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Asymmetry in Retail-Wholesale Price Transmission for Maize: Evidence from Ghana

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Abstract: This article studies the existence of asymmetry in price transmission between retail and wholesale prices in the Ghanaian maize market. With the assistance of the Engle Granger co integration technique, the existence of a long-run relationship between the retail and the wholesale prices was established, while the application of the Granger causality test has shown that the wholesale price Granger causes the retail price whereas the reverse is not valid. The application of the Granger and Lee asymmetric Error Correction Model confirmed the existence of asymmetry in the price transmission mechanism within the maize market studied. Asymmetry in the retail-wholesale response indicates that retailers react more quickly to increasing wholesale prices than decreasing wholesale prices.

Key words: Cointegration · ECM model · Price Asymmetry

INTRODUCTION

The idea that price variables could exhibit asymmetry has a long history in agricultural economics literature. There are number of theoretical models which predict that the adjustment could be asymmetric. That is the transmission differs according to whether the prices are increasing or decreasing. For example Houck [1] developed a test for asymmetric price transmission which is based on the segmentation of price variables into only first difference increasing and decreasing phases. Many analyst followed suit developing a test for asymmetric price transmission which is based on the segmentation of prices into increasing and decreasing phases. Ward [2] extends Houck's specification by including lags of the exogenous variables. Whilst Boyd and Brorsen [3] are the first to use lags to differentiate between magnitude and speed of transmission. These different applications are considered as variants of the Houck's model and denoted by Houck's approaches. Meyer and von Cramon [4] categorize the modeling of asymmetric price transmission into pre-cointegration and cointegration approaches The pre-cointegration approaches refer to the Houck's approaches. Whilst, the cointegration approaches refers to models that incorporate the error correction mechanism. The cointegration techniques are motivated by the fact that the Houck's approaches are not consistent with cointegration between the price series involved. This is the motivation for the asymmetric error correction model first introduced by Granger and Lee [5] which allows for partial adjustment type error correction and has become the mainstay of the method of investigation for the past two decades after the seminal work of Engle and Granger [6]. The focus of the present study is on the price transmission in the Ghanaian maize market. In the spirit of Engle and Granger methodology, this study test for existence of asymmetries in the retail and wholesale price relationships in the maize market. Specifically, the long run price linkage equations among the co integrated price series are estimated while allowing for asymmetric price adjustments.

MATERIALS AND METHODS

Modeling Asymmetries: In this section alternative method of testing for asymmetric price transmission is presented with emphasis on the Houck's approaches and the Error Correction Models (ECM). The basis for using the Error Correction Model instead of Houck's model when the data is cointegrated is discussed.

Numerous studies implement some variant of an econometric technique for estimating irreversibility that was introduced by Wolfram [7] in response to work on irreversible supply reaction by Tweeten and Quance [8]. In investigating the relationship between an output price P_A and input price P_B, Tweeten and Quance [8] used an indicator variable to split the input price into two parts: one variable includes only increasing input

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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:

$$P_{A,t} = \beta_o + \beta_1^+ P_{B,t}^+ + \beta_1^- P_{B,t}^- + \varepsilon_t \quad (1)$$

Symmetric price transmission is rejected if the coefficients β_1^+ and β_1^- are significantly different from one another. On the basis of Tweeten and Quance [8], Wolffram [7] proposes a variable splitting technique that explicitly includes first difference of prices in the equation to be estimated which was later modified by Houck [1].

To allow for possible asymmetric adjustments, in the analysis of the response of price P_A to another price P_B, Houck estimated the following equation.

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

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. Numerous studies estimate a dynamic variant of the Houck's static model. Some analyst distinguish between short-run and long run-asymmetries by introducing lagged terms in $\Delta P_{B,t}^+$ and $\Delta P_{B,t}^-$ into equation (2), in which case β^+ and β^- become lag polynomials. Long-run symmetry is tested by determining whether the sums of the coefficients in these polynomials are identical. Ward [2] extended the Houck's specification by including lags. While, Brorsen [3] was the first to use lags to differentiate between magnitude and speed of transmission. Hahn [9] attempts to generalize the methods discuss so far, referring to them as the pre-cointegration methods.

