PRICE TRANSMISSION AND ADJUSTMENT IN THE ETHIOPIAN COFFEE MARKET

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Abstract

This study focused on the interrelationships among producer, auction and world prices. In so doing, it criticized previous studies and extended technique developed by Hansen (1999) to handle inferential biases occurring as a result of specification errors. The following results were found: unidirectional transmission of shocks from the world price to the auction price and then to the producer price; asymmetries in price transmissions and adjustments in the auction market; weak interrelationship between producer and world prices causing producer price to be less responsive to changes in the world prices. In general, results imply that coffee growers' benefit little from positive changes in the world price compared with participants in the auction markets. This is true given the presence of information asymmetry in the coffee value chain characterized by increasing level of market concentration.

Key words: Coffee, Ethiopia, threshold vector error correction models, nonlinearity

Introduction

The coffee industry plays a vital role in the Ethiopian economy. It accounts for the lion's share of the country's foreign exchange earnings and is a source of livelihood roughly for a quarter of the population.

The industry has survived a number of structural changes caused by changes in the political and economic landscape of the country. Before 1991, coffee markets were highly regulated[1] and coffee producers used to face implicit[2] and explicit taxation.[3] A series of changes in the policy arena which affected coffee production and marketing were introduced in 1992. These included a change in the macroeconomic policies of the country which included stabilization, adjustment and market liberalization programs. The policies in general aimed at leveling the playing field for all participants in the coffee market. It was hoped that this would increase coffee growers' share from export value

[1] During this period, prices were controlled by state owned parastatal called Ethiopian Coffee Marketing Corporation which exported about 80% of the domestic and export marketing. The role of private traders was limited. In line with ideological thinking of the then government, socialist mode of production used to be encouraged and quotas assigned to coffee growers. The parastatal phased out overtime and gave way to private traders locally known as *sebsabis, akrabis,* and a few cooperatives who control the domestic value chain.

[2] Due to fixation of prices and overvaluation of the domestic currency

[3] These include transaction tax, export duty tax, surtax, etc

and result in an increase in total exchange earnings from coffee export by increasing the volume of coffee exported[4].

Some positive results were witnessed in the immediate aftermath of the reform partly due to positive changes in the world coffee market and partly due to the reform itself. These included an increase in the domestic price of coffee (Figure 1)[5], an increase in the volume of export, and an increase in the number of participants in the official coffee market chain[6]. The positive result with regards to the domestic price of coffee did not last long. Coffee prices started falling significantly in 1997 following a fall in the world price of coffee, attributed to global overproduction. This had adverse impact on the contribution of the industry to the country's economy. Coffee price reached its lowest point in real terms for 100 years in 2002 (Quoted in Petit, 2007) (Figure 1). Total earnings from coffee export has been falling by a significant proportion ever since.

Discouraged by disappointing coffee prices in the world market, suppliers and growers responded to the situation. Some suppliers resorted to selling their coffee in the domestic market[7] where the premium was higher, and others engaged in illicit trade such as smuggling to neighboring countries to avoid paying tax to the government. The effect on the growers was worse. According to the BBC (2002), close to 15 million households have been affected by the situation. This was how a farmer interviewed by the BBC correspondent described the situation: "*In the past we had coffee, now the price of coffee has fallen and we have no food. I don't know what to do. I just sit in my home and weep*." There is also a credible fear that discouraged by lower prices, some farmers uproot coffee trees and switch production to alternative cash crops such as '*khat*[8]'. Oxfam estimates, within a decade, '*khat*' will replace coffee as primary export commodity if current trends in coffee prices continue unabated in the international market (The Financial Times, 2003).

Currently, coffee accounts for about 41% of the country's foreign exchange earning which is by far lower than the 65% contribution it made to the economy in the early 1990s (IMF, 2006). Attempts to reverse the situation and make growers prime beneficiaries of their product include embarking on trademarking initiatives in a bid to increase the share of farmgate prices from retail prices[9] by owning stocks in commodity stock exchange markets[10].

Coffee exported through the official channels passes through a number of value chains before it reaches final consumers. We ask in this paper to what extent changes in

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[4] Domestic price was expected to increase by reducing implicit taxation. Export volume on the other hand was expected to increase by discouraging coffee smuggling and diverting coffee to the official market channels.

[5] This could also be the result of coffee price boom in the international market.

[6] Currently over 100 Ethiopian coffee exporters exist compared to the 17 that operated before the reform (Luxner News INC, 2001).

[7] The country consumes 50% of its coffee production.

