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Econometric Analysis of Retail Prices of Major Agricultural Food Commodities in Dire Dawa City Administration, Ethiopia

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Abstract Food commodities prices have increased over the recent decade attracting the attention of market participants and policy makers. The short period between the recent price surges has therefore drawn concerns and raised questions on the causes and future prospects of commodity markets. Instability and variation in food production over years contribute immensely to food insecurity. This study focuses on the objectives include: to explore the trends of prices of selected agricultural food commodities and to examine the short run and long run relationship between the prices of the selected agricultural food commodities. In order to examine the series, the unit root tests (ADF and Phillips-Perron tests), identification of the number of lags and co-integration analyses were conducted. Unit root tests indicate that all series are non-stationary at level and are stationary (first difference) at 5 percent significant level. The Johansen co-integration test suggests that there is at least one co-integration vector, which describes the long run relationship between prices of Rice, white Teff, Maize and Sorghum. The appropriate number of lag identified was two. The VECM analysis findings showed the existence of integration between the prices and revealed that increase in prices of maize and sorghum in the past will decrease price of Rice in the long run. Similarly, the result of VECM showed as prices of white Teff and Rice have positive relationship.

Keywords: *co-integration, retail price, stationarity, vector error correction*

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1. Introduction

In recent years, price fluctuations and price spikes on global commodity markets have increasingly come to the forefront of public attention. In 2008, the world experienced a dramatic rush in the prices of commodities. The prices of food commodities, in particular maize, rice and wheat increased dramatically from late 2006 through to mid-2008, reaching their highest levels in nearly thirty years. Prices stabilized in the summer of 2008 and then decreased sharply in the midst of the financial and economic crisis [1]. Food price volatility is the variation in agricultural prices over time. There are multiple causes of food price dynamics including the supply and demand of crops, drought and other adverse weather conditions, and financial speculation. However, ignoring the source of price peaks and recognizing just the fact of high food prices, developing countries suffer the most from rising food prices, since poor people need to spend more of their disposable income for food.

The rapid rises of food prices, now days, are at the top agenda of the international community. The people of developing countries, particularly, are highly exposed to food insecurity as they are financially incapable to afford basic food crops. [2] indicated that the high food price inflation has been the most adverse economic shock that has continued to adversely affect the Ethiopian economy where significant proportion of households had to adjust food consumption in response.

In the last decade, particularly since 2007/2008, the world food prices have experienced rapid increase volatility [3]. The food price variability experienced had caused risk related agricultural policies to be debatable. According to [4], the rise in volatility experienced in the international markets has successfully exposed the European Union’s domestic prices to international price signals. It was further explained that the high agricultural commodity prices have suppressed the market measures such as border protection, subsidies, production quotas and the likes, and failed to achieve their aims. According to [5], price inflation is characterized by unexpected price changes which involved risk to farmers that react to it by reducing their output supply and investments in productive inputs. Evidence has shown that the effect of price volatility in the global markets is not limited to farm gate, but it has extended its tentacle to the downstream sector, that is, the consumers [6].

In Ethiopia, inflation was not a concern until 2002/03 [7], but afterwards began to increase at an alarming rate. For instance, the annual average food inflation rate between July 2011 and June 2012 was 36.9% and in October 2012 compared to October 2011 was 30.4% [8].

Food price inflation has been soaring throughout the country and the regional distribution of food inflation took the same pattern as the general inflation [9]. Eastern Ethiopia is one of the food insecure parts of the country sharing similar food inflation phenomena. As [10] indicates, Dire Dawa Administration experienced highest inflation rates and high price instability between 2017and 2018. The average annual food inflation rate, as reported by the NBE in 2017/18, was 49.3% for Dire-Dawa. This indicates that the area is vulnerable to high food price inflation. The impact of food price is very evident on the consumers and producers to the extent of reducing their purchasing powers. It leads people to poor people by limiting their food consumption causing ill-health in the short and long run [11].

Instability and variation in food production over years contribute immensely to food insecurity as a result of high volatility and co-movement of food commodity prices. Price volatility (that is, price instability) also interacts with price levels of commodities to affect the welfare and food security. However, [12] explained that the higher the price of commodities, the stronger the welfare consequences of volatility for consumers and vice-versa for the producers.