Other authors Mohanty, Peterson and Kruse [10] take the sum of both sides of equation (1) to derive the following equation.

$$\sum_{t=1}^{T} \Delta P_{A,t} = \alpha_o + \alpha_1 \sum_{t=1}^{T} \Delta P_{B,t}^+ + \alpha_2 \sum_{t=1}^{T} \Delta P_{B,t}^- + \varepsilon_t \quad (3)$$

which can be rearranged as follows:

$$P_{A,t} - P_{A,0} = \alpha_o + \alpha_1 P_{B,t}^{UP} + \alpha_2 P_{B,t}^{DOWN} + \varepsilon_t \quad (4)$$

Where:

$P_{B,t}^{UP}$ is the sum of all positive changes in price B and $P_{B,t}^{DOWN}$ is the sum of all negative changes in price B. A formal test for symmetry using an F test or t -statistic is rejected when the coefficients α_1 and α_2 are unequal.

The Houck model is sometimes used without adequate regards to time series properties of the data. Von Cramon-Taubadel [11] has demonstrated that the model is fundamentally incompatible with cointegration between two price series. In order to demonstrate this point, von Cramon-Taubadel [11] considers two I (1) processes, P_A and P_B and the model below as previously defined in equation 1 and 2:

$$\sum \Delta P_{A,t} = \beta_o + \beta_1^+ \sum \Delta P_{B,t}^+ + \beta_1^- \sum \Delta P_{B,t}^- + \varepsilon_t \quad (5)$$

which can be reparametrized using the identity:

$$\sum \Delta P_{B,t}^+ + \sum \Delta P_{B,t}^- \equiv P_{B,t} - P_{B,0} \quad (6)$$

to yield:

$$P_{A,t} - P_{A,0} = \beta_o + \beta_1^+ \sum \Delta P_{B,t}^+ + \beta_1^- (P_{B,t} - P_{B,0} - \sum \Delta P_{B,t}^+) + \varepsilon_t \quad (7)$$

or:

$$P_{A,t} = (P_{A,0} + \beta_o + \beta_1^- P_{B,0}) + \beta_1^- P_{B,t} + (\beta_1^+ - \beta_1^-) \sum \Delta P_{B,t}^+ + \varepsilon_t \quad (8)$$

This reparametrization of equation (5) was proposed by Ward [2] who tests whether the coefficient $(\beta_1^+ - \beta_1^-)$ differs from 0 in order to test whether price transmission is asymmetric.

Von Cramon-Taubadel [11] asserts that the estimation of equation 8 can lead to four basic results depending on the significance of the term $(\beta_1^+ - \beta_1^-)$ and the stationarity of the error term ε_t :

- Case 1: $\beta_1^+ - \beta_1^- \neq 0$ (asymmetry) and ε_t is I(0)
- Case 2: $\beta_1^+ - \beta_1^- = 0$ (symmetry) and ε_t is I(1)
- Case 3: $\beta_1^+ - \beta_1^- \neq 0$ (asymmetry) and ε_t is I(1)
- Case 4: $\beta_1^+ - \beta_1^- = 0$ (symmetry) and ε_t is I(0)

Case 1 implies that P_A, P_B and $\sum \Delta P_{B,t}^+$ are cointegrated, which precludes cointegration between P_A and P_B alone. Case 2 and 3 are spurious regressions Granger and Newbold [12], while case 4 implies that P_A and P_B are cointegrated. Notably, if the Houck method points to asymmetry, then either the results reflect spurious regression (Case 3), or the prices in question are not cointegrated (Case 1).