[8] It is variously named as 'qat', 'gat', 'chat', and 'miraa'. It is evergreen shrub chewed fresh for its stimulating effect. Some say it alleviates fatigue and reduces appetite. But warn that compulsive use results in a paranoid type of illness accompanied by hallucination. In countries like the USA, 'khat' is considered as a drug. Its consumption is a civil offence and results in incarceration.

[9] It is estimated that retail prices for premium coffees are 46 times the farmgate price.

[10] A lady who works for a coffee roasting company in the United States says the price of Ethiopian coffee or the Arabica type is determined at the commodity stock exchange and is based upon the price of Robusta coffee from other countries being traded in the USA (BBC, 2002).

the world prices would be transmitted to the growers, who are situated right at the beginning of the value chain. We also ask which market in the chain will be most affected by the change. In other words, we test for the presence of asymmetry in price adjustments in these vertically related markets. According to the literature, imperfect competition is one cause for asymmetry in price adjustments in a market chain (Bailey and Brorsen, 1989). It could be in turn caused by market concentration which allows price leadership role to be played by one or more actors in the value chain.

The domestic coffee value chain is currently controlled by companies locally called *sebsabis* (who gather coffee from producers), *akrabis* (who purchase coffee from *sebsabis* and supply the auction market) and exporters. Currently a company could hold more than one license and is allowed to buy coffee directly from growers. This breaks the chain which supposedly should work to stimulate competition in the domestic value chain from which growers emerge as beneficiaries. According to Daviron & Ponte (2005), this system might lead to some companies controlling prices from the farm level to export. If allowed to continue, this may render the auction market non-competitive. They found that of the 72 companies registered as exporters by the Ethiopian Coffee Export Association in 2000/01, the top ten companies commanded 53% of the market share.

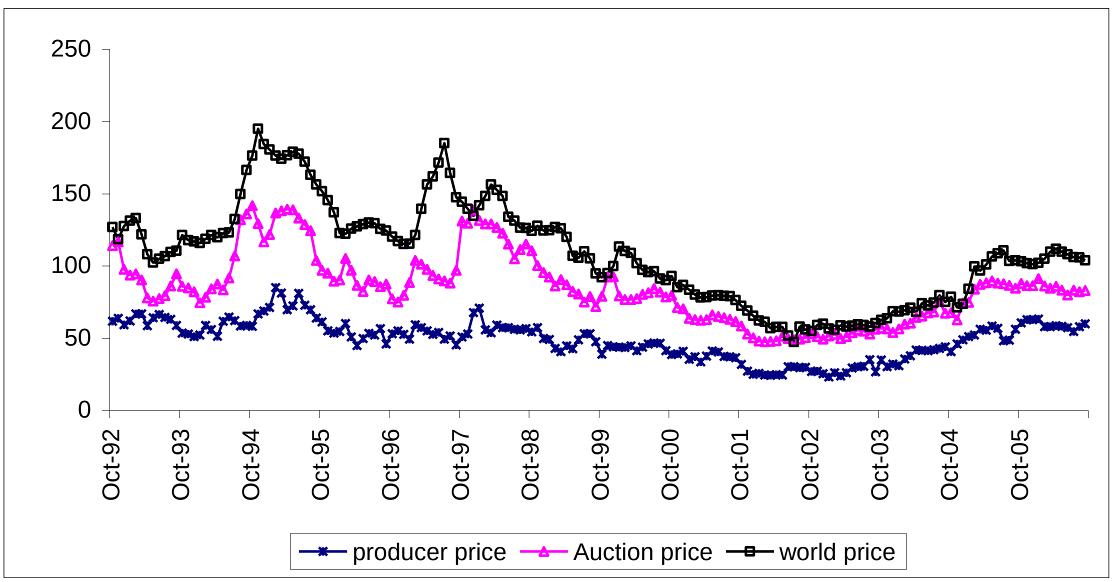

Figure 1: Producer, Auction and FOB prices

As far us our knowledge goes, there is only one study by Krivonos (2005) which attempted to investigate the impact of reforms in the coffee market on producer price and price transmission[11]. This study could be criticized on methodological grounds. Firstly, it assumed that producer price is affected only by the history of its own past and by that of the world price (i.e. price lags). This assumption fails to consider the roles that middlemen play in price determination. We believe that failure to bring participants in the auction market into the picture might create error in specification and overshadow the actual effect of a change in world prices on producer prices. This is because part or all of

[11] The study included major coffee producing countries in the world.

the benefits from the change could be absorbed by traders owing to the presence of high level of information asymmetry in the industry. One can't dismiss the presence of concentration in the wholesale market which could be potential hurdle for price transmission and adjustment. The likelihood that many growers sell at the farm gate rather than at the nearest market where changes in the world market conditions are discernible could be also additional cause for information asymmetry.