Furthermore, up to this recent time, many researches have been conducted on volatility and co-movement of food commodity prices in the world and even in Sub-Saharan Africa. These research works have revealed diverse measurement of dynamics of food commodity prices, but little was done in Ethiopia. Therefore, this study wants to bridge the gap and contribute to this area in analyzing the Prices of the selected food commodity (namely, prices of Rice, Maize, white Teff and Sorghum) in Dire Dawa. This study focuses on the objectives include: to explore the trends of prices of selected agricultural food commodities and to examine the short run and long run relationship between the prices of the selected agricultural food commodities.

2. Methodology

2.1. Data Source

The data used for the study were Monthly time series data for the producers' price of food commodities (Rice, White Teff, Maize and Sorghum) spanning from December 2011 to July 2018 which was obtained from Ethiopian Central Statistical Agency (CSA). The prices were recorded in Ethiopian birr (ETB).

2.2. Econometrics Model Specification

The test for stationarity of the time series was explored using the unit root test. A time series is said to be stationary when its mean and variance are the same over the given time and the covariance that exists between the two variables does not depend on the observed time, but rather on their lag length of time. Out of many tests available to determine the stationarity, the most common tests used were the Augmented Dickey-Fuller and Philips Peron tests were employed for this study.

2.3. The Augmented Dickey–Fuller (ADF) Test

The ADF test constructs a parametric correction for higher order correction by assuming that the series Y_t follows and AR(p) process and adding p lagged difference terms of the dependent variable to the right hand side of the test regression. The ADF test here consists of estimating the following regression:

$$\Delta Y_t = \beta_1 + \beta_2 t + \delta Y_{t-1} + \sum_{i=1}^{p} \alpha_i \Delta Y_{t-i} + \varepsilon_t$$

Where, β_1, β_2, δ and α are the coefficients, t is the stochastic trend, ε_t is a white noise error term and $\Delta Y_{t-1} = Y_{t-1} - Y_{t-2}, \Delta Y_{t-2} = Y_{t-2} - Y_{t-3},$ etc.

2.4. Co-integration Test

In the fully specified regression model $Y_t = \beta X_t + \varepsilon_t$, there is a presumption that the disturbances ε_t are a stationary, white noise series. But this presumption is unlikely to be true if Y_t and X_t are integrated series. Generally, if two series are integrated to different orders, then linear combinations of them will be integrated to the higher of the two orders. Thus, if Y_t and X_t are $I_{(1)}$, that is if both are trending variables, then we would normally expect $y_t - \beta x_t$ to be $I_{(1)}$ regardless of the value of β, not $I_{(0)}$ (i.e., not stationary).

If Y_t and X_t are each drifting upward with their own trend, then unless there is some relationship between those trends, the difference between them should also be growing, with yet another trend. There must be some kind of inconsistency in the model. On the other hand, if the two series are both $I_{(1)}$, then there may be a β such that $\varepsilon_t = Y_t - \beta X_t$ is $I_{(0)}$. Intuitively, if the two series are both $I_{(1)}$, then this partial difference between them might be stable around a fixed mean. The implication would be that the series are drifting together at roughly the same rate. Two series that satisfy this requirement are said to be co-integrated, and the vector [1, −β] (or any multiple of it) is a co-integrating vector. In such a case, we can distinguish between a long-run relationship between Y_t and X_t that is, the manner in which the two variables drift upward together, and the short-run dynamics, that is, the relationship between deviations of Y_t from its long-run trend and deviations of X_t from its long-run trend. If this is the case, then differencing of the data would be counterproductive, since it would obscure the long-run relationship between y_t and X_t. Studies of cointegration and a related technique, error correction, are concerned with methods of estimation that preserve the information about both forms of covariation.

2.5. Vector Error Correction Model

The vector autoregressive (VAR) model is a general framework used to describe the dynamic interrelationship among stationary variables. So, the first step in time-series analysis should be to determine whether the levels of the data are stationary. If not, take the first differences of the series and try again. Usually, if the levels (or log-levels) of the time series are not stationary, the first differences will be.

If the time series are not stationary at level, then the VAR framework needs to be modified to allow consistent estimation of the relationships among the series. The Vector Error Correction model (VECM) is just a special case of the VAR for variables that are stationary in their differences (i.e., I(1)). If the series are co-integrated, the series move together in the long run. A VAR of the first differences does not capture the long run relationship. Therefore, it is appropriate to use VECM rather than VAR in order to reveal the short term and long term tendencies between the series. The VECM can also take into account any co-integrating relationships among the variables.

