Market Efficiency in Agricultural commodities: Vector error correction model (VECM) Approach

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***Abstract*: The study was conducted in Elobied Crops Market to investigate the efficiency market hypothesis (EMH) for sesame, groundnut, and Arabic gum crops. The study used Augmented-Dickey Fuller (ADF) method, Johansen multivariate approach, and Vector error correction model (VECM), and co-integration method. Data was obtained from the Elobied Crops Market database for annual prices and quantities of trading commodities from 1990 to 2017.The study concluded that there is a weak form of EMH for sesame and groundnut and a semi-strong of EMH for Arabic gum.**

***Keywords*: Sudan; Crops Market; Efficiency Market Hypothesis**

I. INTRODUCTION

Prices play an important role in guiding production, consumption and government policies, production decisions of farmers and buying decision of consumers largely. Price information has become even more important with recent changes in North Kordofan State conditions. The fact is that prices of agricultural commodities are more volatile than of most non-farm goods and services. Under such circumstance, producers and marketers of field crops in tradition rain fed subsector will be in conditions of risk and uncertainty about price stability and volatility. For a few decades, dramatic changes in prices in domestic markets with increase in costs of production and deterioration in yields and in rainfall have put producers and marketers in critical situation because of price instability. Moreover, they have not been entirely protected from the consequences of price instability and they have limited ability to deal with it. The buying and selling activities in Elobied crops market are correlating to the rainy agricultural season in Kordofan, where the market season begins in mid-November of each year and reaches its peak in following months of January and February. The flow of crops continue until the end of June. After that, crops send to stores of merchants and companies. Accordingly, prices of crops fluctuate due to the supply and demand processes and that correlate to increase or decrease in the productivity of each crop. The question arise here is to what extend the crops price in Elobied crops market reflect the public and private information in context of market efficiency

A large portion of agricultural economics research is concerned with the efficiency of markets in the agriculture subsector (Aráujo*et al*., 2018; Rodrigues and Martines Filho, 2015; Silva and Takeuchi, 2010; Bitencourt, 2007). A market is supposed to be efficient if prices adjust fast and, as usual, to new information without bias. Under the market efficiency hypothesis, the market price should fully reflect available information so that there exists no strategy from which traders can profit consistently by speculating in the forward or futures market on future levels of the spot price (Lai and Lai, 1991). In its weak form, the efficient markets hypothesis (EMH) emphasizes that the current price fully integrates information covered in the history of prices only. On the other hand, the semi-strong-form of efficiency market hypothesis (EMH)implies that the current price fully integrates all publicly available information, including in addition to the past prices, the data documented in a company's financial statements (annual reports, income statements, filings for the Security and Exchange Commission, etc.). The strong form of efficient market hypothesis (EMH) asserts that the current price fully encompasses both public and private information is called inside information (Dimson and Mussavian, 2000). Therefore, the EMH can be used as a standard for measuring the efficiency of markets (Dupernex, 2007).

The main goal of this study is to test the weak-form of efficiency, which mainly done for commodity time series that are primarily nonstationary and annually nonstationary, hypothesizing that the past markets for crops are efficient and serve the twin purposes of risk management and price discovery. When crops are present in markets, the prices are determined by current and lag sold out quantities of crops. This could be true underprice flexibility, where the direction of the causal relationship is from quantities to prices. Under cobweb theory, this relationship is represented as a demand relationship. Therefore, co-integration between price and quantity arrived in the market is necessary for market efficiency. The market efficiency hypothesis suggests that quantity demanded is an unbiased predictor of price on average (Vanrammawia, 2015), so the second issue in this study is to estimate the inverse demand function.

The study aims to

i. Investigate the efficient market hypothesis (EMH) of selected agricultural commodities in in Elobied crops market in North Kordofan, Sudan. The hypotheses are:

(H0): Agricultural commodity market in North Kordofan is not efficient.

(H1): Agricultural commodity market in North Kordofan is efficient.

ii. Estamte price flexibility of crops in Elobied crops market in North Kordofan, Sudan.

II. METHODOLOGY

The study used data from Elobied Crops Market's database on prices of trading commodities from 1990 to 2017. The stationarity of the data is determined with a unit root test using the Augmented-Dickey Fuller (ADF) method under the random walk concept is characterized by the fact that price changes are independent of each other (Brealey*et al.*, 2005). The existence of co-integration means the price relationship between current and lag one can be adequately represented by an error correction model (ECM). Such methodologies of co-integration and error correction systems could be found in Engle and Granger (1987), Hallam and Zanoli (1993), Hwang (2002), and Awosola *et al*.(2006). Once the co-integration among the variables is established, the ECM is used to analyze the short-term and long-term dynamics in a model that has two distinctive features. The first, an ECM is dynamic as long as the endogenous and exogenous variables include lags. It, therefore, captures the short-run adjustments to changes of particular adjustments into past disequilibria and contemporaneous changes in the explanatory variables. Second, the ECM is transparent in displaying the co-integrating relationship between or among the variables.

