Journal of Economics and Sustainable Development www.iiste.org
ISSN 2222-1700 (Paper) ISSN 2222-2855 (Online)
Vol.8, No.10, 2017

The Link Between Food Import and Cereals Production in Kenya: Evidence from Cointegration and Granger Causality Analysis Using Time Series Data

Dr. Alphonce Juma Odondo (PhD)
Department of Economics, Maseno University, PO box 333, Maseno, Kenya

Abstract
Kenya is the leading economy in the East African Community (EAC) and its economy significantly depends on agriculture both directly and indirectly. Approximately 45% of her revenue is derived from agriculture. Besides employing about 60% of her populace, the sector provides over 75% of industrial raw materials and slightly above 50% of the economy's export earnings. This sector is however, facing a myriad of challenges such as low purchasing power of the population due to high poverty level, frequent drought, high cost of inputs and high global food prices. This situation among other factors, has forced the government to rely on food aid and to divert her foreign exchange reserves and resources earmarked for development to procurement of food. However, the underlying question would be, if Kenya is relying on food aid which is noted to have little effect on local production of food but rather displaces imports, what then is the causality between the food import and food production? This paper sought to address the above question. The study was anchored on the ideas of classical economists, particularly the concepts of production and consumption. It was based on diagnostic research design. Time series data from the World Bank for the period 1976 to 2013 were employed. Granger causality test was undertaken to establish the directional causality between food import and cereals production. This was done by estimating Vector Autoregressive (VAR) models. Vector error correction (VEC) models were also estimated to assess the possibility of long run relationship between the variables and Wald statistics for possible short run relationships. Other econometric tests included: Normality using Jarque-Bera statistics, Breusch-Godfrey LM Test for serial correlation and the ARCH test for Heteroskedasticity. The study revealed bidirectional causality between food import and cereals production in Kenya. In addition, food import had long run causality on cereals production. On the other hand, cereals production had no long run causality on food import, though there was short run causality running from cereals production to food import. The negative significant short run relationship between cereals production and food import imply that food import may react to cereals production, a likely indication that cereals production my alter food import in the long run. The country should thus enhance cereals production to reduce food imports which could be ascribed to food shortage in the economy. This study may be a source of literature for econometricians and help in policy formulation to address the food insecurity situation in the country.
Keywords: Causality, Cointegration, Food Import, Cereals production, Kenya

1. Introduction

Kenya is the leading economy in the East African Community (EAC) (World Bank, 2013), and its economy largely depends on agriculture that directly and indirectly contributes about 24% and 27% of her GDP respectively (WEMA, AATF and KARI 2010; Emogor, 2012). In addition, approximately 45% of the Kenya Government revenue is derived from agriculture. The sector also contributes over 75% of industrial raw materials and slightly above 50% of the export earnings. It is the largest employer in the economy, accounting for about 60% of the total employment. More than 80% of the population, particularly those living in rural areas, draw their livelihoods from agriculture related activities. It is against this background that the Government of Kenya has continued to give high preference to agriculture as a vital tool for promoting national development (KARI, 2012; PKF Consulting Ltd and International Research Network, 2005; UNEP, 2015).

The agricultural sector has however, faced a myriad of challenges ranging from production to marketing systems of its outputs. As a result, the country has been experiencing severe food insecurity problems as evidenced by a high proportion of the population having limited access to food in the right amounts and quality. It is estimated that more than 10 million people are food insecure with majority of them living on relief food and a number of households incurring exorbitant food bills ascribed to inflated food prices (Emogor, 2012). As a partial panacea to the food crisis, the government has resorted to among others, formulation of policies aimed at enhancing maize production to boost the country's food security since for many years food security is equated to self sufficiency in maize production, allowing for imports of tax free maize and discouraging exports and providing subsidy to maize meal millers to bring down the consumer retail prices of the maize meal (Emogor, 2012; AATF & KARI, 2010). Among the subsidies given include fertilizers to maize farmers, which Ariga and Jayne (2010) noted to have increased maize output by 18% between 1997 and 2007.