Consider a VAR with p lags

$$y_t = V + A_1 y_{t-1} + A_2 y_{t-2} + \ldots + A_p y_{t-p} + \varepsilon_t \tag{1}$$

Where y_t is a $K \times 1$ vector of variables, **V** is $K \times 1$ vector of parameters, $A_1 - A_P$ are $K \times K$ matrix of parameters and ε_t is $K \times 1$ vector of disturbances. Any VAR(p) can be rewritten as a VECM. The VEC model is specified as follows:

$$\Delta y_t = V + \Pi y_{t-1} + \sum_{i=1}^{p-1} \Gamma_i \Delta y_{t-i} + \varepsilon_t \tag{2}$$

Where, $\Pi = -I_n + \sum_{i=1}^{p} A_i$, $\Gamma_i = -\sum_{j=i+1}^{p} A_j$ and I_n is an identity matrix.

Specifically, when we use our variables the VECM can be specified as follows: (Equations 3-6)

$$\Delta PR_t = \alpha_1 + \sum_{i=1}^{p-1} \alpha_{2i} \Delta PR_{t-1} + \sum_{j=1}^{p-1} \alpha_{3j} \Delta PWT_{t-1} + \sum_{k=1}^{p-1} \alpha_{4k} \Delta PM_{t-1} + \sum_{l=1}^{p-1} \alpha_{5l} \Delta PS_{t-1} + \delta_1 EC_{t-1} + \varepsilon_{1t} \tag{3}$$

$$\Delta PWT_t = \beta_1 + \sum_{i=1}^{p-1} \beta_{2i} \Delta PR_{t-1} + \sum_{j=1}^{p-1} \beta_{3j} \Delta PWT_{t-1} + \sum_{k=1}^{p-1} \beta_{4k} \Delta PM_{t-1} + \sum_{l=1}^{p-1} \beta_{5l} \Delta PS_{t-1} + \delta_2 EC_{t-1} + \varepsilon_{2t} \tag{4}$$

$$\Delta PM_t = \gamma_1 + \sum_{i=1}^{p-1} \gamma_{2i} \Delta PR_{t-1} + \sum_{j=1}^{p-1} \gamma_{3j} \Delta PWT_{t-1} + \sum_{k=1}^{p-1} \gamma_{4k} \Delta PM_{t-1} + \sum_{l=1}^{p-1} \gamma_{5l} \Delta PS_{t-1} + \delta_3 EC_{t-1} + \varepsilon_{3t} \tag{5}$$

$$\Delta PS_t = \theta_1 + \sum_{i=1}^{p-1} \theta_{2i} \Delta PR_{t-1} + \sum_{j=1}^{p-1} \theta_{3j} \Delta PWT_{t-1} + \sum_{k=1}^{p-1} \theta_{4k} \Delta PM_{t-1} + \sum_{l=1}^{p-1} \theta_{5l} \Delta PS_{t-1} + \delta_4 EC_{t-1} + \varepsilon_{4t} \tag{6}$$

In the formulations above, ΔPR_t is the difference of price of rice at time t, ΔPWT_t is the difference of price of white Teff at time t, ΔPM_t is the difference of price of maize, ΔPS_t is the difference of price of sorghum at time t, EC is the error correction term, which is the estimated residual from the co-integration regression and ε_t is the random disturbance term at time t. Here, Rice is the food commodity consumed by majority of the households of eastern part of Ethiopia, particularly in Dire Dawa administrative. Therefore, the study tried to find the short run dynamics and long run relationship between price of Rice and price of other commodities considered.

3. Results and Discussions

3.1. Descriptive Analysis

To achieve the research objectives, the monthly data span from December 2011 to July 2018 was analyzed. In the empirical analysis, four series namely, the prices of Rice, Maize, White Teff and Sorghum were used. Some descriptive statistics including the mean, the standard deviation, the coefficient of variation, minimum and maximum values of the series under study are presented in Table 1. The results show that the values of summary statistics are more or less similar except standard deviation which indicates relatively high dispersion for White Teff.

Table 1. Descriptive Statistics of the series

Variables	Obs	Mean	Std. Dev.	Min	Max
Rice	80	16.247	2.229	13.96	24.00
White Teff	80	19.415	3.948	11.50	27.14
Maize	80	7.354	1.185	6.00	10.49
Sorghum	80	10.763	1.288	8.07	14.50

The plots of the selected prices of agricultural products were displayed as shown in Figure 1 and suggested that the series of the endogenous variables are non-stationary and shows increasing trend except maize price. Additionally, from the figure we can observe that from 2017 the prices are highly increasing with some spikes around the middle of 2018.

