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THRESHOLD COINTEGRATION AND PRICE TRANSMISSION IN MAJOR BLACK TEA MARKETS AFTER LIBERALIZATION

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Abstract

The study sought to determine the degree of asymmetric price transmission in three major black tea exporting countries; Kenya, Sri Lanka and India. The study used monthly data covering the period from January 1997 to December 2010 obtained from the Pink Sheet of World Bank commodity data. The threshold autoregressive (TAR) and momentum autoregressive (MTAR) cointegration methods were employed. The results indicate that the three price series under investigation had a long run relationship. Both TAR and MTAR models suggested cointegration with no price asymmetry. The study concluded that; the three price series move together in the long run; positive shocks and negative shocks were corrected at the same speed.

Keywords: Asymmetric Price Transmission, Cointegration, Threshold Autoregressive (TAR), Momentum Autoregressive (MTAR)

INTRODUCTION

Research has shown that commodity price fluctuations in the era of economic globalization and increased liberalization of commodity markets have seriously affected the weaker economies of the developing world (Dehn, 2000; Byerlee *et al.,* 2006; Ivanic and Martin, 2008). The adoption of economic reforms meant that participation of governments, through parastatals in markets would be minimal. There was hope that the benefit of higher export prices would be transmitted to domestic markets (World Bank, 2005).

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The liberalization of economies implies that governments are not only worried about random price variations at domestic level but also at global level as well since price variations at the global level are usually transmitted to the domestic markets. International price transmission has therefore received considerable attention by researchers (Listorti, 2009). The impact of the liberalization on spatial price transmission is still a matter of debate among academics and policy makers (FAO, 2005; World Bank, 2005).

It is widely realized that domestic markets in many low income countries are not fully integrated because of high transportation costs, poor infrastructure and communication services (Larson, 1999). In such a case, international price changes will not be fully transmitted to domestic markets, indicating that price signals will not be fully transmitted (FAO, 2005).

The importance of price signals in production planning cannot be overstated. Price signals are important in guiding resource allocation. Wrong signals lead to misallocation of resources and thus, inefficiency. These adverse effects are more pronounced in less developed countries that rely heavily on export earnings. Furthermore, random variations in export prices also have critical concerns for the balance of payments and exchange rates. The extent of adjustment and the speed of transmission of price shocks from global to domestic prices are critical as it mirrors the actions of participants along the marketing channel (Espoti and Listorti, 2013).

Problem Statement

In 1980's and 1990's several governments of Sub-Sahara Africa (SSA) adopted economic reforms under the wider context of SAPs following suggestions by World Bank (WB), International Monetary Fund (IMF) and governments of developed countries in line with the Uruguay Round of 1986-1994. Among others, the recommendations included were removal of price controls, trade liberalization and privatization of state-owned enterprises. It was purported that adoption of economic reforms would lead to improved producer prices and enhance trade efficiency (White and Levy, 2001).

Trade liberalization required gradual abolition of state interventions in agricultural markets. Governments were required to open up to international trade by eliminating trade barriers and tariffs in order to improve economic growth and welfare in developing countries (Amikuzuno, 2009). It was postulated that trade liberalization would lead to improved commodity market performance (Mofya-Mukuka and Abdulai, 2013), integrate markets and offer farmers higher prices and incentives (Amikuzuno, 2009) and the benefit of higher export prices would be transmitted to domestic markets (WB, 2005). Furthermore, adoption of market reforms would lead to improved efficiency by increasing productivity of human talent and physical assets

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(Akiyama *et al.*, 2003). Increased efficiency is crucial for countries that rely on agriculture (Ankamah-Yeboah, 2012).

Theoretically, in a free market regime, global demand or supply shocks would have the same impact on domestic and international prices. Free trade would ensure markets are integrated and price transmission would be complete (FAO, 2005). In such situations, markets would function efficiently (Akiyama *et al.*, 2003) and all market participants would have complete and accurate information on which they will base their production and consumption decisions (FAO, 2005).

Economic theory postulates that developing countries can enhance markets for their produce through trade liberalization. Trade liberalization was thus recommended as an effective tool for improving price transmission between markets for agricultural commodities and inputs at national and international levels (Stiglitz, 2002; WTO 2003). However, the actual net benefit from trade liberalization is subject to the ability of domestic markets to transmit price changes rapidly and on the competitiveness of domestic commodities (Amikuzuno, 2010). Kilima (2006) also notes that for export crop producers in particular, the success of such market reforms depends partly on the strength of the transmission of price signals between international markets and domestic producer prices.