Despite the conceited government's efforts, there are persistent food insecurity problems which are blamed on numerous factors, including the frequent droughts in most of the productive parts of the country, high costs of domestic food production due to high costs of inputs, displacement of a large number of farmers in the high potential agricultural areas following the post-election violence which occurred in early 2008, high global food prices and low purchasing power of the population due to high poverty level(Reginah and Kitiabi, 2012)

A study by Gerbens, Nonhebel and Krol (2010) on food consumption patterns and economic growth, showed that GDP increase is accompanied by changes towards food consumption patterns with large gaps between supply and actual consumption. The implication of this revelation is that a country can be more food secure if its food supply outweighs its demand. Other related studies such as Awuor (1997) who focused on determinants of agricultural productivity in Kenya, noted that Kenya's agricultural productivity is versatile and vary from region to region and that poor households generally perceive the market to be too risky for the purchase of their food needs, an indication that they cannot rely on the market to meet their food demands. This suggests that there was need to reduce costs in the food system so as to increase their affordability. Francis and Watanabe (2015); Moylan 2012; Paul *et al,* 2015 as well as Corrie, Andrew and Trail (2000) revealed that rainfall anomalies have led to numerous incidences of droughts and this could also have a negative effect on food production. Moderate rainfall may also promote food crop production. Ogada *et al*, 2014, who focused on the technical efficiency of Kenya's smallholder food crop farmers concurred that environmental factors are inevitable in crop production and that a country should improve on its production activities by addressing environmental and farm-level constraints.

A number of empirical studies on the food security situation in Kenya have also attributed the problem to rising food prices. For instance, Mongor (2012) looked at how food prices affect food security in Kenya and revealed that since 2006, food prices have been on the rise thus diminishing access to food by the poor population. On the other hand, Wanjiru (2014) revealed that Kenya relies on food aid which has negatively impacted on the market trends of locally available food especially at the county levels. However, Barrett and Heisey (2002) maintain that food aid has little effect on local production, but rather displaces imports. With Kenya's population projected to be 43.1 million by the year 2020, the demand for food particularly maize is likely to be 5 million metric tonnes against the prevailing growth rate of 1.2 million metric tonnes (Nyoro et al., 2007). This scenario implies that there will be continued reliance on imports, a likely indication that the country's foreign exchange reserves and resources earmarked for development will be diverted to procurement of food. From the foregoing literature, it is overt that there are numerous efforts aimed at addressing food insecurity, some of which overlap and have multiplier effects on others. However, the underlying question would be, if Kenya is relying on food aid which is noted to have little effect on local production of food but rather displaces imports, what then is the causality between the imports and food production? The paper sought to address the above question.

2. Research Methodology

2.1 Study Area

Kenya is located in the Continent of Africa and lies between latitudes 41/2^{0}N and 41/2^{0}S and longitudes 34^{0}E and 42^{0}E. The country covers 569,140 square kilometers of land and 11,227 square kilometers of water, with a total area of 580,367 square kilometers. Her population is approximately 43,013,341 according to the 2009 population census. It is neighbouring Uganda, Sudan, Tanzania, Somalia and Ethiopia. The country largely depends on agriculture and tourism subsectors of the economy.

Figure 1: Position and Shape of Kenya
Source: Office for the Coordination of Humanitarian Affairs (2010)

2.2 Data type and Source

The study employed time series data on food imports and cereals production in Kenya. The data were sourced from the World Bank data bank and covered the period 1976-2013.

2.3 The unit root test

Generally, time series data are characterized by a stochastic trend which can be removed by differencing. Some macro economics variables may be stationary at levels, others become stationary after one or more differentiation (Mukras, 2012).The use of non stationary data in estimation may lead to spurious results. In order to assess stationarity of the two macroeconomic variables, the study employed Johansen's methodology. Johansen's methodology begins with vector auto regressive (VAR) model of order " ρ " given as:

$$y_t = \mu + A_1 y_{t-1} + \ldots + A_\rho y_{t-\rho} + \varepsilon_t \qquad (1.1)$$

Where: y_t is an $n\,x\,1$ vector of variables that are integrated of order one.

ε_t is an $n\,x\,1$ vector of innovations. $\varepsilon_t \sim IID(0, \delta^2{}_\varepsilon)$. The Vector Autoregressive (VAR) Model can be re specified as:

$$\Delta y_t = \mu + \Pi y_{t-1} + \sum_{i=1}^{\rho-1} \Gamma_i \Delta y_{t-i} + \varepsilon_t \qquad (1.2)$$

Where: $\Pi = \sum_{i=1}^{p} A_i - I$ and $\Gamma_i = -\sum_{j=i+1}^{\rho} A_j$

Johansen (1988) and Johansen and Joselius (1990) proposed two different likelihood ratio tests: the trace test and maximum eigenvalue test, shown in equations (1.3) and (1.4) respectively.

