Threshold Effects and Asymmetric Price Adjustments in the Ghanaian Plantain Market

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Abstract: This study investigates if there is an asymmetric relationship between Ghanaian retail and wholesale plantain prices. Using the Consistent Threshold Autoregressive Model (C-TAR), this study finds that the retail and wholesale plantain prices are threshold co integrated. The study also finds that the retail and wholesale plantain prices adjust asymmetrically for deviation from the long run equilibrium. The findings of this study further indicate that 63.2% of the positive deviations and 24.9% of the negative deviations persist to the next period. These results suggest that any price movement that squeezes the margins is transmitted more rapidly than an equivalent that stretches the margin.

Keywords: *Asymmetric price transmission; Threshold adjustment; Co integration, AIC, BIC*

1. Introduction

Do prices rise faster than they fall? Numerous studies in an attempt to answer this question have focused on the vertical transmission of prices from producers to retailers or from wholesalers to retailers in a vast number of industries and countries. For instance, Boyd and Brorsen (1998) studied the US pork market and find no evidence of price asymmetry. Appel (1992) finds that both speed and degree of price transmission from the producer to the retail level for broilers in Germany is asymmetric. The recent article by Peltzman (2000) takes these studies to the limit. He tries to answer the above question by analyzing 242 products in the U.S. He claims that the output prices tend to respond faster to input increases than to decreases and therefore the adjustments are asymmetric. Recent studies have shown that the approaches used in these studies to test for asymmetric adjustments are inadequate because they do not take into account the co integration or long run relation between wholesale and retail prices. In order to correct this anomaly, Engle and Granger (1987) introduces the concept of co integration and assumes a symmetric adjustment in the long run relationship between two time series. Subsequently, most previous studies examining traditional time series model assumed that the underlying variables exhibited linear and symmetric adjustment process. However, Enders and Siklos (2001) note that if the adjustment is asymmetric then the standard co integration test may be misspecified. Subsequently, they emphasize assuming asymmetric adjustment in the long run equilibrium relationship. However, previous studies analyzing asymmetric price transmission in Ghanaian agricultural markets have not focused on testing asymmetric adjustment in the long run relationship between the plantain retail and wholesale prices using the recently developed Enders and Siklos technique. Fundamentally, the extent of integration and price transmission between the retail and wholesale plantain markets is not well understood since the issue has not received considerable attention. Empirically, no studies have been devoted to examine whether the adjustment is asymmetric within the Ghanaian plantain markets. Against this background, this paper uses this recently developed Enders and Siklos (2001) threshold co integration technique to empirically investigate the existence of asymmetries in the long run relationship between the retail and wholesale plantain prices.

2. Literature Review

Asymmetric Price transmission refers to unreciprocal relationship between increases and decreases in prices. For example, farm and retail prices. Positive asymmetry defines a set of reactions in which any price movement that squeezes the margins is transmitted more rapidly than an equivalent that stretches the margin. Whilst negative asymmetry defines a set of reactions, in which any price movement that stretches the margin is transmitted more rapidly than those that squeeze the margin. Asymmetric price transmission has widely been studied in the various agricultural markets. Earlier studies investigating price asymmetry applies the Houck's approaches, which splits the price series into increasing and decreasing phases to enable one test