Though understanding the extent and speed of price transmission from international to domestic markets is imperative in assessing how producers and consumers in local markets are likely to respond to changes in external markets (Kilima, 2006), empirical evidence is limited in the international black tea markets. FAO (2005) recommends studies to analyze the extent to which price signals are transmitted in the international tea markets.

Research Objective

The objective was to determine the degree of asymmetric price transmission in major international black tea markets over the post liberalization period. The degree and speed of adjustment at which changes in prices in one market are transmitted to the other markets and the asymmetry of price adjustment to movements in price in another market is important. Asymmetric response of one price to another means that upward and downward movements in the price in one market are symmetrically or asymmetrically transmitted to the other. This may be a result of market characteristics and the distortions to which the markets are subjected to. In the short run, asymmetric price transmission may also occur due to inventory holding and the subsequent release of stocks post the realization of high international price expectations; or to high fixed costs and excess capacity in the production chain (FAO, 2005).

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METHODOLOGY

Data Types and Sources

Three series comprising monthly prices for three major tea exporting countries; Sri Lanka, India and Kenya were used. The prices are measured in common currency, that is, nominal US dollar per kilogram of black tea. The price data were obtained from the *Pink Sheet* of World Bank commodity data. The data covered the period from January 1997 to December 2010 representing the post liberalization era. For each price series, there were 168 observations.

Unit Root Tests

In line with time series analysis, the first step was to test for stationarity. Mohammad and Zulkorian (2010) opine that the choice of the most appropriate unit root test is difficult. To counter this difficulty, Enders (2004) suggests that one should use both conventional unit root tests; ADF and PP tests. Thus, two unit roots tests; Augmented Dickey Fuller (ADF) and Philips-Perron (PP) were used to test for stationarity in each of the three price series.

Two threshold cointegration models were adopted; threshold autoregressive model (TAR) and momentum autoregressive model (MTAR).The TAR model captures asymmetrically 'deep' movements in the series, while the MTAR model captures asymmetrically sharp or 'steep' movements (Uchezuba, 2010).

Threshold Autoregressive Model

Threshold autoregressive model (TAR) attributed to Tong (1978) postulates that a price shock has to reach a certain critical level before an adjustment can occur. The model accommodates both nonlinearities as well asymmetries of price adjustment following a shock. The first step involves obtaining residuals from the following relationship;

$$P_{1t} = \alpha + \beta P_{2t} + \gamma P_{3t} + \mu_t \qquad (1)$$

Where P_{1t} is the price in one market at time t; P_{2t} is the price of the same commodity in another market in time $t. P_{1t}$, P_{2t} and P_{3t} should be integrated of order one (1[1]). α, β and γ are parameters and μ_t is the disturbance term which may suffer from serial correlation.

In the second step, Engle and Granger propose an OLS estimate of ρ in the following regression equation;

$$\Delta\mu_t = \rho\mu_{t-1} + \varepsilon_t \qquad (2)$$

Where the estimated regression residuals in equation 3.18 are used to estimate equation 2. To capture asymmetry, the deviations from the long run equilibrium in equation 2 3.19 are allowed to follow a TAR process, that is, threshold autoregression is applied to capture asymmetric movements of the residuals. Following Enders and Granger (1998) and Enders and Siklos (2001), a two- regime TAR model can be modeled using the residuals (μ_t) from equation 1 giving;

$$\Delta\mu_t = I_t\rho_1\mu_{t-1} + (1 - I_t)\rho_2\mu_{t-1} + \varepsilon_t \quad (3)$$

Where I_t is the Heaviside indicator function such that;

$$I_t = \begin{cases} 1 \ if \mu_{t-1} \geq \pi \\ 0 \ if \mu_{t-1} < \pi \end{cases} \quad (4)$$

Where π denotes the threshold value. Enders and Granger (1998) set the equilibrium point at $\mu_t = 0$. This infers that a zero threshold value. The values of ρ_1 and ρ_2 capture asymmetric adjustment, that is, they are the speed of adjustment coefficients. When μ_{t-1} is above the long run equilibrium value, the adjustment equals the value $\rho_1\mu_{t-1}$ and when it is below the long run equilibrium value, the adjustment equals $\rho_2\mu_{t-1}$. If $\rho_1 > \rho_2 > -1$, the positive phase of μ_t will be more persistent than the negative phase on the assumption of equality of positive and negative shocks. A symmetric adjustment (linear cointegration) occurs when $\rho_1 = \rho_2$ while asymmetry occurs when $\rho_1 \neq \rho_2$.