$$J_{trace} = -T \sum_{i=r+1}^{n} \ln(1 - \hat{\lambda}_i) \qquad 1.3$$

$$J_{\max} = -T \ln(1 - \hat{\lambda}_{r+1}) \qquad 1.4$$

where: T = sample size and $\hat{\lambda}_i$ is the i[th] largest canonical correlation. The trace test tests the null hypothesis of "*r* "cointegrating vectors against the alternative hypothesis of "n"cointegrating vectors. The maximum eigenvalue test, on the other hand, tests the null hypothesis of "r"cointegrating vectors against the alternative hypothesis of "r+1"cointegrating vectors.

Granger causality test was then carried out to establish the directional causality between food import and cereals production. This was done by estimating the Vector Autoregressive (VAR) model specified as below:

$$\Delta FIM_t = \phi_0 + \sum_{i=1}^{k} \phi_i \Delta FIM_{t-1} + \sum_{t=1}^{k} \ell_i \Delta CRP_{t-1} + \varepsilon_t, \ \varepsilon_t \sim IID(0, \delta^2{}_{\varepsilon}) \quad (1.5)$$

$$\Delta CRP_t = \alpha_0 + \sum_{i=1}^{k} \alpha_i \Delta CRP_{t-1} + \sum_{i-1}^{k} \gamma_i \Delta FIM_{t-i} + \mu_t, \quad \mu_t \sim IID(0, \delta^2{}_{\mu}) \quad (1.6)$$

Where: ε_t and μ_i are un correlated error terms.

CRP = Cereals production

FIM = Food import

Vector error correction (VEC) models were also estimated to assess the existence of long run relationship between the variables and Wald Chi-statistic determined to establish any possible short run relationships. Other econometric tests carried out included the Normality test using Jarque-Bera statistics, Breusch-Godfrey LM Test for serial correlation and the ARCH test for Heteroskedasticity. The analyses were carried out using Eviews quantitative Microsoft soft ware version 7.1.

3. Results and Discussions

The time series data were log transformed to avoid heteroscedasticity and also to ensure normality of the data (Baltagi, Jung & Song, 2009). After log transformation, normality test was conducted using Jarque-Bera statistics and the results are presented in Figures 2 and 3. In both Figures, the P- values for the Jarque-Bera statistics are more than 5% i.e 44.27% and 31.99% in Figure 2 and Figure 3 respectively. These imply that the data used were normally distributed.

