A THRESHOLD COINTEGRATION ANALYSIS OF ASYMMETRIC ADJUSTMENTS IN THE GHANAIAN MAIZE MARKETS

Henry de-Graft Acquah, Senior Lecturer

University of Cape Coast, Cape Coast, Ghana
Phone: +00233245543956, E-mail: henrydegraftacquah@yahoo.com

Received August 14, 2012

ABSTRACT

This paper analyzes the long-run equilibrium relationship between retail and wholesale Ghanaian maize prices with cointegration test assuming asymmetric adjustment. Using the Enders-Siklos asymmetric cointegration tests, it is found that the retail and wholesale prices are cointegrated with threshold adjustment. Furthermore, the adjustment process is asymmetric when the retail and wholesale prices adjust to achieve the long-term equilibrium. Finally, there is faster convergence for negative deviations from long-term equilibrium than for positive deviations. These results imply that price increases tend to persist whereas decreases tend to revert quickly towards equilibrium.

KEY WORDS

Threshold cointegration; Asymmetric adjustment; Price transmission; Maize; Equilibrium relationship; Negative deviations.

Cointegration technique has been extensively employed to investigate relationship among price variables. The two widely used cointegration methods are Johansen and Engle-Granger two-step approaches. However these methods assume symmetric relationship between variables. These methods do not test for the possibility that the long run relationship may be asymmetric in nature. The technique of Enders and Siklos (2001) is well suited to the task of uncovering long-run relationships between time series when deviations from the long-run are asymmetric in nature. The technique generalizes the standard Dickey–Fuller test by allowing for the possibility of asymmetric movements in time-series data. This makes it possible to test for cointegration without maintaining the hypothesis of asymmetric adjustment to a long-term equilibrium. This study is aimed at empirically testing Enders and Siklos's hypothesis of asymmetric adjustment to a long-run equilibrium between the Ghanaian retail and wholesale maize prices. First, this study test for the order of integration of the price series. Second the study analyzes asymmetric adjustment using threshold cointegration methodology.

Asymmetric price transmission. Empirical studies analyzing whether prices rise faster than they fall, have categorised the price dynamics into symmetric and asymmetric processes. Meyer and von Cramon-Taubadel (2004) notes that those processes for which the transmission differs according to whether the prices are increasing or decreasing (i.e. asymmetric price transmission) are of keen interest. By definition, asymmetry is an unreciprocal relationship between rises and falls in prices.

Price transmission has extensively been studied in agricultural commodity markets. However, a major limitation of some earlier studies (Mohanty, Peterson and Kruse, 1995; Boyd and Brorsen, 1998) is that they fail to take into account the possibility of the presence of an equilibrium relationship between any price series being examined (von CramonTaubadel, 1998). The first attempt to draw on cointegration technique in testing for asymmetry in vertical price transmission is von Cramon-Taubadel and Fahlbusch (1994) and later elaborated by von Cramon-Taubadel (1998). Numerous price transmission studies (Capps and Sherwell, 2007)) implements von Cramon-Taubadel and Loy testing procedure for asymmetric price transmission or some variants of their proposed Error Correction Modeling (ECM) approach.

Following the introduction of the threshold technique, it is possible to consider an intuitively appealing type of ECM in which deviation from the long-run equilibrium between two prices will lead to a price response if they exceed a specific threshold level. Balke and Fombe (1997) point out that the presence of fixed costs of adjustment may prevent economic agents from adjusting continuously. Only when deviation from equilibrium exceeds a critical threshold do the benefits of adjustment exceed the costs and cause economic agents to act to move the system back towards the equilibrium. Due to the above reasons, the threshold models of dynamic economic equilibrium have gained increased attraction in the analysis of price transmission asymmetries. Subsequently, several studies (Esso, 2010; Awokuse et al, 2009; Meyer, 2004;Cook, 2003;Cook, 2003; Cook, 2003; Cook et al, 2002; Hansen, 2002; Cook, 2000; and Balke and Fomby, 1997) measuring asymmetric price transmission have used the threshold modeling approach.

METHODOLOGY

Stationarity test. Kwiatkowski et al. (1992) proposed a LM-test for testing trend and/or level stationarity (henceforth: KPSS-test). They consider the following model:

$$y_t = \xi t + r_t + \varepsilon_t \text{ eq. (1)}$$
$$r_t = r_{t-1} + u_t \text{ eq. (2)}$$

where $r_t$is a random walk and the error process is assumed to be i.i.d $(0, \sigma_u^2)$. The initial value r_0 is fixed and corresponds to the level. If ξ=0, then this model is in terms of a constant only as deterministic regressors. Under the null hypothesis, ε_t is stationary and therefore y_t is either trend stationary or in the case of ξ=0, level stationary.