It should be noted that although some researchers set a zero threshold value, there are several techniques that can be used to estimate a consistent threshold for example Tsay (1998). Enders (2004) points out that a non-zero threshold accounts for strategic behaviour and adjustment costs that would rarely be detected with small changes. The study further argues that a TAR model with a zero threshold value does not significantly display the degree of asymmetry hence indicating that there is a possibility that the threshold value may not be zero.

The error term, ε_t in equation 3 should be white noise assuming zero mean, constant variance and no serial autocorrelation. This implies that equation 3 does not fully capture the convergence of $\Delta\mu_t$ towards long run equilibrium. A higher order residual process is estimated when residuals are found to be serially correlated (Enders and Granger, 1998; Enders and Siklos 2001). The lagged dependent variable values are added in order to ensure that the residuals are white noise. The lag lengths are selected using AIC, SBIC and HQIC. Introducing lags to equation3 yields equation 5 below:

$$\Delta\mu_t = I_t\rho_1\mu_{t-1} + (1 - I_t)\rho_2\mu_{t-1} + \sum_{i=1}^{p}\delta_i\Delta\mu_{t-1} + \varepsilon_t \quad (5)$$

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The null hypothesis tested in the threshold model: $\rho_1 = \rho_2 = 0$ that is, there is no cointegration. The test statistic was compared to Φ critical values provided by Enders and Siklos (2001) and Wane *et al.* (2004). The Φ critical values are the F test modified by Enders and Siklos (2001).The point estimates of ρ_1 and ρ_2 imply convergence when ($\rho_1 < 0, \rho_2 < 0$). Alternatively the maximum t-statistic can be used to test the null hypothesis, $\rho_1 = \rho_2 = 0$. If the null hypothesis of no cointegration is rejected, then a standard F-test of symmetric adjustment can be performed by testing if $\rho_1 = \rho_2$.

If both null hypotheses; $\rho_1 = \rho_2 = 0$ and $\rho_1 = \rho_2$ are rejected, it implies threshold cointegration and asymmetric adjustment (meaning price pairs exhibit nonlinear adjustment). The distribution of the test of the null of no cointegration is nonstandard and depends on the number of regressors included in equation 5 and the deterministic components (Ankamah-Yeboah, 2012).

To find a non-zero threshold value, one can employ Chan's (1993) to identify appropriate threshold value. The approach allows a grid search over potential thresholds that minimize the sum of squared errors from the fitted model to yield a consistent estimate of the threshold value. To do this, the estimated residuals are sorted in ascending order, i.e.,$\mu_1 < \mu_2 < \cdots < \mu_T$ where T denotes the number of valid observations. Following Mofya-Mukuka (2013) and Ankamah-Yeboah (2012), the largest and smallest 15 percent of the values are eliminated and each of the middle 70 percent of the series is considered as potential threshold. For each of the potential thresholds, the models were estimated using equations 3 and 4 and this is termed Consistent Threshold Autoregressive Models. Diagnostic tests were performed on the model with Ljung-Box statistics to ensure the residuals were white noise. $|\rho_1| < |\rho_2|$ implies positive asymmetry exists while $|\rho_1| > |\rho_2|$ implies negative asymmetry exists.

If the price series are confirmed to be cointegrated, an error correction term can be augmented to equation 5 to capture the short-run dynamics (Engle and Granger, 1987).The threshold ECM can be presented as follows;

$$\Delta P_{1t} = \varphi_0 + \sum_{h=1}^{r} \varphi_h \Delta P_{1t-h} + \sum_{h=0}^{m} \propto_h \Delta P_{2t-h} + \sum_{h=1}^{n} \gamma_h \Delta P_{3t-h} + \lambda_1 ECM_{t-1}^{+} + \lambda_2 ECM_{t-1}^{-} + \omega_{1t} \quad (6)$$

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Where ω_t is the innovation with zero mean and constant variance; $\varphi_0, \varphi_h, \alpha_h, \gamma_h, \lambda_1$ and $\lambda_2$are parameters to be estimated. α_h and γ_h are the short run parameters for the independent variables while λ_j are error correction coefficients which denote the speed of adjustment.