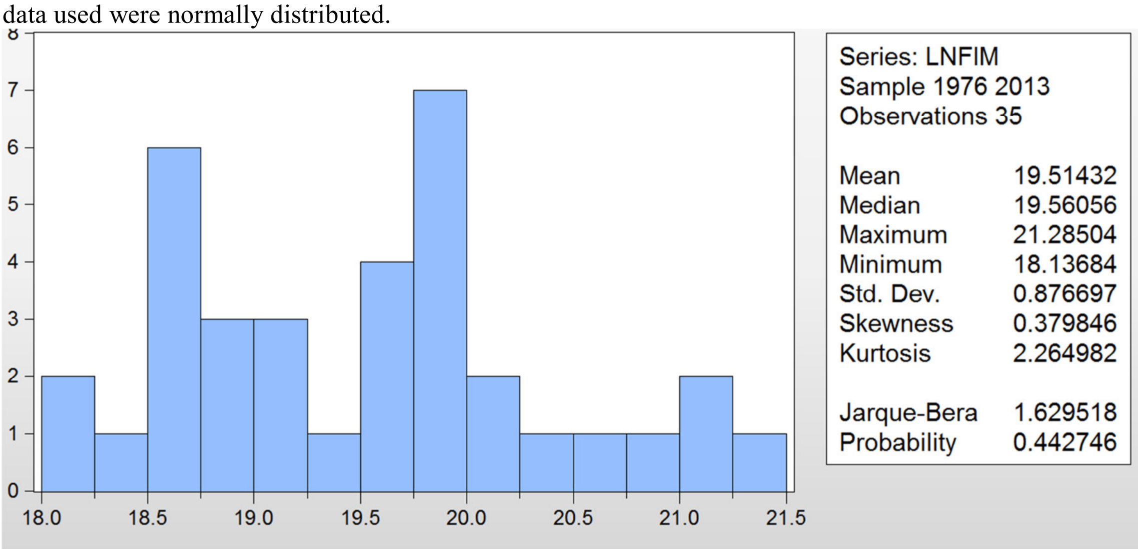

Figure 2: Normality test for Food import data

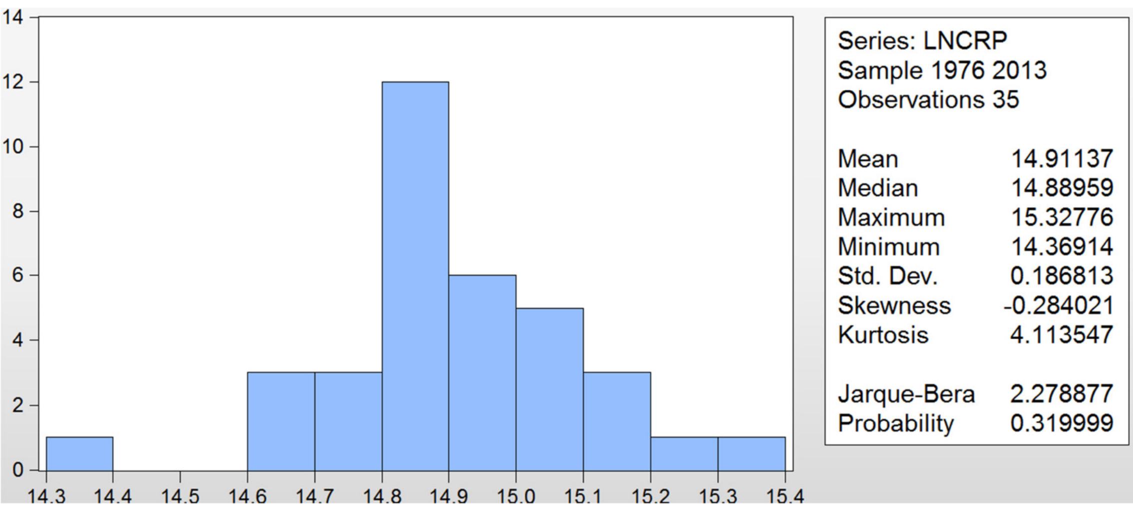

Figure 3: Normality test for Cereals production data

Breusch-Godfrey LM Test was also conducted on the data to assess any possibility of serial correlation. The test yielded an observed R^2 of 0.598971 at P = 0.8967, suggesting lack of serial correlation (Baum & Schaffer, 2013).

Table 1.1: Breusch-Godfrey Serial Correlation LM Test

F-statistic	0.131349	Prob. F(3,20)	0.9403
Obs*R-squared	0.598971	Prob. Chi-Square(3)	0.8967

The study further tested for the Autoregressive Conditional Heteroskedasticity (ARCH) effect, with the null hypothesis that there was no ARCH effect. Since the estimated P-value corresponding to the observed R-squared was 0.5378 > 0.05, the null hypothesis that there was no ARCH effect was confirmed as seen in Table 1.2.

Table 1.2: Heteroskedasticity Test: ARCH

F-statistic	0.674117	Prob. F(3,25)	0.5760
Obs*R-squared	2.170357	Prob. Chi-Square(3)	0.5378

Since most series are generally non stationary, unit root test was necessary. The first step was to establish the lag length that would be considered in the test. The underlying assumption was that all the two variables were non stationary. Table 1.3 shows VAR Lag Order Selection Criteria. From the Table, LR test statistic, Final prediction error (FPE), Akaike information criterion (AIC), Schwarz information criterion (SC) and the Hannan-Quinn information criterion (HQ) all suggest that the suitable lag order to be used in the system equation model was 3.

Table 1.3: VAR Lag Order Selection Criteria

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-20.57298	NA	0.017192	1.612356	1.707514	1.641447
1	12.41138	58.90065	0.002172	-0.457956	-0.172483	-0.370684
2	19.12002	11.02133	0.001801	-0.651430	-0.175642	-0.505977
3	25.79028	10.00540*	0.001509*	-0.842163*	-0.176061*	-0.638529*
4	26.75273	1.306180	0.001923	-0.625195	0.231222	-0.363380
5	28.35924	1.950765	0.002380	-0.454231	0.592501	-0.134235
6	30.43827	2.227526	0.002912	-0.317019	0.920028	0.061159
7	33.12645	2.496172	0.003520	-0.223318	1.204044	0.213041