for evidence of asymmetry. Unfortunately, a major shortcoming of these earlier studies (Houck 1977; Boyd and Brorsen 1998; Hahn 1990) is that they fail to take into consideration the possibility of the presence of an equilibrium relationship between the price series being studied. Von Cramon-Taubadel (1998) notes that the variants of the Houck model is sometimes used without adequate regards to time series properties of the data. Subsequently, He proposes a co integration technique in testing for price asymmetry if the two prices may drift apart in the short run, but in the long run, economic forces bring them together. Though these methods consider the time series properties of the data, they propose symmetric adjustment in the co integration relationship. Applications of these approaches include Mensah-Bonsu, Afrane & Kuwornu (2011). The authors studied integration of plantain markets in Ghana and found evidence of cointegration. Similarly, Nkendah and Nzouessin (2007) finds evidence of cointegration and asymmetry in plantain markets in Cameroon using the asymmetric error correction model. However, 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-mentioned reasons, the threshold models of dynamic economic equilibrium were developed and have gained increased attraction in the analysis of price transmission asymmetries (*e.g.*, Azzam 1999). Most recent studies of price transmission (*e.g.*, Abdulai 2002) have followed the methodology of Enders and Granger (1998) and Enders and Siklos (2001). They consider the time series properties of the variables and extend the Engle and Granger procedure to encompass possible asymmetric adjustments to equilibrium. Subsequently, Abdulai (2002) uses both the threshold autoregressive model (TAR) and momentum threshold autoregressive model (MTAR) to estimate asymmetric price transmission in the Swiss pork markets and finds that price transmission between producer and retail prices are asymmetric. Similarly, Abdulai (2000) investigates spatial price transmission and asymmetry in the Ghanaian maize markets and finds evidence of asymmetry on the basis of TAR and MTAR approaches.

3. Methodology

The methodology describes the data and the econometric techniques employed in the study. Econometric techniques such as Augmented Dickey Fuller test is used to test for unit roots. The test for asymmetry is developed and Enders and Siklos Threshold cointegration procedure is used to test for evidence of cointegration and asymmetry in the price series.

Data: The study employed weekly wholesale and retail plantain prices in Gh¢ per 12kg. A total sample size of 80 observations from August 2008 to March, 2010 was used. The Researcher used retail and wholesale plantain prices from the Mankessim market for the purposes of studying the dynamic nature of the plantain markets in the Central region of Ghana. The secondary data were obtained from the Ministry of Food and Agriculture in Ghana.

Unit root test: If a series is non-stationary and the first difference of the series is stationary, then the series is said to contain a unit root. To test for a unit root, regression of the following form is run:

$$Y_t = \beta_0 + \sum \beta_j \Delta Y_{t-j} + \gamma Y_{t-1} + u_t \quad (1)$$

This is done with enough lags of ΔY_t so that u_t contain no autocorrelation. The model may be run with or without a trend. This test usually has a null hypothesis of the presence of a unit root: $H_0 = \beta = \gamma = 0$ against the alternative of no unit root: $H_0 = \beta = \gamma = < 0$. The F test is used in the presence of a trend whiles the t test is used in the absence of a trend. The ADF (Dickey and Fuller 1979) test is applied here because it is the commonly used method. If we fail to reject the null hypothesis, we assume that there is a unit root and the data is differenced before running the regression. If the null is rejected, the data is stationary and can be used without differencing.

Price Transmission Models: In investigating the relationship between an output price P_A and input price P_B , Tweeten and Quance (1969) used an indicator variable to split the input price into two parts: one variable includes only increasing input prices P_B^+ and another includes only decreasing input prices P_B^- . From this, two input price adjustments coefficients (i.e. β_1^+ and β_1^-) can be estimated as specified below.

$$P_{A,t} = \beta_o + \beta_1^+ P_{B,t}^+ + \beta_1^- P_{B,t}^- + \varepsilon_t \quad (2)$$

Symmetric price transmission is rejected if the coefficients β_1^+ and β_1^- are significantly different from one another. Based on Tweeten and Quance (1969), Wolfram (1971) proposes a variable splitting technique that explicitly includes first difference of prices in the equation to be estimated which was later modified by Houck (1977). Within the context of the Wolfram-Houck (W-H) method, the response of price P_A to another price P_B is estimated with the following equation.

$$\Delta P_{A,t} = \beta_o + \beta_1^+ \Delta P_{B,t}^+ + \beta_1^- \Delta P_{B,t}^- + \varepsilon_t \quad (3)$$

Where ΔP^+ and ΔP^- are the positive and negative changes in P_B respectively, $\beta_o, \beta_1^+, \beta_1^-$ are coefficients and t is the current period. A formal test for symmetry using an F test or t -statistic is rejected when the coefficients β_1 and β_2 are unequal.