The Granger and Lee asymmetric error correction model (ECM) approach is motivated by the fact that all the variants of the aforementioned Houck approach discussed above are not consistent with cointegration between the price series. If the prices P_A and P_B are cointegrated, then an error correction representation exists [8]. Granger and Lee [5] propose a modification to the error correction representation that makes it possible to test for asymmetric price transmission between cointegrated variables. This involves a Wolffram-type segmentation of the error correction term into positive and negative components. They suggested that in the case of cointegration between the price series, an error correction model extended by the incorporation of asymmetric adjustment terms provides a more appropriate specification for testing for asymmetric price transmission. In effect, when equation (9) is estimated and the test proves that it is not a spurious regression, then P_A and P_B is referred to as being cointegrated and equation (9) can be considered as an estimate of the long-run relationship between them.

$$P_{At} = \beta_o + \beta_1 P_{Bt} + \varepsilon_t \qquad (9)$$

The Error Correction Model (ECM) then relates changes in P_A to changes P_B as well as the so called Error Correction Term (ECT), the lagged residuals derived from estimation of equation (9). The ECT measures the deviation from the long-run equilibrium between P_A and P_B and including it in the ECM allows P_A not only to respond to changes in P_B but also to correct any deviations from the long-run equilibrium that may be left over from previous periods. Splitting the ECT into positive and negative component (i.e. positive and negative deviation from the long-run equilibrium-ECT^+ and ECT^-) makes it possible to test for asymmetric price transmission.

Test for Stationarity and Cointegration: The Augmented Dickey-Fuller (ADF) and Philip Peron (PP) test were used to check on the stationarity of the retail and wholesale price series. The application of the Augumented Dickey Fuller-ADF method Dickey and Fuller [13] and Philip Peron (PP) method [14] confirmed that the time series of the variables under consideration are I (1) as detailed in discussion of results.

The two step residual-based test by Engle and Granger [6] was used to test for cointegration when the price series were found to be integrated of the same order. The first step is the co integrating regression of I (1) price series between the retail as dependent against the wholesale as independent.

$$P_r = \beta_0 + \beta_1 P_w + \varepsilon_t \qquad (10)$$

Where:

P_r = the retail price
P_w = the wholesale price, ε_t = error term

The second step involves testing whether the residuals from the cointegrating regression are non stationary by using ADF test and PP test.

$$\varepsilon_t = P_r - \beta_0 - \beta_1 P_w + u_t \qquad (11)$$

Where u_t is the error term.

RESULTS

Weekly retail and whole sale prices for maize from January 1994 to December 2003 from Kumasi in the Ashanti Region of Ghana were used in this analysis. The weekly data for all prices are cedi per 100 kg 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 agriculture in Ghana.

Before estimating the asymmetric price transmission equation, it is important to test for the direction of causality so as to ensure that the asymmetric price transmission model is not misspecified. To solve the issue of causal direction, the Granger causality test is carried out to determine the direction of causality between the retail and wholesale maize prices as illustrated in Table 1.

The hypothesis that wholesale prices Granger cause (proceed) retail prices and vice versa must be tested. Empirically, this hypothesis rests on a regression of retail price as a function of lagged retail and wholesale prices as well as a regression of wholesale price as a function of lagged wholesale and retail prices. If wholesale prices Granger cause retail prices, then in the case where retail price is the dependent variable, the F-test corresponding to all coefficients associated with lagged wholesale prices should be statistically significant. If retail prices fail to Granger cause wholesale prices, then, in the case where wholesale price is the dependent variable, the F-test corresponding to all coefficients associated with lagged retail prices should not be statistically significant. According to the results of our Granger causality test in Table 1, it can be concluded that the wholesale prices Granger causes the retail prices.

With the results of Augmented Dickey-Fuller (ADF) and Philip Peron (PP) test, it was confirmed that the time series of the variables under consideration are I (1) as illustrated in Tables 2 and 3.

The cointegrating results for the first step in the Engle Granger two stage procedure is shown in Table 4 with it resultant unit root test of the residuals in the lower part of Table 4. With the results of the Engle Granger cointegration technique [6], it was confirmed that the retail and wholesale prices are cointegrated.