If there is a positive deviation from long-run equilibrium depending on the Heaviside Indicator (Equation 4), the speed of adjustment was given by λ_1 while for negative deviation from long run equilibrium, the speed of adjustment was given by λ_2.

Momentum Autoregressive Model (MTAR)

According to Enders and Granger (1998) and Enders and Siklos (2001), when the adjustment path proves to be more persistent in one direction than in another, the resulting model takes the form of a momentum-threshold autoregressive (MTAR) process. The MTAR model allows the decay to depend on $\Delta\mu_{t-1}$. MTAR model is presented as:

$$\Delta\mu_t = \rho_1 I_t \mu_{t-1} + \rho_2(1 - I_t)\mu_{t-1} + \varepsilon_t \quad (7)$$

Where I_t is the Heaviside indicator function such that;

$$I_t = \begin{cases} 1 \ if \Delta\mu_{t-1} \geq \pi \\ 0 \ if \Delta\mu_{t-1} < \pi \end{cases} \quad (8)$$

Based on equation 7, the null hypothesis tested in the MTAR model: $\rho_1 = \rho_2 = 0$ that is, there is no cointegration. The test statistic is compared to critical values provided by Enders and Siklos (2001) and Wane *et al.* (2004) when the point estimates of $\rho_1$and $\rho_2$imply convergence ($\rho_1 < 0, \rho_2 < 0$), alternatively the maximum t-statisticcan be used. Following a rejection of the null hypothesis of no cointegration, a standard F-test of symmetric adjustment can be performed by testing if $\rho_1 = \rho_2$.

If both null hypotheses; $\rho_1 = \rho_2 = 0$ and $\rho_1 = \rho_2$ are rejected, it implies threshold cointegration and asymmetric adjustment (meaning price pairs exhibit nonlinear adjustment) can adopted to identify appropriate threshold value as explained under the TAR model. The only difference is that in the MTAR model, the differenced residuals $\Delta\mu_i$ are used unlike in TAR where the residuals μ_i are used. $|\rho_1| < |\rho_2|$ implies positive asymmetry exists while $|\rho_1| > |\rho_2|$ implies negative asymmetry exists. If the price series are confirmed to be cointegrated, an ECT can be augmented to equation 7 to capture the short-run dynamics (Engle and Granger, 1987).

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The MTAR-ECM is presented as follows;

$$\Delta P_{1t} = \varphi_0 + \sum_{h=1}^{r} \varphi_h \Delta P_{1t-h} + \sum_{h=0}^{m} \propto_h \Delta P_{2t-h} + \sum_{h=1}^{n} \gamma_h \Delta P_{3t-h} + \lambda_1 ECM_{t-1}^{+} + \lambda_2 ECM_{t-1}^{-} + \omega_{1t} \quad (9)$$

Where ω_t is the innovation with zero mean and constant variance, $\varphi_0, \varphi_h, \propto_h, \gamma_h, \lambda_1$ and λ_2 are parameters to be estimated. $\propto_h$ and γ_h are the short run parameters for the independent variables while λ_j are error correction coefficients which denote the speed of adjustment.

If there is a positive deviation from long-run equilibrium depending on the Heaviside Indicator (Equation 8), the speed of adjustment is given by λ_1 while for a negative deviation from long run equilibrium, the speed of adjustment will be given by λ_2. Cointegration infers the existence of causality between variables but suggests nothing about the direction of causality. The VECM model is thus a remedy for determining the direction of causality.

Why use both TAR and MTAR models? The two models capture different types of asymmetry. Sichel (1993) differentiates two types of asymmetry; 'deepness' and 'steepness'. The deepness of symmetry refers to the magnitude of the distance from equilibrium of positive and negative deviations and is captured by TAR model. On the other hand, the steepness of asymmetry captures the speed of adjustment (of positive and negative shocks) following a deviation from long run equilibrium and is captured by MTAR model. This implies that the interpretations of the two models differ.

If asymmetric cointegration is confirmed following rejection of $H_0: \rho_1 = \rho_2 = 0$ and $H_0: \rho_1 = \rho_2$ in the TAR model it is concluded that there is long run relationship and size of disequilibrium following positive or negative deviations differ. In the MTAR model, if asymmetric cointegration is confirmed following rejection of $H_0: \rho_1 = \rho_2 = 0$ and $H_0: \rho_1 = \rho_2$, it is concluded that there is a long run relationship and the rate of adjustment to a positive shock differs from the rate of adjustment to a negative shock. Model selection information criteria such as AIC, SBIC and HQIC are used to select the best adjustment model among TAR and MTAR.