* indicates lag order selected by the criterion
LR: sequential modified LR test statistic (each test at 5% level)
FPE: Final prediction error
AIC: Akaike information criterion
SC: Schwarz information criterion
HQ: Hannan-Quinn information criterion

The data were then subjected to Cointegration test for stationarity, where the approaches developed by Johansen (1988) and Johansen and Joselius (1990) were adopted. The estimated statistics were captured in Table 1.4 and Table 1.5. The Table on Trace statistics has two Null Hypotheses; the first null hypothesis is that there is no Cointegrating equation. Since the computed Probability (P = 0.0025 < 0.05), the null hypothesis that there is no cointegrating equation is rejected. The second null hypothesis is that at most one cointegrating equation exists. Given the probability value (P = 0.0758 > 0.05), we accept the null hypothesis that the two variables are co integrated. The maximum Eigen values in Table 1.5 also indicate that there is at most one cointegrating equation at 0.05% level of significance. The results suggest that in the long run, the two variables move together or have a long run association.

Table 1.4: Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.481613	23.52024	15.49471	0.0025
At most 1	0.096685	3.152201	3.841466	0.0758

Trace test indicates 1 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Table 1.5: Unrestricted Cointegration Rank Test (Maximum Eigen value)

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None *	0.481613	20.36804	14.26460	0.0048
At most 1	0.096685	3.152201	3.841466	0.0758

Max-eigenvalue test indicates 1 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Engel and Granger (1987) posit that if cointegration exists between two variables in the long run, then there may be either unidirectional or bidirectional Granger causality between the variables and the cointegrating variables can be represented using Vector error correction (VEC) mechanism. From Table 1.6 on Granger causality test, it can be deduced that food import (LNFIM) Granger causes cereals production (F=3.09588, p = 0.045) and that Cereals production (LNCRP) also granger causes food import (F=7.07768, p =0.0013), thus there exists a bidirectional causality between the two variables.

Table 1.6: Pair wise Granger Causality Tests

Null Hypothesis:	Obs	F-Statistic	Prob.
LNFIM does not Granger Cause LNCRP	32	3.09588	0.0450
LNCRP does not Granger Cause LNFIM		7.07768	0.0013

Since there exists a long run relationship between the two variables, it was important to estimate vector error correction (VEC) models. The following system generated equation where cereals production was considered endogenous was estimated and results presented in Table 1.7

D(LNCRP) = C(1)*(LNCRP(-1) - 0.0972882664644*LNFIM(-1) - 12.9913534645) + C(2)*D(LNCRP(-1)) + C(3)*D(LNCRP(-2)) + C(4)*D(LNCRP(-3)) + C(5)*D(LNFIM(-1)) + C(6)*D(LNFIM(-2)) + C(7)*D(LNFIM(-3)) + C(8) (1.7)

Equation 1.7 is the Error correction model and the cointegrating equation derived from it is stated as: D (LNCRP) = C (1)*(LNCRP (-1) - 0.0972882664644*LNFIM (-1) - 12.9913534645) (1.8)

Where: C (1) is the error correction term or one (1) period lag residual of cointegrating vector between cereals production and food import. The estimated parameters of equation 1.7 are presented in Table 1.7. The error correction term estimated was -1.030077, which was statistically significant (P = 0.0408 < 0.05), suggesting that food import had a long run causality on cereals production. i.e. food import caused cereals production in the long run.

Table1.7: Estimated parameters for Equation 1.2

	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	-1.030077	0.475204	-2.167652	0.0408
C(2)	0.353910	0.461233	0.767313	0.4507
C(3)	0.000851	0.381267	0.002233	0.9982
C(4)	0.188508	0.292287	0.644941	0.5253
C(5)	-0.056788	0.160074	-0.354759	0.7260
C(6)	0.063897	0.181522	0.352008	0.7280
C(7)	-0.005870	0.137237	-0.042774	0.9663
C(8)	0.015362	0.046950	0.327193	0.7465

R-squared	0.456113	Mean dependent var	0.020842
Adjusted R-squared	0.290582	S.D. dependent var	0.199380
S.E. of regression	0.167932	Akaike info criterion	-0.512885
Sum squared resid	0.648623	Schwarz criterion	-0.142823
Log likelihood	15.94971	Hannan-Quinn criter.	-0.392254
F-statistic	2.755451	Durbin-Watson stat	1.937715
Prob(F-statistic)	0.031110		

Short run causality from food imports to cereals production was also established by using the Chi-square value of Wald statistics, where it was hypothesized that food import of lag three (3) could not jointly influence cereals production {C (5) = C (6) = C (7) =0}. The estimated Chi-square value of Wald statistic was statistically insignificant ($p = 0.8349 > 0.05$). The study thus confirmed the null hypothesis, meaning that there was no short run causality running from food import to cereals production.