Secondly, Krivonos estimated a linear error correction model within autoregressive distributed lag ARDL (1,1) framework. The model assumes that adjustments are uniform. This is regardless of the size of shocks. This disregards the possibility that the model in question could be nonlinear. Nonlinearity instigate threshold-type adjustments where shocks greater than some threshold amounts might result in greater responses than smaller shocks.

Thirdly, a problem common to all applied Threshold Vector Error Correction Model (TVECM), which analyzed vertical as well as spatial price transmissions, is errors in model specification. Available studies assumed error variances as homoskedastic without conducting formal tests to validate their assumptions (Goodwin & Piggott, 2001; Lo & Zivot, 2001; Goodwin & Harper, 2001; Serra & Goodwin, 2002; Lo & Zivot, 2001). It has also become a common practice to fit a three regime TVECM without checking whether the data could be best captured by a two regime model (Goodwin & Harper, 2001; Serra & Goodwin, 2002; Goodwin & Piggott, 2001). These might lead to inferential bias which warrants attention.

In this study, we attempt to handle weaknesses of past studies as follows. Firstly, we consider producers, traders and exporters as active participants in the domestic value chain. Assuming that both producers and traders are too small to affect world coffee price, world price measured by free on board price (fob price) enters the system as exogenous variable. Secondly, with the objective of handling specification errors and avoiding their consequence on inference we apply TVECM and extend recent developments in time series econometrics to test for the presence of heteroskedasticity in error variances and to test whether a two or three regime model best fits the data using a technique developed by Hansen (1999). This technique was originally developed for threshold autoregressive (TAR) models.

Econometric Methods

The data

The analysis is based on monthly nominal time series national price data which include producer price, auction price and world price ranging from October 1992 to September 2006. The data was obtained from the Central Statistical Agency and Agricultural Market Supporting Department in the Ministry of Agriculture and Rural Development, in Addis Ababa, Ethiopia. Prices are measured in US cents per pound. The official exchange rate was used to convert domestic prices into US dollars which were then converted to logarithms.

The model

Let x_t be a two dimensional I (1) time series variable $x_t = (P_t, A_t)'$), $\hat{x}_t = (P_t, A_t, W_t)'$. Where P_t is producer price of coffee at time t, A_t is auction price of coffee at time t, and

W_t is world price of coffee at time t. The linear form of vector autoregressive (TVAR$_1$) model is given by

$$[1] \qquad x_t = \lambda_0 + \lambda_1 \hat{x}_{t-1} + \lambda_2 \hat{x}_{t-2} + \ldots + \lambda_k \hat{x}_{t-k} + \varepsilon_t,$$

Where, *t=1,2,3*...T, *k* is the lag length. It is assumed unknown. It is determined using available lag length selection criteria. Vector Error Correction representation of [1], in other words $TVECM_1$ is given by

$$[2] \qquad \Delta x_t = \lambda_0 + \hat{\prod} \hat{x}_{t-1} + \sum_{i=1}^{k-1} \rho_i \Delta \hat{x}_{t-i} + \upsilon_t^{(j)}$$

Where, $\hat{\Pi} = \sum_{i=1}^{k} \lambda_i - I_2 = \nabla \beta' = \begin{pmatrix} \nabla_1 \\ \nabla_2 \end{pmatrix} (1, \alpha_1, \alpha_2)$, $\beta' = (1, \alpha_1, \alpha_2)$ is a cointegrating vector, $\nabla = \begin{pmatrix} \nabla_1 \\ \nabla_2 \end{pmatrix}$ is a vector of adjustment coefficients, and $\rho_i = -\sum_{l=i+1}^{k} \lambda_i$.

The three regime threshold vector autoregressive representation of [1] i.e. $TVAR_3$ may be given by

$$[3] \qquad x_t = \vartheta_0^j + \vartheta_1^j \hat{x}_{t-1} + \vartheta^j{}_2 \hat{x}_{t-2} + \ldots + \vartheta_k^j \hat{x}_{t-k} + \varepsilon^j{}_t, \quad \text{for } \gamma_{(j-1)} \le z_{t-d} \le \gamma_{(j)}$$

Where t is defined as before; *j=1,2,3*; $-\infty = \gamma_{(0)} < \gamma_{(1)} < \gamma_{(2)} < \gamma_{(3)} = \infty$; $\varepsilon^j{}_t \sim IIN\left(0, \Sigma^j\right)$, for a three regime $\gamma = (\gamma_1, \gamma_2)$ is threshold value; z_{t-d} is threshold variable and '*d'* is delay parameter. The threshold variable is assumed known but the threshold values $\gamma = (\gamma_1, \gamma_2)$, the delay parameter 'd' and the lag length 'k' are assumed unknown.