RESULTS

The results showed that all variables were nonstationary at levels but were all stationary at first difference implying that they have unit root or are I (1). The lack of stationarity at levels laid the basis for cointegration tests.

TAR Cointegration and Price Asymmetry

The results of the TAR model are shown in table 1. The results indicate that the estimated value of $\rho_1, -0.3693$, was significant at 1% level. The negative sign shows that prices converge to equilibrium following a positive shock. The estimated value of $\rho_2, -0.0701$ had the expected negative sign though it was not significant.

The point estimates of $\rho_1 = -0.3693$ and $\rho_2 = -0.0701$ indicates that, approximately 37 percent of positive deviations (deviations above $\pi = 0)$ and 7 percent of negative deviations (deviation below $\pi = 0$) from the equilibrium were eliminated within one month. If there was a positive shock, 37 percent of the discrepancy would be eliminated and 7 percent of the discrepancy would be eliminated if the shock was negative. This implies 63 percent and 93 percent of positive and negative discrepancies from the equilibrium would still persist in the following months.

The calculated F value was compared to the critical ϕ values in the table provided by Enders and Siklos (2001) and Wane *et al*. (2004). The table indicates that the first null hypothesis $\rho_1 = \rho_2 = 0$ that tests for cointegration was rejected in favour of the alternative since the estimated value of 13.60 was greater than the tabulated ϕ statistic (a non-standard F test) critical values of 10.71 and 8.23 at 1% and 5% significance levels respectively. The rejection of the null hypothesis leads to the conclusion that ρ_1 and ρ_2 are significantly different from zero and thus, cointegration exists among the prices under study.

Having rejected the first null hypothesis, the study proceeded to test the second null hypothesis $\rho_1 = \rho_2$ for price asymmetry using the standard F test. The results indicate that the null hypothesis could not be rejected at 1% thus showing no evidence of asymmetry in the size (magnitude) of positive and negative deviations. Thus, disequilibrium following positive shocks did not differ from the disequilibrium following negative shocks. Both positive and negative deviations are corrected back to equilibrium.

This implies that black tea markets respond to both to positive shocks and negative shocks, that is, markets respond to shocks that increase profit margins as well as shocks that decrease margins. Thus, confirming that there is no asymmetry in the magnitude of the disequilibrium from positive and negative shocks in international black tea markets under the TAR model.

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Table 1: TAR Cointegration and Price Asymmetry Test Results

		F(df, n)	p value	Φ Critical Values 1%	5%
Threshold value	0.0000				
ρ_1	-0.3693*** (0.0853)		0.0000		
ρ_2	-0.0701 (0.1006)		0.4870		
$\Delta\mu_{t-1}$	0.1844** (0.0773)		0.018		
H_{01}: $\rho_1 = \rho_2 = 0$ (Φ statistic)	13.60***	F(2,162)		10.71	8.23
H_{02}: $\rho_1 = \rho_2$ (F statistic)	3.59	F(1,162)	0.0600		

*Notes: Numbers in brackets are the standard errors. *** and ** represent statistical significance at 1% and 5%. Critical values of ϕ were obtained from Enders and Siklos (2001) and Wane et al, (2004). The optimal lag length of 1 was selected using AIC and SBIC.*

TAR Short Run Dynamics

After establishing that the price series were cointegrated, an error correction model (ECM) was estimated to evaluate the nature of convergence given TAR specification of the error term. The results are shown in table 2.

Table 2: TAR ECM Results

Dependent Variable	Independent Variable	Coefficient	Standard Error	T	P>$\lvert t \rvert$
$\Delta\ Kenya$	ΔECT^{+}_{t-1}	-0.350***	0.111	-3.15	0.002
	ΔECT^{-}_{t-1}	0.036	0.118	-0.30	0.762
	$\Delta Kenya_{t-1}$	0.127	0.113	1.13	0.261
	$\Delta\ Sri\ Lanka_t$	0.371***	0.095	3.92	0.000
	$\Delta\ Sri\ Lanka_{t-1}$	-0.052	0.114	-0.46	0.648
	$\Delta\ India_t$	0.010	0.038	0.26	0.799
	$\Delta\ India_{t-1}$	-0.011	0.043	-0.26	0.793
	Constant	0.032	0.022	1.53	0.129

*Notes: *** and ** represent statistical significance at 1% and 5% respectively.*
The optimal lag length of 1 was selected using AIC and SBIC.