The efficiency of the market is a test based on the following co-integrating regression of prices:

$$P_{it}= \beta_{i1} + \beta_2 P_{it-1} + U_{it} \qquad (1)$$

Where P_{it} is the current price and P_{it-1} is lag prices. It can be inferred that the lag prices are unbiased and efficient if the null hypothesis: $\beta_1 = 0$ and $\beta_2 = 1$ of (1) is not rejected, and since the efficiency of the market implies that the current prices reflect all past or historical information, the lag terms are reflected in the general model as:

$$P_{it}= \beta_{i1} + \Sigma\beta_{ij}P_{it-j} + U_{it} \qquad (2)$$

The current price is regarded as efficient if the null hypothesis: $\beta ij = 0$ of (4) is not rejected; otherwise, it is not.

The inverse demand function in the market used to test the market efficiency representing as follows:

$$P_{it}= \theta_0 + \theta_1 Q_{it} + \theta_2 Q_{it-1} +\nu_t \qquad (3)$$

Q_{it} is the current arrival quantity, and Q_{it-1} is the lag arrival quantity.

ECM Model is represented as follows:

$$\Delta P_{it}= \alpha_0 + \alpha_1 T+\Sigma\alpha j\Delta Pit_{-j}+ \Sigma\alpha_j\Delta Q_{it-j}+ \alpha_j U_{it-1} + \varepsilon_t (4)$$

III. RESULTS AND DISCUSSION

The results of the unit root test are reported in Table 1. As shown by the ADF test. When the test is applied to the first differences of the variables, the results strongly imply that prices and quantities variables of groundnut and Arabic gum crops in the market are stationary, being integrated of order one, 1(1). Still, the quantity of sesame is being integrated of order 1(2). So, the null hypothesis that a random walk process generates the level of each series would not be rejected. That means if the error term is stationary and white noise, the markets show a co-movement of prices and quantities of crops. The exception was made for the Sesame price variable (P^s_t), which was integrated with order 1(0). However, before applying the VEC model, it is necessary to ensure that the same order of integration is co-integrated. Therefore, Johansen's (1988) co-integration test is done before applying the VEC model. The co-integration results for two equations, i.e., quantity and price functions as mentioned above, are described in Tables 2, 3, and 4. Testing of the co-integration between two sets of variables is done using the Johansen procedure with the Eigenvalues and likelihood ratio. Both tests reject the hypothesis of more than one co-integrating vector at a5 percent level for quantity and price of sesame, indicating a unique co-integrating vector between the variables. At the same time, both tests for quantities and prices for groundnut and Arabic gum show two co-integrating vector(s) at a 5% significance level. Co-integration between variables suggests a long-term relationship among the variables under concern. Thus, the presence of co-integration implies that there is a long-run equilibrium relationship between the two series of groundnut and Arabic gum.

Table 5 shows the VECM estimates of sesame price response to the lagged price and quantities of sesame. The model fits better as the adjusted R-squared was 0.45, and F-statistics is well above the 1% significance level. It could be observed from the result that the coefficient of lagged quantity is not significant but retains the theoretical negative sign. As expected, the significance of the negative error correction coefficient (-0. 26231) suggested that about 26% of deviation from long-run equilibrium is made up within one period.

The VECM results for groundnut are portrayed in Table6. The coefficients of lagged price and quantity are insignificant, so no one of them significantly affects price behavior. Moreover, the model does not fit well since the adjusted R-squared value is meager and the F-statistics. However, the error correction coefficient showing the speed of adjustment toward the long-run equilibrium is negative as expected and highly significant. It implies that about 9% of the deviation is corrected in one year.

Table 7 shows the VECM estimates of Arabic gum price response to lagged prices and quantities of Arabic gum. The model fits better as the adjusted R-squared is 0.50, and F-statistics are well above the 5% significance level. It could be observed from the result that the coefficient of lagged quantity for one period is not significant and does not retain the theoretical negative sign. As expected, the significance of the negative error correction coefficient (-0.793167) suggested that about 79% of deviation from long-run equilibrium is made up within one period (one year).