First, regress y_t on a constant or on a constant and a trend depending on whether one wants to test level or trend stationary; second, calculate the partial sums of the residuals $\check{\varepsilon}_t$ from this regression as:

$$S_t = \sum_{i=1}^{t} \check{\varepsilon}_i\,, t = 1, 2, \dots, T. \text{ eq. (3)}$$

The test statistic is then defined as:

$$LM = \frac{\sum_{t=1}^{T} s_t^2}{\check{\sigma}_\varepsilon^2} \text{ eq. (4)},$$

with $\check{\sigma}_\varepsilon^2$ being an estimate of the error variance from step one. The authors suggest the utilization of a Bartlett window w(s, $\check{\varepsilon}_i$l) =1-s/ (l+1) as an optimal weighing function to estimate the long run variance$\check{\sigma}_\varepsilon^2$; that is:

$$\check{\sigma}_\varepsilon^2 = s^2(l) = T^{-1}\sum_{t=1}^{T} \check{\varepsilon}_t^2 + 2T - 1\sum_{s=1}^{1} 1 - \frac{s}{l+1}\sum_{t=s+1}^{T} \check{\varepsilon}_t\, \check{\varepsilon}_{t-1} \text{ eq. (5)}$$

The upper tail critical values of the level and trend stationary version are given in Kwiatkowski et al. (1992).

Econometric Model. The Engle- Granger two- stage approach focuses on the time series property of the residuals from the long run equilibrium relationship (Engle and Granger, 1987).

Consider y_t the retail prices and x_t the wholesale prices both of which are integrated of the order one.

Let the co integration relationship be:

$$y_t = \beta_o + x_t + u_t \text{ eq. (6)},$$

where u_t measures the deviation from the equilibrium relationship between $x_t$and y_t. Consistent estimates of the equilibrium error u_t , can be obtained using ordinary least squares method. For the two variables to be cointegrated, u_t should be stationary.

In order words, rejecting the null hypothesis of no co integration, that is ρ=0 against accepting the alternative hypothesis of cointegration, that is -2< ρ<0, implies that the residuals in equation 1 is stationary.

$$\Delta u_t = \rho u_{t-1} + \sum_{l=1}^{b} \emptyset_i \Delta u_{t-1} + \varepsilon_t \text{ eq. (7)},$$

where ε_t is white-noise disturbance.

This framework can be employed to analyse symmetric price transmission. The above co integration tests assume symmetric price transmission. This implicit assumption of symmetric price adjustment is problematic if adjustments are asymmetric. Enders and Siklos (2011) argue that the test for co integration is misspecified and proposes a two-regime threshold co integration approach to entail asymmetric adjustment in the co integration analysis. The alternative model modifies equation 2 such that:

$$\Delta u_t = \rho_1 I_t u_{t-1} + \rho_2(1 - I_t)u_{t-1} + \sum_{i=1}^{p} \emptyset_i \Delta u_{t-1} + \varepsilon_t \text{ eq. (8)}$$

$$I_t = 1 \text{ if } u_{t-1} \geq \tau, 0 \text{ otherwise}$$

Where I_t is the Heavside indicator, p the number of lags, ρ_1, ρ_2 and $\emptyset$ the coefficients and τ the threshold value. The lag p is specified to account for serially correlated residuals and it can be calculated using Bayesian Information Criteria (BIC) or Akaike Information Criteria (AIC).

The threshold value τ can be specified as zero. Alternatively, Chan (1993) proposes a search method for obtaining a consistent estimate of the threshold value. A super consistent estimate of the threshold value can be attained with several steps. First, the process involves sorting in ascending order the threshold variable, i.e.u_{t-1} for the threshold model. Second, the possible threshold values are determined. If the threshold value is to be meaningful, the threshold variable must actually cross the threshold value. Thus, the threshold value τ should lie between the maximum and minimum values of the threshold variable. In practice, the highest and lowest 15% of the values are excluded from the search to ensure an adequate number of observations on each side. The middle 70% values of the sorted threshold variable are used as potential threshold values. Third, the threshold model is estimated with each potential threshold value. The sum of squared errors for each trial can be calculated and the relationship between the sum of squared errors and the threshold value can be examined. Finally, the threshold value that minimizes the sum of squared errors is deemed to be the consistent estimate of the threshold. Against this background, two competing models are considered namely the Threshold model with $\tau = 0$ (i.e. TAR) and the consistent threshold model with τ estimated. Given the alternative models, model selection procedures such as the Akaike Information Criterion (AIC) and Bayesian Information Criterion (BIC) provides a basis for choosing between the Threshold Model (TAR) and Consistent Threshold Model (CTAR). A model with the lowest AIC and BIC should be preferred.

