KT does not Granger Cause ET	9.1740	0.0039***
ET does not Granger Cause KT	3.1220	0.0834*
NRT does not Granger Cause ET	0.2930	0.5908
ET does not Granger Cause NRT	1.6060	0.2110
NT does not Granger Cause ET	0.0007	0.9785
ET does not Granger Cause NT	3.4256	0.0702
NRT does not Granger Cause KT	0.5922	0.4452
KT does not Granger Cause NRT	0.1165	0.7343
NT does not Granger Cause KT	0.1953	0.6605
KT does not Granger Cause NT	0.3685	0.5466
NT does not Granger Cause NRT	0.0119	0.9135
NRT does not Granger Cause NT	0.0466	0.8300

Notes: Statistical significance levels:***1%; **5%; *10%

5. Policy implications and concluding remarks

The basic premise of spatial market integration studies is to establish the effectiveness of market liberalization policies particularly those geared towards creation of efficient markets. Efficient and liberalized markets have a tendency of enhancing consumer's economic welfare as well as contributing significantly to economic prosperity.

The study is an attempt to unlock the empirical gap in knowledge that exists on the integration of indigenous egg markets in Kenya. In particular, we employ Johansen's cointegration approach to unveil policy answers. We find a strong empirical evidence of a well-integrated indigenous egg markets in Kenya. However, in terms of Granger causality, only Kisumu and Eldoret markets exhibited causal relationships in prices. This implies that the LOP was only evident between Eldoret and Kisumu markets.

In light of these findings, policy direction ought to focus on creation of market access while at the same time unlocking information asymmetry within the markets. Moreover, taking advantage of consumer preference for indigenous eggs offers a promising niche enhancing marketing channels for the benefit of farmers and consumers. This will help in achieving the agricultural policy goal of enhancing productivity and incomes especially of small holder farmers.

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