However, the Houck model requires the data to be stationary in order to avoid spurious regression. Von Cramon-Taubadel (1998) demonstrates that the model is fundamentally not consistent with cointegration between two price series. In the presence of cointegration, Engle and Granger (1987) two-step procedure is employed to analyze the long run relationship between the two price series P_A and P_B . First, the long run relationship between prices P_A and P_B is estimated in the equation below using the ordinary least squares technique.

$$P_{At} = \beta_o + \beta_1 P_{Bt} + \varepsilon_t \quad (4)$$

Where P_A and P_B are non-stationary I(1) prices and β_o and β_1 are coefficients of the regression analysis. β_o accounts for the constant, β_1 denotes the price transmission elasticity and ε_t is the error term, which may be serially correlated. In a second step, a Dickey Fuller test is conducted on the estimated residuals as follows:

$$\Delta \varepsilon_t = \gamma \varepsilon_{t-1} + u_t \quad (5)$$

Where u_t is a white noise error term. When the null hypothesis of no co integration is rejected, it implies that the residuals in the above equation are stationary. However, Enders and Siklos (2001) argue that the test for cointegration and its extensions are mis-specified if adjustment is asymmetric. Subsequently, they consider an alternative specification, called the threshold autoregressive (TAR) model, such that the above equation can be written as:

$$\Delta \varepsilon_t = I_t \gamma_1 \varepsilon_{t-1} + (1 - I_t) \gamma_2 \varepsilon_{t-1} + u_t \quad (6)$$

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

This specification allows for asymmetric adjustment. If the system is convergent, then the long run equilibrium value of the sequence is given by $\varepsilon_t = \tau$. The sufficient conditions for the stationarity of ε_t are $\gamma_1 < 0$, $\gamma_2 < 0$ and $(1 + \gamma_1)(1 + \gamma_2) < 1$ (Petrucelli and Woolford, 1984). In this case if ε_{t-1} is above its long run equilibrium value, then adjustment is at the rate γ_1 and if below long run equilibrium then adjustment is at the rate γ_2 . The adjustment would be symmetric if $\gamma_1 = \gamma_2$. However, if the null hypothesis $H_0 : (\gamma_1 = \gamma_2)$ is rejected then using the TAR model we can capture signs of asymmetry. If for example, $-1 < \gamma_1 < \gamma_2 < 0$ then the negative phase of the estimated residuals will tend to be more persistent than the positive phase. In the above case, it is necessary to estimate the value of the threshold that will be equal to the

co integrating vector. A method of searching for a consistent estimate of the threshold was undertaken by using a method proposed by Chan (1993).

Enders and Siklos (2001) suggest a further alternative such that the threshold depends on the previous periods change in the estimated residuals. The Momentum Threshold Autoregressive Model (MTAR) and the heaviside Indicator in this case can be set to the Momentum-Heaviside Indicator as follows:

$$\Delta \varepsilon_t = I_t \gamma_1 \varepsilon_{t-1} + (1 - I_t) \gamma_2 \varepsilon_{t-1} + u_t \quad (7)$$

$$I_t = 1 \text{ if } \Delta \varepsilon_{t-1} \geq \tau \text{ 0 otherwise}$$

The TAR model is designed to capture asymmetrically deep movements in the deviations from the long run equilibrium, while the MTAR model is useful to capture the possibility of asymmetrically “steep” movements in the deviations. Negative deepness (i.e. $|\rho_1| < |\rho_2|$) of the residuals means that increases tend to persist but decreases tend to revert quickly towards the equilibrium (Enders and Granger, 1998). Chan (1993) proposes a search method for obtaining a consistent estimate of the threshold value. A consistent estimate of the threshold value can be attained with the following steps. First, the process involves sorting in ascending order

the threshold variable, i.e. ε_{t-1} for the TAR model or the $\Delta \varepsilon_{t-1}$ for the MTAR model. Second, the possible threshold values are estimated. If the threshold value is to be meaningful, the threshold variable must actually cross the threshold value (Enders, 2004). 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 TAR or MTAR 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 the consistent estimate of the threshold. Given these considerations, two competing models are considered namely the Consistent Threshold Autoregressive Model (C-TAR) with τ estimated and the Consistent Momentum Threshold Autoregressive Model (C-MTAR) 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 Consistent Threshold Model (CTAR) and Consistent Momentum Threshold Model (CTAR). A model with the lowest AIC and BIC should be preferred. Detecting 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 Consistent TAR or Consistent MTAR 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.