The estimated flexibilities in Table 8 have all been negative except the one of Arabic gum in the short run. It has a positive sign. This result implies a negative relationship between the quantity consumed and the own price of crops. With an exception to Arabic gum flexibility in the short run, an increase in amount consumed, increasing in its price. Most flexibilities of the crop are inflexible and less than one in the short and long runs, but the flexibility of groundnut, in the long run, is more than one, indicating that groundnut price is flexible in the long run. Inflexible prices in short and long runs mean demand is elastic in two runs. Flexible price means demand for groundnut is inelastic in the long run. Nevertheless, all coefficients from which the flexibilities are computed are un-significant in the short run; suggesting there is no significant relationship between prices and quantities of three crops. The un-significant relationships mean changes in prices of crops in the Elobied Crops Market do not depend on changes in quantities demanded in the short run.

IV. CONCLUSION

This study used the co-integration VEC model to test the market efficiency hypothesis. The issues taken in the study are random walk and inverse demand system to investigate the price efficiency in the Elobied Crops Market for three crops: sesame, groundnut, and Arabic gum. The random walk test shows a weak form of EMH for three crops. In addition, the co-integration and VEC models show a weak form of EMH in the long run and a short one for sesame and groundnut, but for Arabic gum, the two models give evidence of semi-strong EMH. The study also concluded that little changes in quantities demand lead to great changes in prices, depending to prices flexibilities. The findings are relevant to the formulation and implementation of policies that would influence the futures market transactions. It is recommended that increased effort be made to encourage information accessibilities to improve market efficiency and reduce risk comes from lack in market information.

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Table 1: Unit Root Test for the Data Series

Series	Level	1st difference	2nd difference	M - Values			conclusion
				10%	5%	1%	
Sesame quantity (Q^s_t)	-1.69865	-1.857903	-4.624723	-2.6552	-3.0294	-3.8304	1(2)
Sesame price (P^s_t)	-4.17292	----	-----	-2.6552	-3.0294	-3.8304	1(0)
Groundnut quantity (Qgrt)	-1.76646	-3.355961	-----	-2.6552	-3.0294	-3.8304	1(1)
Groundnut price(P^{gr}_t)	-1.86313	-3.463039	-----	-2.6552	-3.0294	-3.8304	1(1)
Arabic Gum quantity (Q^g_t)	-2.06504	-3.731368	-----	-2.6552	-3.0294	-3.8304	1(1)
Arabic Gum price (P^g_t)	-1.94029	-3.667872	-----	-2.6552	-3.0294	-3.8304	1(1)

Notes:

- ***, ** and * denote rejection of hypothesis of a unit root at 1%, 5% and 10% level respectively.
- The value of k is determined by using Akaike's AIC criterion.
- Instead of t-statistics, Mackinnon critical values denoted by M-Values have been applied here.

Table 2: Co-integration Test (P^s_t and Q^s_t)

	Likelihood	5 Percent	1 Percent	Hypothesized
Eigenvalue	Ratio	Critical Value	Critical Value	No. of CE(s)
0.550303	16.22989	12.53	16.31	None *
0.053537	1.045439	3.84	6.51	At most 1

Note:

- *(**) denotes rejection of the hypothesis at 5%(1%) significance level
- L.R. test indicates 1 cointegrating equation(s) at 5% significance level
- Test assumption: No deterministic trend in the data
- Lags interval: 1 to 1
- Co-integrating Equation: $lnP^S_t = -0.522237 lnQ^{S***}_t$ (0.06645)

Table 3: Co-integration Test (P^{gr}_t and Q^{gr}_t)

	Likelihood	5 Percent	1 Percent	Hypothesized
Eigenvalue	Ratio	Critical Value	Critical Value	No. of CE(s)
0.635490	23.93196	18.17	23.46	None **
0.221493	4.757162	3.74	6.40	At most 1 *

Note:

- *(**) denotes rejection of the hypothesis at a 5% (1%) significance level.
- L.R. test indicates 2 cointegrating equation(s) at a 5% significance level.
- Test assumption: Quadratic deterministic trend (T) in the data
- Lags interval: 1 to 2
- Co-integrating Equation: $lnP^{gr}_t = 45.83113 - 3.144903 lnQ^{gr}_t - 0.588180T$ (1.05061)

Table 4: Co-integration Test (P^g_t and Q^g_t)

	Likelihood	5 Percent	1 Percent	Hypothesized
Eigenvalue	Ratio	Critical Value	Critical Value	No. of CE(s)
0.584945	24.85290	18.17	23.46	None **
0.348647	8.145375	3.74	6.40	At most 1 **

Note:

- *(**) denotes rejection of the hypothesis at 5%(1%) significance level.
- L.R. test indicates 2 cointegrating equation(s) at 5% significance level.
- Test assumption: Quadratic deterministic trend (T) in the data
- Lags interval: 1 to 2
- Co-integrating Equation: $lnP^g_t = 3.818661 - 0.427633 lnQ^g_t - 0.206088T$(0.15962)

Table 5: VECM estimates of sesame price function

Error Correction:	$D(LNP^s_t)$	$D(LNQ^s_t)$
ECM(-1)	-0.262319** (0.06069)	-0.001673(0.05776)
$D(LNP^s_t (-1))$	-0.222997(0.18716)	-0.042787(0.17811)
$D(LNQ^s_t (-1))$	-0.088857(0.26187)	0.235167(0.24921)
R-squared	0.454236	0.033619
Adj. R-squared	0.386016	-0.087179
Sum sq. resides	6.452812	5.844233
S.E. equation	0.635060	0.604371
F-statistic	6.658358	0.278309
Log likelihood	-16.70056	-15.75949
Akaike AIC	2.073743	1.974683
Schwarz SC	2.222865	2.123805
Mean dependent	0.418997	0.088870
S.D. dependent	0.810468	0.579633

Note:

- Schwarz Determinant Residual Covariance:0.099384
- Log Likelihood:- 31.98643
- Akaike Information Criteria: 4.209098
- Criteria: 4.606757
- Standard errors in parentheses
- *(**) denotes rejection of the hypothesis at 5% (1%) significance level.

Table 6: VECM estimates of groundnut price function

Error Correction:	$D(LN P^{gr})$	$D(LN Q^{gr}_t)$
ECM(-1)	-0.087729(0.13368)	0.457483**(0.10002)
$D(P^{gr} (-1))$	-0.272480(0.29697)	-0.380445(0.22219)
$D(LNP^{gr} (-2))$	-0.226852(0.35248)	-0.551432*(0.26371)
$D(LN Q^{gr}_t (-1))$	-0.051826(0.31587)	0.741128**(0.23633)
$D(LN Q^{gr}_t (-2))$	-0.103135(0.36576)	0.712946*(0.27366)
C	1.045738(0.67180)	0.995735*(0.50262)
T	-0.035174(0.03388)	-0.045228(0.02534)
R-squared	0.226523	0.655902
Adj. R-squared	-0.160216	0.483852
Sum sq. resides	5.338563	2.988354
S.E. equation	0.666993	0.499029
F-statistic	0.585726	3.812289
Log likelihood	-14.89975	-9.387527
Akaike AIC	2.305237	1.725003
Schwarz SC	2.653188	2.072954
Mean dependent	0.322337	-0.071812
S.D. dependent	0.619230	0.694606

Note:

- Determinant Residual Covariance: 0.043263
- Log Likelihood:-24.08539
- Akaike Information Criteria: 4.219515
- Schwarz Criteria: 5.014832
- Standard errors parentheses
- *(**) denotes rejection of the hypothesis at 5%(1%) significance level.

Table 7: VECM estimates of Arabic gum price function

Error Correction:	**D(LNP^g_t)**	**D(LNQ^g_t)**
ECM(-1)	-0.793167*(0.36582)	0.823337*(0.35811)
D(LNP^g_t (-1))	0.184484(0.34505)	-0.152071(0.33778)
D(LNP^g_t (-2))	0.047701(0.26536)	-0.129177(0.25977)
D(LNQ^g_t (-1))	0.187697(0.22946)	0.009149(0.22462)
D(LNQ^g_t (-2))	-0.129207(0.21385)	-0.127363(0.20934)
C	0.579290(0.62519)	-0.227839(0.61201)
T	-0.020704(0.03457)	0.019530(0.03384)
R-squared	0.502607	0.462809
Adj. R-squared	0.253910	0.194213
Sum sq. resides	7.932954	7.602055
S.E. equation	0.813068	0.795930
F-statistic	2.020964	1.723069
Log likelihood	-18.66240	-18.25764
Akaike AIC	2.701306	2.658699
Schwarz SC	3.049257	3.006650
Mean dependent	0.315363	-0.010170
S.D. dependent	0.941307	0.886676

Note:

- Determinant Residual Covariance: 0.139004
- Log Likelihood: -35.17374
- Akaike Information Criteria: 5.386710
- Schwarz Criteria: 6.182027
- Standard errors parentheses
- *(**) denotes rejection of the hypothesis at 5%(1%) significance level.

Table 8: Long run and Short run demand flexibilities for crops in Elobied Crops Market

crops	Short run flexibility	Long run flexibility
Sesame	-0.088857	-0.522237
Groundnut	-0.051826	-3.144903
Arabic Gum	0.187697	-0.427633