3.2. Unit Root Properties of Individual Series

The time series under consideration should be checked for stationary before one can attempt to fit a suitable model. That is, variables have to be tested for the presence of unit root(s) thereby the order of integration of each series is determined. The stationarity of the series were tested by using an Augmented Dickey-Fuller test and a Phillips and Perron test. The hypothesis to be tested is: H_0: the series has unit root against H_1: the series has no unit root.

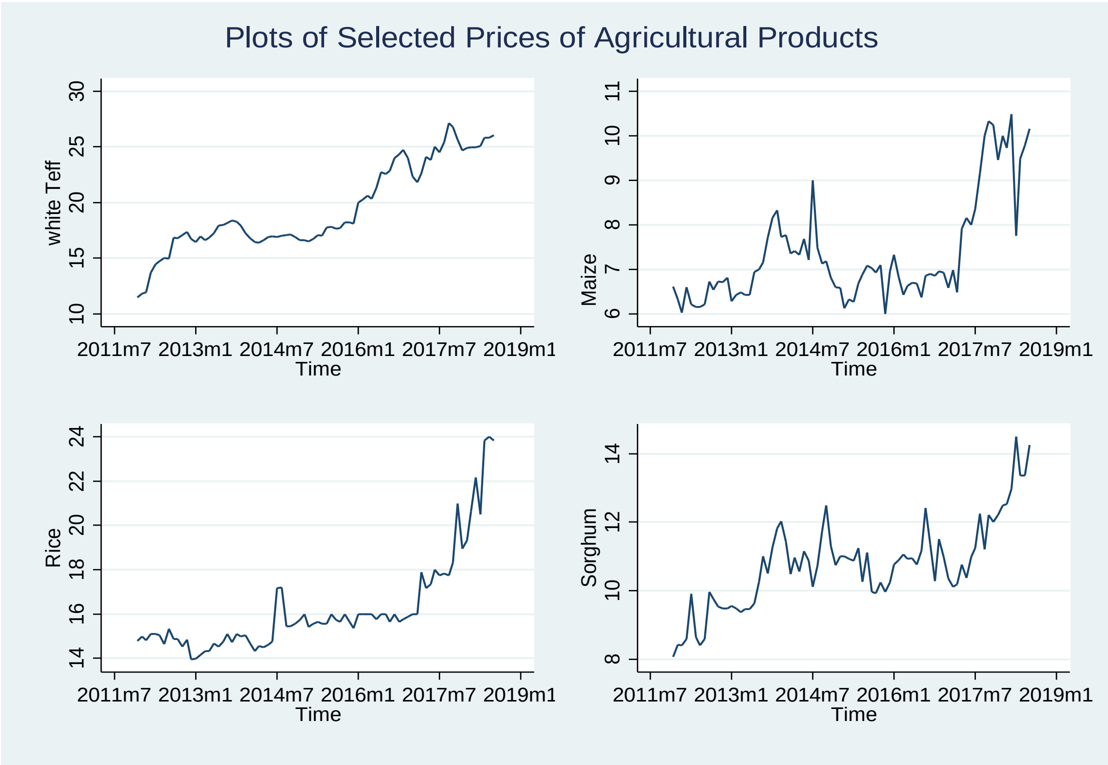

Figure 1. Plots of selected prices of Agricultural food products

The results of ADF and PP tests, with constant and trend both at level and first difference for each series are presented in Table 2. Test results indicated that the null hypothesis that the series in levels contain unit root could not be rejected for all the four series. That is, the respective p-values are greater than conventional significance levels α =0.05 and 0.01. Since the null hypothesis cannot be rejected, in order to determine the order of integration of the non-stationary time series, the same tests were applied to their first differences. The order of integration is the number of unit roots that should be contained in the series so as to be stationary.

Table 2. Unit root test results (At level and first differences)

Series	ADF		Phillips Peron Test	
	At level	At first difference	At level	At first difference
	p-value	p-value	p-value	p-value
Rice	0.994	0.000	0.875	0.000
Maize	0.760	0.000	0.201	0.000
Sorghum	0.266	0.000	0.058	0.000
White Teff	0.433	0.000	0.611	0.000

3.3. Co-integration Analysis

Since the variables are integrated of order one, we proceed to test for co-integration. Johansen (1995) co-integration test is applied at the predetermined lag 1. In these tests, Maximum Eigenvalue statistic or Trace statistic is compared to special critical values. The maximum eigenvalue and trace tests proceed sequentially from the first hypothesis no co-integration to an increasing number of co-integrating vectors. The results of co-integration tests for Rice, Maize, Sorghum and white Teff are reported in Table 3. The trace statistic indicates that at least one co-integrating vector ($r \geq 1$) exists in the system at the 95 percent confidence level (estimated LR statistic, 29.68>29.01, 95 percent critical value).