Table 1: Granger causality test

Market	Effect	Hypothesized cause	F Statistic	p-value
Kumasi	Retail Price	Wholesale Price	3.659	0.03
	Wholesale Price	Retail Price	0.462	0.63

Table 2: Results of unit root test in levels of maize prices in Kumasi market

Market/Test	None	P value	Intercept	P-value	Intercept and Trend	P-value
Kumasi Wholesale Price						
ADF test	-1.3	0.1709	-4.4	0.0004	-4.4	0.0021
PP test	-1.3	0.1923	-4.4	0.0003	-4.5	0.0016
Kumasi Retail Price						
ADF test	-1.3	0.1839	-4.4	0.0043	-4.3	0.0021
PP test	-1.3	0.2269	-4.4	0.0004	-4.4	0.0025

Table 3: Results of unit root test in differences of maize prices in Kumasi market

Market /Test	None	P value	Intercept	P-value	Intercept and Trend	P-value
Kumasi Wholesale Price						
ADF test	-24.1	0.000	-24.0	0.000	-24.0	0.000
PP test	-24.1	0.000	-24.0	0.000	-23.8	0.000
Kumasi Retail Price						
ADF test	-24.2	0.000	-24.2	0.000	-24.2	0.000
PP test	-24.5	0.000	-24.5	0.000	-24.5	0.000

Table 4: Engle Granger Test for maize

Results of 1st Stage test for Maize				
Market Pair Name	Constant	Coefficient	P-value for	
Kumasi Retail -Wholesale	63218.68	0.905705	0.0000	
Results of 2nd Stage test for Residuals				
Mkt Name	ADF Test	P-value	PP test	P- value
Kumasi	-6.0515	0.0000	-5.7440	0.0000

Table 5: Testing for asymmetry using an analysis of variance

Model	Res. DF	RSS	DF	Sum of Sq	F	Pr(>F)
Symmetric	495	1.0497e+11				
Asymmetric	494	1.0413e+11	1	8.4217e+08	3.9953	0.04618*

Significance Codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Commonly used information criteria are such as the Akaike Information Criterion, Akaike [15] and the Bayesian Information Criterion, Schwarz [16] are applied to determine the number of lags to be included in all models. This study demonstrate that there are significant asymmetries in the adjustment of retail prices in response to wholesale prices when the price transmission process is analyzed using the Granger and Lee asymmetric error correction model. The result of the test for asymmetry is presented in the analysis of variance Table below in which the symmetric model specified in equation 12 below is compared with the asymmetric model specified in equation 13.

$$\Delta P_{A,t} = \beta_o + \beta_1 \Delta P_{B,t} + \beta_2 \, ECT_{t-1} + \beta_3 \Delta P_{B,t-1} + \beta_4 \Delta P_{A,t-1} + \varepsilon \quad (12)$$

When this is compared to the full or asymmetric model as follows:

$$\Delta P_{A,t} = \beta_o + \beta_1 \Delta P_{B,t} + \beta_2^{+} ECT^{+}_{t-1} + \beta_2^{-} ECT^{-}_{t-1} + \beta_3 \Delta P_{B,t-1} + \beta_4 \Delta P_{A,t-1} + \varepsilon \quad (13)$$

Essentially, it is hypothesize that the effect of increasing wholesale prices and decreasing wholesale prices are the same on the retail price. In this case the null or symmetric model takes the form of equation 12. Thus the formal test of the asymmetry hypothesis using equation (13) is: $H_0 : \beta_2^+ = \beta_2^-$. In effect asymmetric behavior is assessed by an F-test. It is hypothesized that the effect of increase and decrease in wholesale price on the retail price was the same. The p-value of 0.04618 indicates that the null can be rejected here, meaning that there is significant evidence that positive and negative components of the Error Correction Term needs to be treated separately in the context of this particular model. In effect null hypothesis of symmetric transmission is rejected at 5%. What this asymmetric results suggest is that retailers react more quickly to increasing wholesale prices than to decreasing wholesale prices.

CONCLUSIONS

This study analyzed the behavior of tests of asymmetric price transmission according to the Granger and Lee asymmetric ECM approach for retail and wholesale prices in the Ghanaian maize market. Empirical results suggested that the retail-wholesale price transmission process for maize in Kumasi clearly was asymmetric. The economic interpretation is that the adjustment of retail price to the wholesale price is faster when there is an increase in the wholesale price than when there is a decrease. The asymmetric price transmission observed in this study may be due to the nature of maize as a necessary good (of low demand elasticity in retail markets), it may also be explained by its level of competitiveness. What will be more interesting is to see whether this asymmetry is present in other agricultural markets in Ghana.

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