4. Results and Discussion

Unit root tests were conducted to examine the time series properties of the wholesale and retail plantain prices. Specifically, the test for the order of integration was done using Augmented Dickey Fuller test (ADF) (1979) unit root testing procedures. The results of the Augmented Dickey Fuller test in Table 1 show that the retail and wholesale plantain prices are non-stationary and integrated of the order one.

Table 1: Unit root test of plantain markets using ADF

Variable	Level	First difference	Critical values
Mankessim wholesale	-2.40	-9.57	-3.51*** -2.89** -2.59*
Mankessim retail	-1.566	-11.238	-3.51*** -2.89** -2.59*

Source: Author's construct significance at 1% (***), 5 %(**) and 10% (*)

Threshold cointegration analysis is implemented using the Threshold Auto regression models. The Consistent TAR and Consistent MTAR are estimated and the results are displayed in Table 2. In order to select an appropriate lag to address possible serial correlation in the residual series, a maximum lag of 12 is specified and tried at the beginning. However, diagnostic analyses on the residuals through AIC and BIC all reveal that a lag of two is sufficient. In estimating the threshold values for consistent TAR or MTAR, the method by Chan (1993) is followed. The lowest sum of squared errors for the consistent TAR model is 227.274 at the threshold value of -2.554. Whilst the lowest sum of squared errors for consistent MTAR is 238.592 at the threshold value of -2.00. While both the CTAR and CMTAR models have similar results (Table 2), the consistent TAR model has the lowest AIC statistic of 311.858 and BIC statistic of 323.577, and therefore, is deemed the most appropriate model. Emphasizing the results from the consistent TAR model, the F-test for the null hypothesis of no cointegration has a statistic of 6.842 and it is highly significant at the 1 % level as displayed in Table 2 and 3.

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

	Consistent Threshold Autoregressive Model (C-TAR)	Consistent Momentum Threshold Autoregressive Model (C-MTAR)
ρ_1	-0.368(-2.944) ¹	-0.383(-2.895) ¹
ρ_2	-0.751(-2.834) ¹	-0.459(-1.694) ¹
$\rho_1 = \rho_2 = 0$	6.842(0.002) ²	4.786(0.011) ²
$\rho_1 = \rho_2$	3.716(0.058) ²	0.077(0.782) ²
γ	-2.069	-2.00
SSE	227.274	238.592
AIC	311.858	315.600
BIC	323.577	327.319

Notes: ¹ Values in the parentheses are t values. ² Values in the parentheses are estimated probability values; outside parentheses are the F statistic values. Source: Author's calculation

Thus, the retail and wholesale prices of plantain in Ghana are co integrated with threshold adjustment. Furthermore, the F statistic for the null hypothesis of symmetric price transmission has a value of 4.786 and it is significant at the 10 % level as illustrated in Table 4. In effect, the adjustment process is asymmetric when the retail and wholesale prices of Ghanaian plantain adjust to achieve the long-term equilibrium. The point estimate for the price adjustment is -0.368 for positive shocks and -0.751 for negative shocks. The point estimate of ρ_1 (-0.368) for the retail and wholesale prices indicates that approximately 36.8 % of a positive deviation from the long-run equilibrium relation is eliminated within a week. Alternatively, the point estimate of ρ_2 (-0.751) indicates that 75.1 % of a negative deviation from the long-run equilibrium relation is eliminated within a week. In effect, the adjustment is almost two times faster for negative deviations from equilibrium than for positive deviations. In effect, there is substantially faster convergence for negative (below threshold) deviations from long-term equilibrium than positive (above threshold) deviations.