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AIC and BIC criteria were used to select appropriate lag length of the dependent variable to ensure that the residuals were white noise. The criteria showed that ECM with one lag was the most appropriate. Student's t-statistics were used to test for significance of each coefficient.

The coefficient of the first error correction term (ECT^{+}_{t-1}) was -0.350 with t-statistic of -3.15. The coefficient had the expected negative sign and was significant at 1 percent implying that there is evidence of convergence towards long run equilibrium when prices are above equilibrium. This means that if prices are above equilibrium, current prices in the markets adjust (reduce) towards equilibrium prices by 35 percent compared to previous tea prices.

The coefficient of the second error correction term (ECT^{-}_{t-1}) was -0.036 with t-statistic of -0.30. Even though the coefficient had the expected negative sign, it was insignificant at 5 percent. Therefore, there is no evidence to suggest convergence in the markets when prices are below equilibrium prices in the short run.

MTAR Cointegration and Price Asymmetry

MTAR model measures whether positive and negative shocks exhibit different speeds of adjustment towards long run equilibrium. It proceeded in two steps. In the first step, test for cointegration was carried out while in the second step, a test for price asymmetry was done. Table 3 shows the results of MTAR cointegration and price asymmetry results.

Table 3: MTAR Cointegration and Price Asymmetry Test Results

		F(df, n)	p value	Φ Critical Values	
				1%	5%
Threshold value	0.0000				
ρ_1	-0.2370*** (0.0732)		0.001		
ρ_2	-0.2366*** (0.0657)		0.000		
$\Delta\mu_{t-1}$	0.1697 (0.0797)		0.034		
H_{01}: $\rho_1 = \rho_2 = 0$ (Φ statistic)	11.55***	F(2,162)		11.11	8.62
H_{02}: $\rho_1 = \rho_2$ (F statistic)	0.0000	F(1,162)	0.9971		

*Notes: Numbers in brackets are the standard errors. *** and ** represent statistical significance at 1% and 5% respectively. Critical values of ϕ were obtained from Enders and Siklos (2001) and Wane et al, (2004). The optimal lag length of 1 was selected using AIC and SBIC.*

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The results indicate that the point estimates of $\rho_1 = -0.237$ and $\rho_2 = -0.2366$. It implies that if there is a shock, 23.7 percent of positive deviations and 23.66 percent of negative deviations would be eliminated within a month. It therefore means that 76.3 percent of positive deviations and 76.34 percent of the negative deviations would persist in the following months. Both point estimates had negative values and both were significant implying that the markets converge to equilibrium following both positive and negative shocks.

In the first stage, the table shows that the study rejected the null hypothesis, $\rho_1 = \rho_2 = 0$ since the computed value, 11.55 was greater than the Φ critical values of 11.11 and 8.62 at 1% and 5% levels of significance respectively. Thus, it was concluded that the price series were cointegrated, that is, there existed a long run relationship among the three price series.

In the second stage, the study failed to reject the null hypothesis of symmetric cointegration, $\rho_1 = \rho_2$ since the calculated value 0.000 was lower than the critical value under the F test. The study failed to reject the null hypothesis implying that ρ_1 and ρ_2 are not significantly different from each other.

The study concluded that there was symmetry in the speed of adjustment of both positive and negative shocks in the markets. This means that positive and negative discrepancies tended to revert to long run equilibrium at the same speed. The study concluded that there was symmetry in the speed of adjustment for both positive and negative shocks according to the MTAR model.

MTAR Short Run Dynamics

The existence of long run relationship among the three price series justified the estimation of an ECM to evaluate the short run dynamics under the MTAR model. The results are shown in table 4.

Table 4: MTAR ECM Results

Dependent Variable	Independent Variable	Coefficient	Standard Error	t	P>$\lvert t \rvert$
$\Delta\ Kenya$	ΔECT^{+}_{t-1}	-0.241**	0.095	-2.54	0.012
	ΔECT^{-}_{t-1}	-0.186***	0.062	-2.98	0.003
	$\Delta Kenya_{t-1}$	0.122	0.118	1.04	0.302
	$\Delta\ Sri\ Lanka_{t}$	0.375	0.097	3.86	0.000
	$\Delta\ Sri\ Lanka_{t-1}$	-0.055	0.115	-0.48	0.632
	$\Delta\ India_{t}$	0.009	0.373	0.23	0.815

Table 4…

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$\Delta\ India_{t-1}$	-0.007	0.042	-0.16	0.876
Constant	0.004	0.011	0.37	0.715

*Notes: *** and ** represent statistical significance at 1% and 5% respectively.*

The optimal lag length of 1 was selected using AIC and SBIC.