Table 1.8: Wald Test of short run causality from food import to cereals production

Test Statistic	Value	df	Probability
F-statistic	0.286935	(3, 23)	0.8343
Chi-square	0.860804	3	0.8349

Null Hypothesis: C(5)=C(6)=C(7)=0

Null Hypothesis Summary:

Normalized Restriction (= 0)	Value	Std. Err.
C(5)	-0.056788	0.160074
C(6)	0.063897	0.181522
C(7)	-0.005870	0.137237

Restrictions are linear in coefficients.

Equation 1.9 is a system generated equation for the error correction model where food import was considered as an endogenous variable.

D(LNFIM) = C(9)*(LNCRP(-1) - 0.0972882664644*LNFIM(-1) - 12.9913534645) + C(10)*D(LNCRP(-1)) + C(11)*D(LNCRP(-2)) + C(12)*D(LNCRP(-3)) + C(13)*D(LNFIM(-1)) + C(14)*D(LNFIM(-2)) + C(15)*D(LNFIM(-3)) + C(16) (1.9)

From the equation, C (9) is the error correction term or speed of adjustment towards long run equilibrium. The computed value of the term is 2.215732, which is statistically significant ($P = 0.0003 < 0.05$) as shown in Table 1.9. This indicates that there was no long run causality from cereals production to food import. Generally causality exists if the error correction term is negative and is statistically significant (Engel & Granger, 1987)

Table1.9: Estimated parameters for Equation 1.5

	Coefficient	Std. Error	t-Statistic	Prob.
C(9)	2.215732	0.514360	4.307745	0.0003
C(10)	-1.942354	0.499238	-3.890636	0.0007
C(11)	-1.313735	0.412683	-3.183399	0.0041
C(12)	-0.374601	0.316371	-1.184057	0.2485
C(13)	-0.656567	0.173263	-3.789414	0.0009
C(14)	-0.133523	0.196479	-0.679578	0.5036
C(15)	0.016306	0.148545	0.109771	0.9135
C(16)	0.178954	0.050819	3.521413	0.0018

R-squared	0.633474	Mean dependent var	0.091333
Adjusted R-squared	0.521923	S.D. dependent var	0.262888
S.E. of regression	0.181769	Akaike info criterion	-0.354525
Sum squared resid	0.759919	Schwarz criterion	0.015536
Log likelihood	13.49514	Hannan-Quinn criter.	-0.233894
F-statistic	5.678773	Durbin-Watson stat	1.971332
Prob(F-statistic)	0.000668		

Short run causality from cereals production to food import was tested using Wald statistics, with the null hypothesis that cereals production of lag three (3) could not jointly influence food import {C (10) = C (11) = C (12) =0}. The estimated Chi-square value of Wald statistic was statistically significant (p = 0.000), meaning that C (10) = C (11) = C (12) ≠ 0. The null hypothesis was therefore rejected, implying that there was short run causality running from cereals production to food import.

Table 1.10: Wald Test of short run causality from cereals to food import production

Test Statistic	Value	df	Probability
F-statistic	8.051629	(3, 23)	0.0008
Chi-square	24.15489	3	0.0000

Null Hypothesis: C(10)=C(11)=C(12)=0
Null Hypothesis Summary:

Normalized Restriction (= 0)	Value	Std. Err.
C(10)	-1.942354	0.499238
C(11)	-1.313735	0.412683
C(12)	-0.374601	0.316371

Restrictions are linear in coefficients.

4. Conclusion and Recommendations

The study concludes that bidirectional causality exists between food import and cereals production in Kenya. This suggests that policy makers should focus on both cereals production and food import in order to make informed decision that deals with the two macro economic variables in the Kenyan economy. In addition, food import had long run causality on cereals production. However, there was no short run causality running from food import to cereals production. The insignificant negative short run relationships suggest that food import may not significantly change the long term trend of cereals production. However food import should not be ignored in making decisions on cereals production. Perhaps focus should be on the importation of cereals for the purposes of bridging the gap between the economy's demand for food and domestic supply.