Table 3. Co-integration test

Maximum rank	Parameters	LL	Eigenvalue	Trace statistic	5%critical value
0	20	-400.93761	.	52.7374	47.21
1	27	-389.07425	0.26228	29.0107*	29.68
2	32	-378.9028	0.22957	8.6678	15.41
3	35	-374.56909	0.10517	0.0003	3.76
4	36	-374.56892	0.00000		

From the Johansen co-integration test, it was determined that the rank of co-integration matrix to be equal to one. Consequently (Table 5), the co-integrating vector is given by β= (1, -1.064054, 0.0287828 and -1.809817). The values correspond to the co-integrating coefficients of Rice (normalized to one), Maize, white Teff and Sorghum, respectively. Thus, the vector above can be expressed as follows (Table 5):

$$\begin{aligned} ECT_{-1} &= PR - 1.084054PM_t \\ &+ 0.0287828PWT_t - 1.809817PS_t \end{aligned} \quad (7)$$

Ho: there is no co-integration among variables
Ha: there is co-integration

3.4. Optimal Lag Length Selection

Akaike Information Criterion (AIC), Hannan-Quinn Information Criterion (HQIC) and Schwarz Bayesian Information Criterion (SBIC) were used to determine the appropriate lag length (Table 4). Lag two are selected to be the optimum lag lengths, as these are selected by the majority of the criterion.

Table 4. Maximum Lag length selection

Lag	LL	LR	Df	P	FPE	AIC	HQIC	SBIC
0	-492.059				11.3352	13.7794	13.8298	13.9059
1	-342.371	8.973	16	0.915	0.382677	10.3857	10.8389	11.524
2	-337.885	299.38	16	0.000	0.276721*	10.0659*	10.3176*	10.6983*
3	-329.265	17.238	16	0.370	0.474834	10.5907	11.2453	12.235
4	-321.371	15.789	16	0.468	0.606941	10.8159	11.6719	12.966
5	-312.017	18.709	16	0.284	0.754815	11.0005	12.0579	13.6566
6	-302.17	19.693	16	0.234	0.942102	11.1714	12.4302	14.3334
7	-290.688	22.965	16	0.115	1.14893	11.2969	12.7571	14.9648
8	-274.895	31.586*	16	0.011	1.27897	11.3026	12.9643	15.4765

Table 5. Vector Error Correction Model Output

	Coef.	Std. Err.	Z	P>|z|	[95% Conf. Interval]	
ΔPR_t						
Ec_{t-1}	-0.1006366	0.0077236	-13.03	0.000	-0.1157746	-0.0854986
ΔPR_{t-1}	-3.998554	0.8080586	-4.95	0.000	-5.5823524	-2.4414818
ΔPWT_{t-1}	0.0302659	0.0880756	0.34	0.731	-0.1423592	0.2028909
ΔPM_{t-1}	-0.1006366	0.0077236	-13.03	0.000	-0.1157746	-0.0854986
ΔPS_{t-1}	-0.0806778	0.1520791	-0.53	0.596	-0.3787473	0.2173917
_cons	0.1631411	0.112257	1.45	0.146	-0.0568786	0.3831607
ΔPWT_t						
Ec_{t-1}	0.2740625	0.0891136	3.08	0.002	0.0994031	0.4487219
PR_{t-1}	0.2091554	0.1965174	1.06	0.287	-0.1760116	0.5943224
ΔPWT_{t-1}	-0.0273734	0.1269424	-0.22	0.829	-0.2761759	0.2214291
ΔPM_{t-1}	-0.3018996	0.2475861	-1.22	0.223	-0.7871595	0.1833603
ΔPS_{t-1}	0.1831521	0.0732546	2.50	0.012	0.0395756	0.3267286
cons	0.045223	0.1617947	0.28	0.780	-0.2718888	0.3623348
ΔPM_t						
Ec_{t-1}	-0.061093	0.0156947	-3.89	0.000	-0.0918542	-.0303322
PR_{t-1}	0.0749033	0.1203032	0.62	0.534	-0.1608866	0.3106933
ΔPWT_{t-1}	-0.0155244	0.0063323	-2.45	0.014	-0.0279355	-0.0031133
ΔPM_{t-1}	-0.2409417	0.1515663	-1.59	0.112	-0.5380061	0.0561227
ΔPS_{t-1}	0.0575055	0.1341827	0.43	0.668	-0.2054878	0.3204988
cons	0.0056259	0.0990468	0.06	0.955	-0.1885023	0.1997541
ΔPS						
Ec_{t-1}	0.1617882	0.0501172	3.23	0.001	0.0635603	0.2600162
ΔPR_{t-1}	0.0228854	0.0059291	3.86	0.000	0.0112646	0.0345063
ΔPWT_{t-1}	-0.0252946	0.071392	-0.35	0.723	-0.1652205	0.1146312
ΔPM_{t-1}	0.2181312	0.1392418	1.57	0.117	-0.0547776	0.4910401
ΔPS_{t-1}	-0.0873788	0.1232718	-0.71	0.478	-0.328987	0.1542294
Cons	0.0087713	0.0909929	0.10	0.923	-0.1695715	0.1871141