Lag selection was done using AIC and BIC criteria. The criteria showed that ECM with one lag was the most appropriate. Student's t-statistics were used to test for significance of the coefficients.

The first error correction term ($ECT*I_t$) had a coefficient of -0.241 with t-statistic value of -2.54. The coefficient had the expected negative sign and was significant at 5 percent implying that there is evidence of convergence towards long run equilibrium when prices are above equilibrium. This means that if prices are above equilibrium, current prices in the markets adjust (reduce) towards equilibrium prices by 24.10 percent compared to previous tea prices.

The second error correction term ($ECT * (I - I_t)$) had a coefficient of -0.186 with t-statistic of -2.98. The coefficient had the expected negative sign and was significant at one percent. Therefore, there was evidence to suggest convergence in the markets when prices are below equilibrium prices. The results indicate that following a negative deviation from equilibrium, 18.6 per cent of the deviations are corrected within one month. This means that the prices will adjust (increase) towards equilibrium by 18.6 per cent compared to prices in the previous time period.

The fact that both coefficients of $ECT_{t-1}^{+}$and ECT_{t-1}^{-} had the expected negative signs and were both significant shows that both positive and negative deviations were corrected towards long run equilibrium.

Model Selection

Having estimated both TAR and MTAR models, the next step was select the model that fits the data. The study used both AIC and SBIC criteria in model selection. Both criteria selected MTAR model over the TAR model because their values are lower in MTAR model (-185.853 and -160.957 for AIC and SBIC respectively) compared to the TAR model (-190.043 and -165.147 for AIC and SBIC respectively).This is in line with Enders and Siklos (2001) who opine that MTAR model has greater power over TAR model. Mofya-Mukuka (2013) and Ankamah-Yeboah (2012) also selected MTAR as a better model over TAR model using AIC and SBIC criteria.

CONCLUSION

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Both TAR and MTAR models rejected the first null hypothesis of no cointegration. This was evidence that there existed a long run relationship between the three price series. However, both models failed to reject the second null hypothesis of price symmetry. Failure to reject the second null hypothesis of price symmetry is interpreted differently under the two models.

The conclusion under TAR model was that the magnitude of the distance from equilibrium does not differ between positive and negative shocks. Failure to reject the second null hypothesis under MTAR model meant that there was symmetry in the speed of adjustment of correcting positive and negative deviations after a shock. This means that positive and negative deviations are corrected back to the equilibrium at the same speed.

Under TAR ECM, the ECT coefficient for positive discrepancies had the expected negative sign and was significant implying that positive deviations converge to equilibrium after a shock. However, the ECT for negative discrepancies had a wrong (positive) sign and was not significant. This means that negative discrepancies are not corrected back to long run equilibrium following a shock.

Both ECT coefficients had the expected negative sign and were significant under the MTAR model. This implies that both positive and negative deviations converge to equilibrium at the same speed after a shock. The study concluded that the rate of adjustment from disequilibrium in response to positive and negative discrepancies was the same.

REFERENCES

Akiyama, T., Baffes, J. Larson, D. F. and Varangis, P. (2003). Common Commodity Reform in Africa: Some Recent Experience. *World Bank Research Working Paper No.2995*.

Amikuzuno, J. (2009).Spatial Price Transmission and Market Integration in Agricultural Markets after Liberalization in Ghana: Evidence from Fresh Tomato Markets. Unpublished PhD Thesis, Georg-August University Goettingen, Germany.

Ankamah-Yeboah, I. (2012).Spatial Price Transmission in the Regional Maize Markets in Ghana. MPRA Paper No. 49720. Available online at http://mpra.ub.uni-muenchen.de/49720/

Byerlee, D., T. Jayne, and R. Myers. (2006). Managing Food Price Risks and Instability in a Liberalizing Market Environment: Overview and Policy Options. *Food Policy,* 31: 275-287.

Chan, K.S. (1993). Consistency and Limiting Distribution of the Least Squares Estimator of a Threshold Autoregressive Model. *Annals of Statistics,* 21(1): 520-533.