The general form of threshold vector error correction representation of [3] $TVECM_3$ is given by

$$[4] \qquad \Delta x_t = \vartheta_0^j + \prod^j \hat{x}_{t-1} + \sum_{i=1}^{k-1} \theta_i^{(j)} \Delta \hat{x}_{t-i} + \varepsilon_t^{(j)} \quad \text{for } \gamma_{(j-1)} \le z_{t-d} \le \gamma_{(j)}$$

Where $\Pi^j = \sum_{i=1}^{k} \lambda_i^j - I_2 = \nabla^j \beta' = \begin{pmatrix} \nabla_1^j \\ \nabla_2^j \end{pmatrix} (1, \alpha_1, \alpha_2)$ and $\theta_i^j = -\sum_{l=i+1}^{k} \vartheta_l^{(j)}$, '*j*' is defined as before.

From [4], a Two-regime Threshold Vector Error Correction Model $TVECM_2$ could be defined by allowing 'j' to take values j=1, 2 and making $\gamma_{(2)} = \infty$.

The parameters $\vartheta_0^{(j)}, \nabla^j$, and θ_i^j are estimated after a two-dimensional grid search is applied to determine γ by selecting those values of γ which minimize the log determinant of the variance covariance matrix of residuals $\hat{\sum}_m (\hat{\gamma}, \hat{d})$. The search was restricted to a minimum of 20 observations in each regime.

Next, an extension to Hansen's (1999) approach was applied to test for linearity i.e. the null hypothesis of $TVECM_1$ against its alternative hypothesis of $TVECM_m$ for

$m = 2{,}3$. After threshold nonlinearity was confirmed, we determined the number of regimes by testing the null hypothesis of $TVECM_2$ against its alternative of $TVECM_3$. To do this a nonstandard test procedure was applied. See Hansen (1999) for detailed discussion within threshold autoregressive (TAR) context. According to Hansen (1999), the sampling distribution of the simulated Sup-LR i.e. LR_{im} in [5] depends on whether error variances in $TVECM_i$ are hetroskedastic. This was tested by the regression of squares of residuals from $TVECM_i$ on squares of the variables and the dummies identifying regimes and testing for the joint significance of the variables. Where hetroskedastic error variances were found, the necessary corrections were made (see Hansen (1999) for the method).

[5] $$LR_{im} = T * (\ln(|\hat{\Sigma}|) - \ln(|\hat{\Sigma}_m(\hat{\gamma}, \hat{d})|))$$ for i=1,2 and m=2,3…

Where LR_{im} represents the test statistics, $\hat{\Sigma}$ and $\hat{\Sigma}_m(\hat{\gamma}, \hat{d})$ respectively stand for variance covariance matrix of residuals obtained from $TVECM_i$ and $TVECM_m$.

Empirical Application
Data Generating Process

Time series properties of price variables were studied using the Augmented Dickey Fuller (ADF) test. According to the results found, the null hypothesis of unit root was not rejected for all price series. Next we tested the same hypothesis after prices were differenced only once. This time however we could reject the unit root null hypothesis at acceptable levels of significance (Table 1). The results imply that price variables are integrated of order one *I (1)*. We also applied Johansen's procedure to test for the long run relationships (cointegration) between price variables. To do this the criteria-LR, FPE, AIC, and HQ-were used to decide on lag length. The majority of the test statistic identified a VAR of order two (Table 2). Therefore, long-run relationships among the variables were tested by fitting a Vector Autoregressive (VAR) Model with two lags[12]. Results indicated the presence of one cointegrating relationship among the three price variables (Table 3).

Table 1: Test for the stationarity of prices

Variables	Deterministic component	Statistic	Probability
Producer price First difference	With constant	-2.005 -14.964	0.28 0.000
Auction price First difference	With constant	-2.1590 -10.460	0.22 0.000
Fob price First difference	No constant no trend	-0.460 -9.870	0.60 0.000

[12] The test was conducted with an intercept term included in the cointegration equation. No intercept term was included in the VAR because first difference of each variable was found to be close to zero.