On the other hand, cereals production had no long run causality on food import, though there was short run causality running from cereals production to food import. The negative significant short run relationship between cereals production and food import imply that food import may react to cereals production, a likely indication that cereals production my alter food import in the long run. The country should thus enhance cereals production to reduce food imports which could be ascribed to food shortage in the economy. Generally, imported inflation is associated with international trade activities, a scenario that may negatively impact on the economy if not checked and well managed.

References

Baum,C.F& Schaffer, E. M (2013), A general approach to testing for autocorrelation, a paper presented in Stata Conference, New Orleans, July 2013

Baltagi, B. H., Jung, B. C. and Song, S. H. (2009), Testing for heteroskedas-ticity and serial correlation in a random e§ects panel data model. Journal of Econometrics, 154, 122-124

Corrie A., Andrew J., and Trail F. (2000), Effects of rainfall and temperature on production of *Perithecia* by *Gibberella Zeae* in field debris in Michigan available at < https://scabusa.org/pdfs/forum_00_proc_edm.pdf>

Emogor, R. A. (2012), Food price crisis and food insecurity in Kenya, a report prepared at Kenya Agricultural Research Institute (KARI) Headquarters, Nairobi, Kenya

Engle, F. R and Granger, C. W. J. (1987), Co-Integration and Error Correction: Representation, Estimation, and Testing, Econometrica, 55 (2), 251-276

Johansen, S. (1988), "Statistical Analysis of Cointegration Vectors," *Journal of Economic Dynamics and Control*, Vol. 12, No. 2–3, pp. 231–254

Johansen and Juselius, K. (1990), "Maximum Likelihood Estimation and Inference on Cointegration–with Applications to the Demand for Money," *Oxford Bulletin of Economics and Statistics*,Vol. 52, No. 2, pp. 169–210

Francis N & Watanabe, T. (2015), Influences of rainfall on crop production and suggestions for adaptation *International Journal of Agricultural Sciences,* 5 (1), 367-374

Gerbens-Lee, P.W., Nonhebel, S, Krol M.S. (2012), Food consumption patterns and economic growth. Increasing affluence and the use of natural resources. Appetite, doi:10.1016/j.appet.2010.09.013

Joshua A. and T.S. Jayne, (2010), Factors Driving the Increase in Fertilizer Use by Smallholder Farmers in Kenya, 1990-2007, a draft report under the Egerton University Tegemeo Agricultural Monitoring and Policy Analysis (TAMPA) project, funded by USAID/Kenya.

Moylen G. H. (2012), The impact of rainfall variability on agricultural production and household welfare in rural malawi, published thesis

Mukras M. (2012), Fundamental Principles of Time Series Econometrics II, Germany, LAP Lambert Academic Publishing

Nyoro J., Ayieko M., Muyanga M. (2007), The Compatibility of Trade Policy with Domestic Policy Interventions Affecting the Grains Sector in Kenya.Tegemeo Institute, Egerton University.

Ogada, J. M., Dianah M., Germano M., Mary M. (2014), Technical efficiency of Kenya's smallholder food crop farmers: do environmental factors matter? *Springer, 15(6),* 1065–1076

Owuor, J. (1997), "Determinants of Agricultural Productivity in Kenya". Retrieved on June 28, 2013, from www.fsg.afre.msu.edu./Kenya/detr_agprod.pdf

Paul P. S.T, Mely C, Goh T., Jonatan A. L. (2015), Impact of climate change on food production: Options for importing countries, Published Policy Brief, available at < https://www.rsis.edu.sg/wp-content/uploads/2015/05/PB150529_Impact-of-Climate-Change-on-Food-Production.pdf>

PKF Consulting Ltd and International Research Network, (2005), Grains Production in Kenya 2005, A report prepared for Export Processing Zones Authority– Kenya.

Reginah, K & Kitiabi M.K. (2012), The Impact of Election (2007/2008) Violence on Kenya's Economy1: Lessons Learned? A paper presented at the African Research and Resource Forum (ARRF) in December, 2012

UNEP (2015), Green Economy Sector Study on Agriculture in Kenya, Published working document

Wanjiru K. M. (2014), The effects of food aid on food security in Kenya, Published MA research project, University of Nairobi, Kenya.

Water Efficient Maize for Africa (WEMA), African Agricultural Technology Foundation (AATF), Kenya Agricultural Research Institute (KARI) (2010), Reducing maize insecurity in Kenya: the WEMA project, Policy brief prepared in 2010