Enders, W. (2004). *Applied Econometrics Time Series*. Second Edition. Birmingham, AL: University of Alabama.

Enders, W. and C. W. J. Granger (1998). Unit-Root Tests and Asymmetric Adjustment With an Example Using the Term Structure of Interest Rates. *Journal of Business and Economic Statistics.*16: 304 - 11.

Enders, W. and Siklos, P. L. (2001).Cointegration and Threshold Adjustment. *Journal of Business and Economic Statistics,* 19: 166-176.

Engle, R.F. (1982). Autoregressive Conditional Heteroscedasticity with Estimates of Variance of United Kingdom Inflation. *Econometrica,* 50(4): 978-1008.

Engle, R.F. and Granger, C.W.J., (1987). Co-integration and Error Correction: Representation Estimation and Testing. *Econometrica,* 55: 251-276.

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FAO (2005). Committee on Commodity Problems, Intergovernmental Group on Tea. Application of Price Transmission on Selected Tea Markets.

Im, K. S., Pesaran, M. H., and Shin, Y. (1995). Testing for Unit Roots in Heterogeneous Panels. *Working Paper*, Department of Applied Economics, University of Cambridge.

Im, K. S., Pesaran, M. H., and Shin, Y. (1997). Testing for Unit roots in Heterogeneous Panels. *Discussion Paper*, University of Cambridge.

Ivanic, M., and W. Martin. (2008). Implications of higher global food prices for poverty in low income countries. *World Bank Policy Research Working Paper No. 4594*. Washington, DC: World Bank.

Kilima, F.T.M. (2006). Are Price Changes in the World Market Transmitted to Markets in Less Developed Countries? A Case Study of Sugar, Cotton, Wheat, and Rice in Tanzania. *IIIS Discussion Paper No. 160*.

Larson, D. (1999). Using markets to deal with Commodity Price Volatility. *PREM Notes, Economic Policy 3*. The World Bank, Washington, D.C.

Listorti, G. (2009). Testing International Price Transmission under Policy Intervention: An Application to the Soft Wheat Market. Unpublished PhD Thesis, Università Politecnicadelle Marche, Italy.

Mofya-Mukuka, R. (2011).Effects of Policy Reforms on Price Transmission and Price Volatility in Coffee Markets: Evidence from Zambia and Tanzania. Unpublished PhD Thesis, Kiel University, Germany.

Mofya-Mukuka, R. and Abdulai, A. (2013). Effects of Policy Reforms on Price Transmission in Coffee Markets: Evidence from Zambia and Tanzania. *Indaba Agricultural Policy Research Institute (IAPRI) Working Paper 79.*

Mohammad M. H. and Zulkornian Y., (2010) Impacts of Trade Liberalization on Aggregate Import in Bangladesh: An ARDL Bounds Test Approach. *Journal of Asian Economics,* 21, (2010) 37-52.

Stiglitz, J. E. (2002). Capital Market Liberalization and Exchange Rate Regimes: Risk without Reward. *The Annals of American Academy of Political and Social Science*, 579: 219-248.Tong, H. (1978). On a Threshold Model. In: C.D. Chen (eds.), Pattern Recognition and Signal Processing, Sijthoff and Noordhoff, Amsterdam: 101-141.

Tsay, R.S. (1989). Testing and Modeling Threshold Autoregressive Processes. *Journal of the American Statistical Association,* 82: 590-604.

Tsay, R.S. (1998). Testing and Modeling Threshold Models. *Journal of the American Statistical Association,* 93(443): 1188-1202.

Uchezuba, D. (2010). Measuring Asymmetric Price and Volatility Spillover in the South African Poultry Market. Unpublished PhD Thesis, University of Free State, South Africa.

Wane, A., Gilbert, S. and Dibooglu, S. (2004). Critical Values of the Empirical F-Distribution for Threshold Autoregressive and Momentum Threshold Autoregressive Models. Available at: http://opensiuc.lib.siu.edu/econ_dp/23/

White, H. and J. Levy (2001).Economic Reforms and Economic Performance:\Evidence from 20 developing Countries. *European Journal of Economic Research,* 2(13):120-143.

World Bank. (2005). Managing Food Price Risks and Instability in an Environment of Market Liberalization. Agriculture and Rural Development Department, The World Bank, Washington, D.C.

World Trade Organization (2003). Factors shaping the Future of World Trade. *World Trade Report, 2013.* Available online at www.wto.org

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