Insights into the asymmetric adjustments in the context of a long run cointegration relation can be obtained with two tests. First, an F-test is employed to examine the null hypothesis of no cointegration (H_0: $\rho_1 = \rho_2 = 0$) against the alternative of cointegration with either TAR or Consistent TAR threshold adjustment. The test statistic is represented by F. This test does not follow a standard distribution and the critical values in Enders and Siklos (2001) should be used. The second one is a standard F-test to evaluate the null hypothesis of symmetric adjustment in the long-term equilibrium(H_0: $\rho_1 = \rho_2$). Rejection of the null hypothesis indicates the existence of an asymmetric adjustment process.

Data. This study employs weekly retail and wholesale prices for maize from January 1994 to December 2003 from Kumasi in the Ashanti Region of Ghana. The weekly data for all prices are Ghana cedi per 100kg and given the high level of inflation in the period covered, prices are deflated using consumer price index (CPI) deflator. The data was obtained from the Ministry of Food and Agriculture in Ghana.

RESULTS AND DISCUSSION

Unit root test. To determine the data-generating properties of the individual data, the Kwiatkowski, Phillips, Schmidt and Shin (KPSS) test for stationarity (Kwiatkowski, et al., 1992) was performed. The results of the KPSS test in Table 1 show that the retail and wholesale prices are non stationary and integrated of the order one.

Table 1 – KPSS unit root test

n/n	Test statistics	Critical values 10 % 5 % 2.5% 1%
Wholesale (Levels)	0.2755	0.119 0.146 0.176 0.216
Wholesale (First Difference)	0.017	0.119 0.146 0.176 0.216
Retail (levels)	0.3839	0.119 0.146 0.176 0.216
Retail (First Difference)	0.0151	0.119 0.146 0.176 0.216

Source: Author's calculation

Threshold cointegration analysis. The nonlinear cointegration analysis is conducted using the Threshold Autoregression models. The TAR and Consistent TAR models are estimated and the results are reported in Table 2. In selecting an appropriate lag to address possible serial correction in the residual series, a maximum lag of 12 is specified and tried at the beginning. Diagnostic analyses on the residuals through AIC and BIC all reveal that a lag of 2 is sufficient. In estimating the threshold values for consistent TAR, the method by Chan (1993) is followed. The lowest sum of squared errors for the consistent TAR model is 1191.69 at the threshold value of -2.554. Alternatively, the threshold value for

TAR is set at 0. While the competing threshold cointegration models have similar results (table 2), the consistent TAR model has the lowest AIC statistic of 1908 and BIC statistic of 1930, and therefore, is deemed to be the best. Focusing on the results from the consistent TAR model, this study finds that the F-test for the null hypothesis of no cointegration has a statistic of 18.371 and it is highly significant at the 1% level. Thus, the retail and wholesale prices of maize in Ghana are cointegrated with threshold adjustment.

Table 2 – Estimates of the speed of adjustments parameters of the Threshold Model

n/n	Threshold Autoregressive Model (TAR)	Consistent Threshold Autoregregressive Model (CTAR)
ρ_1	-0.12057(-4.517)*	-0.11202(-4.5671)*
ρ_2	-0.14732(-3.948)*	-0.19787(-4.327)*
$\rho_1 = \rho_1$	17.081(0.000)**	18.371(0.000)**
$\rho_1 = \rho_1 = 0$	0.354(0.550)**	2.779(0.096)**
γ	0	-2.554
SSE	1197.313	1191.693
AIC	1911	1908
BIC	1932	1930

*Notes: * Values in the parentheses are t values. ** Values in the parentheses are estimated probability values; outside parentheses are the F statistic values. Source: Author's calculation.*

Furthermore, the F statistic for the null hypothesis of symmetric price transmission has a value of 2.779 and it is also significant at the 10% level. Therefore, the adjustment process is asymmetric when the retail and wholesale prices of Ghanaian maize adjust to achieve the long-term equilibrium.

The point estimate for the price adjustment is -0.11202 for positive shocks and -0.19787 for negative shocks. The point estimate of ρ_1 (-0.11202) for the retail and wholesale prices indicates that approximately 11.2 % of a positive deviation from the long-run equilibrium relation is eliminated within a week. Alternatively, the point estimate of ρ_2 (-0.19787) indicates that 19.8 % of a negative deviation from the long-run equilibrium relation is eliminated within a week. In effect, the adjustment is almost 1.7 times faster for negative deviations from equilibrium than for positive deviations. Therefore, there is substantially faster convergence for negative (below threshold) deviations from long-term equilibrium than positive (above threshold) deviations.