Table 3: Hypothesis - No co integration between the two variables using C-TAR

	Res. DF	RSS	DF	Sum of sq	F	Pr(>F)
Restricted model	75	269.88				
Unrestricted model	73	227.27	2	42.604	6.8421	0.00189**

Significance codes: 0 '***', 0.001 '**', 0.01 '*', 0.05 '.', 0.1 ' ' 1

Source: Author's calculation

With $\rho_1 = -0.368$ and $\rho_2 = -0.751$, it is implied that 63.2% of the positive deviations and 24.9% of the negative deviations persist to the next period. This means retailers and wholesalers are characterized by positive asymmetric price transmission. Retailers therefore react more quickly to shocks that squeeze their margins than to those that stretch them.

Table 4: Hypothesis - Symmetric adjustment in the long run equilibrium using C-TAR

	Res. DF	RSS	DF	Sum of sq	F	Pr(>F)
Restricted model	74	238.84				
Unrestricted model	73	227.27	1	11.569	3.716	0.05778**

Significance codes: 0 '***', 0.001 '**', 0.01 '*', 0.05 '.', 0.1 ' ' 1

Source: Author's calculation

About the estimation results of the MTAR model, Table 5 suggests that the null hypothesis of no co integration between the two variables is rejected. Table 6 suggests that the null hypothesis of symmetric adjustment in the long run relationship is not rejected in the MTAR approach but rejected in the consistent TAR approach as shown in Table 3. These empirical results suggest that differences in inferences are possible for alternative threshold modeling approaches to detecting asymmetry

Table 5: Hypothesis 1: No co integration between the two variables using C-MTAR

	Res. DF	RSS	DF	Sum of sq	F	Pr(>F)
Restricted model	75	269.88				
Unrestricted model	73	238.59	2	31.287	4.7862	0.01114*

Significance codes: 0 '***', 0.001 '**', 0.01 '*', 0.05 '.', 0.1 ' ' 1

Source: Author's calculation

Table 6: Hypothesis 2: Symmetric adjustment in the long run equilibrium using C-MTAR

	Res. DF	RSS	DF	Sum of sq	F	Pr(>F)
Restricted model	74	238.84				
Unrestricted model	73	238.59	1	0.25210	0.0771	0.782

Significance codes: 0 '***', 0.001 '**', 0.01 '*', 0.05 '.', 0.1 ' ' 1

Source: Author's calculation

The foregoing discussion points to the fact that the Ghanaian plantain markets are co integrated and asymmetric with threshold adjustments. These results are consistent with previous studies, which studied plantain markets. Mensah-Bonsu, Afrane & Kuwornu (2011) studied plantain markets in Ghana and found evidence of cointegration. Nkendar and Nzouessin (2007) finds evidence of cointegration in majority of the plantain markets studied in Cameroon. The authors furthermore finds that majority of the plantain markets are asymmetric on the basis of the asymmetric error correction model.

5. Conclusion

This study estimated the price transmission in the Ghanaian plantain market using retail and wholesale prices. Specifically, the study tested for the order of integration of the price series and analyzed asymmetric adjustment to equilibrium 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 ADF test show that the retail and wholesale prices are non-stationary and integrated of the order one. The retail and wholesale prices of plantain in Ghana are co integrated with threshold adjustment. The Enders and Silkos (2001) procedure provides support for the alternative hypothesis of asymmetric adjustment to equilibrium. The findings of this study indicate that there is a faster convergence for negative deviations from long-term equilibrium than positive deviations. The results suggest that the plantain markets are characterized by positive asymmetry. In effect, a price movement that squeezes the margins is transmitted more quickly than an equivalent that stretches the margin. On the basis of the consistent TAR approach, this study finds asymmetry. This conclusion is not supported by the Consistent Momentum Threshold Modeling approach. It is recommended that future studies consider the C-TAR approach in addition to C-MTAR approach when modeling asymmetries. In order for policy to address the problem of asymmetry in the Ghanaian plantain markets, it is imperative for further research to investigate the causes of this asymmetry. Future research may also be extended to other agricultural markets.

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