Normalized co-integrating coefficients (p values in parentheses)

PR	PM	PWT	PS
1.000	-1.084054	0.0287828	-1.809817
	(0.033)	(0.034)	(0.000)

3.5. Vector Error Correction Model Estimation

Co-integration and non-spurious regression are the fundamental requirements of VECM. Results of co-integration test (Table 3) provide enough evidence on the long run relationship between the variables under consideration as there is a co-integration relationship. Result of ADF and PP tests provides enough evidence of stationarity of the prices (Table 1) at first difference. Since the series are co-integrated and non-spurious it enables us to estimate VECM (Table 5). The results of VECM are given in Table 5.

In the Rice (ΔPR) equation, the lagged EC term (δ_1 = -0.1006366, P = 0.000) is negative and the coefficient is significant at 5% level meaning that system corrects its previous period disequilibrium at a speed of 10.06% monthly. It implies that the model identified the sizable speed of adjustment by 10.06% of disequilibrium correction monthly for reaching long run equilibrium steady state position. The coefficient of the lagged EC term for white Teff (δ_2 = 0.0891136, $P=0.002$) and the coefficient of the lagged EC term for sorghum (δ_4 =0.1617882, P=*0.001*) are positively significant at 5% level.

The short-run dynamics are captured through the individual coefficients of the difference terms. The examination of the short-term relationship between the variables demonstrated that price of Rice is negatively affected by only the first lag of price of maize ($\alpha_{4,1}$ = -0.1006366, $P=0.000$) and its own past values

($\alpha_{2,1}$ = -0.1006366, P=0.000). The other short-run coefficients in this equation are not significantly different from zero. This implies that the prices of white Teff and Sorghum have no temporal short term effects on the price of Rice. In the white Teff regression, the effects of the one lag of price of sorghum ($\beta_{5,1}$ = 0.1831521, P=0.012) is positively significant. For the Maize equation, the short-run coefficient of the first lag of price of white Teff ($\gamma_{3,1}$ = -0.0155244, P=0.014) is negatively significant, but the other short-run coefficients in this equation are not significantly different from zero. In the Sorghum regression, the effects of the one lag of price of Rice ($\theta_{2,1}$ = 0.0228854, P=0.000) is positively significant.

4. Conclusions

The purposes of this study were to see the structure of the selected series and to determine whether integration exists between the selected agricultural food commodity prices. The analysis was based on the monthly data from December 2011 to July 2018. The series used in this study are monthly prices of Rice, white Teff, Maize and Sorghum. Over the time period considered, all the three series showed an increasing pattern, that is, there is the sign of non stationarity in each of the series. In order to examine the series, the unit root tests (ADF and Phillips-Perron tests), identification of the number of lags and cointegration analyses were conducted. Unit root tests indicate that all series are non stationary at level and are stationary at first difference at 5 percent significant level. The Johansen cointegration test suggests that there is at least one cointegration vector, which describes the long run relationship between prices of Rice, white Teff, Maize and Sorghum. The appropriate number of lag identified was two.

Previous studies on integration in various countries and commodity prices that are discussed in the theory section did not clearly indicate whether price integration occurs but suggested it depends on the location and commodities being analyzed. Thus, research specific to the study area is important. Analyzing the prices movements, the integration was observed between the prices of the selected food commodities. This observation was then empirically tested and verified using a VECM analysis. The VECM analysis findings showed the existence of integration between the prices and revealed that increase in prices of maize and sorghum in the past will decrease price of Rice in the long run. Similarly, the result of VECM showed as prices of white teff and Rice have positive relationship.

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