Model estimation results suggest that the Consistent TAR model detects asymmetry whilst TAR model fails to support this evidence. These results imply that differences in inferences are possible depending on weather the threshold parameter is estimated from the data or imposed by the researcher.

CONCLUSION

This study estimated the price transmission in the Ghanaian maize market using retail and wholesale prices. Specifically, the study tested for the order of integration of the price series and analyzed asymmetric adjustment using threshold cointegration methodology. The threshold cointegration technique makes it possible to test for cointegration without maintaining the hypothesis of a symmetric adjustment to a long-term equilibrium. The results of the KPSS test show that the retail and wholesale prices are non stationary and integrated of the order one. The retail and wholesale prices of maize in Ghana are cointegrated with threshold adjustment. The Enders and Silkos (2001) procedure provides support for the alternative hypothesis of asymmetric adjustment. The findings of this study indicate that there is a faster convergence for negative deviations from long-term equilibrium than positive deviations. These results suggest that price increases tend to persist whereas decreases tend to revert quickly towards equilibrium.

Furthermore, alternative threshold modeling approaches leads to differences in conclusion. It is recommended that CTAR be used together with the TAR and the cause of the positive asymmetry identified be investigated.

REFERENCES

Awokuse, T.O. and Wang, X. (2009), Threshold Effects and Asymmetric Price Adjustments in U.S. Dairy Markets. Canadian Journal of Agricultural Economics.

Balke, N.S and Fomby, T.B. (1997). Threshold Cointegration. International Economic Review, 38, 627-645.

Boyd, M.S. and Brorsen, B.W. (1998). Price Asymmetry in the US Pork Marketing Channel, North Central Journal of Agricultural Economics, 10, pp.103-109.

Capps, O. and Sherwell, P. (2007). Alternative Approaches in Detecting Asymmetry in Farm-Retail Prices Transmission of Fluid Milk. Journal of Agribusiness, 23 (3), 313-331.

Chan, K.S. (1993). Consistency and limiting distribution of the least squares estimator of a threshold autoregressive model. The Annals of Statistic, 21, 520-533.

Cook, S. (2000). Frequency domain and time series properties of asymmetric error correction models, Applied Economic, 32, pp. 297-307.

Cook, S. and Holly, S. (2002) Threshold specification for asymmetric error correction models, Applied Economics Letters, 9, pp. 711–13.

Cook, S. (2003). A sensitivity analysis of threshold determination for asymmetric error correction models, Applied Economic Letters, 10, pp. 611-616.

Cook, S. and Manning N. (2003) The power of asymmetric unit root tests under threshold - consistent estimation. Applied Economic Letters, 35, pp. 1543-1550.

Cook, S. (2003). The properties of asymmetric unit root tests in the presence of misspecified asymmetry, Economics Bulletin Vol. 3, No. 10 pp. 1-10.

Enders, W. and Siklos, P.L. (2001). Cointegration and threshold adjustment.Journal of Business and Economic Statistics, 19, 166-167.

Engle, R.F. and Granger, C.W.J. (1987). Cointegration and error correction: Representation, estimation and testing. Econometrica, 55, 251-276.

Esso L.J. (2010) Threshold cointegration and causality relationship between energy use and growth in seven African countries, Energy Economics, 32(6): 1383-1391

Hansen, B.E. and Seo, B. (2002). Testing for Two-Regime Threshold Cointegration in Vector Error Correction Models. Journal of Econometrics, 110, pp. 293-318.

Kwaitkowski, D., Phillips, P.C.B., Schmidt P, Shin Y. (1992). Testing the null hypothesis of stationarity against the alternative of a unit root. Journal of Econometrics, 54, 159-178.

Mohanty, S., Peterson, E.W.F. and Kruse, N.C. (1995). Price Asymmetry in the International Wheat Market. Canadian.Journal of Agricultural Economics, 43, 355-366.

Meyer, J. and von Cramon-Taubadel, S. (2004), Asymmetric Price Transmission: A Survey. Journal of Agricultural Economics, 55: 581–611.

Meyer, J. (2004) Measuring market integration in the presence of transaction costs—a threshold vector error correction approach. Journal of Agricultural Economics,31: 327-334

V. Cramon-Taubadel, S. (1998). Estimating asymmetric Price Transmission with the Error Correction Representation: An Application to the German Pork Market", European Review of Agricultural Economics, 25, pp. 1-18.

V. Cramon-Taubadel, S. and Fahlbusch, S. (1994). Identifying asymmetric price Transmission with error correction models. Poster Session EAAE European Seminar in Reading.