Linearity Test

After time series properties of variables had been studied and cointegration confirmed (Table 3), we conducted a linearity test using Hansen's (1999) procedure[13]. In addition, the procedure was used to decide on the number of regimes after nonlinearity has been confirmed. The method uses sup-LR statistic and is given by equation [5].

Table 2: Lag Length Order Selection

Lag	LR	FPE	AIC	SC	HQ
0	NA	1.66E-07	-7.10	-7.04	-7.08
1	908.46	5.48E-10	-12.81	-12.58*	-12.71
2	31.91*	4.98e-10*	-12.91*	-12.50	-12.74*
3	6.23	5.35E-10	-12.84	-12.24	-12.60

* indicates lag order selected by the criterion
LR, FPE, AIC, SC and HQ stand respectively for likelihood ratio, final prediction error, Akaike Information criterion, Schwartz information criterion, and Hannan-Quinn criterion.

Because the parameters needed to test linearity are identified only in the alternative hypothesis but not in the null hypothesis, the test was conducted using a nonstandard test procedure which made use of bootstrap distributions[14] from which p-values were computed (Table 4). The experiment was done as follows. Firstly, we generated random samples (with replacement) from residuals obtained from $TVECM_1$. Next, using the initial sample values and parameters obtained from $TVECM_1$, we simulated sample of variables for dependent variables. The simulated values were then used to calculate the LR_{im} statistic in equation [5]. This was repeated 2000 times. Finally, the p-values were calculated by calculating the number of times the simulated LR_{1m} exceeded the calculated LR_{1m}.

Table 3: Cointegration testing results

Maximum Eigenvalue test statistic		
Rank	**Statistic**	**Critical value**
None*	29.915	22.300
At most 1	15.637	15.892
At most 2	1.543	9.165
Trace statistic		
None	47.095	35.193
At most 1	17.180	20.262
At most 2	1.543	9.165

*Maximum Eigenvalue test statistic and trace statistic indicate one cointegrating relationship

[13] Similar technique was applied by Lo & Zivot (2001).
[14] In stead of asymptotic distributions we used bootstrap distributions in this study to calculate p-values. Bootstrap distributions are more powerful than asymptotic distributions (quoted in Hansen, 1999).

Bootstrap distributions are sensitive to conditional heteroskedasticity in errors (Hansen, 1999). This problem was handled by first testing for the presence of heteroskedasticity in errors and then where necessary by correcting for it. We found conditional heteroskedasticity in errors in the $TVECM_1$. But errors in the $TVECM_2$ were found to be Homoskedastic. Therefore, following Hansen (1999), bootstrap distributions were computed taking heteroskedasticity into account when the null hypothesis of $TVECM_1$ was tested against its alternatives of $TVECM_2$ and $TVECM_3$ (see Hansen for the method).

Table 4 gives results from the linearity test. It also identifies the number of regimes that best characterizes the TVECM. The test was conducted in two steps. In step one, we tested for linearity i.e. we tested the hypotheses $TVECM_1$ versus $TVECM_2$ and then $TVECM_1$ versus $TVECM_3$. Results rejected the linearity null at 1% level of significance (Table 4). In step two, after nonlinearity was confirmed, we asked whether a two regime $TVECM_2$ or a three regime $TVECM_3$ best fits the data assuming that error variances are homoskedastic. The test rejected $TVECM_2$ at 1% level of significance (Table 4). Therefore a $TVECM_3$ was fitted. The two threshold values required to form the three regimes were calculated in a manner discussed in the methods section.

Table 4: Test for Linearity and the number of regimes

Hypothesis	Likelihood Ratio	Bootstrap p-values	
		Homoskedastic	Hetroskedastic
LR12	73.56	0.000	0.000
LR13	138.26	0.000	0.000
LR23	64.77	0.000	0.000

Thresholds and regime switching

In this section, results from threshold estimates (γ_1 & γ_2) and regime switching indicators are discussed. Two thresholds with values $\hat{c}_1$ =-0.29 and $\hat{c}_2$ =0.28 were calculated. These values indicate that deviations from equilibrium are symmetrically distributed within the three regimes with 26% of the time deviations from equilibrium falling within regime I, 47% of the time in regime II, and 27% of the time in regime III (Appendix 1). Regimes I and III represent regimes in which producer prices are less than and greater than equilibrium price respectively. On the other hand, in regime II, producer price is different from equilibrium price only by the threshold values. Regimes II could be regarded as equilibrium regime or band.

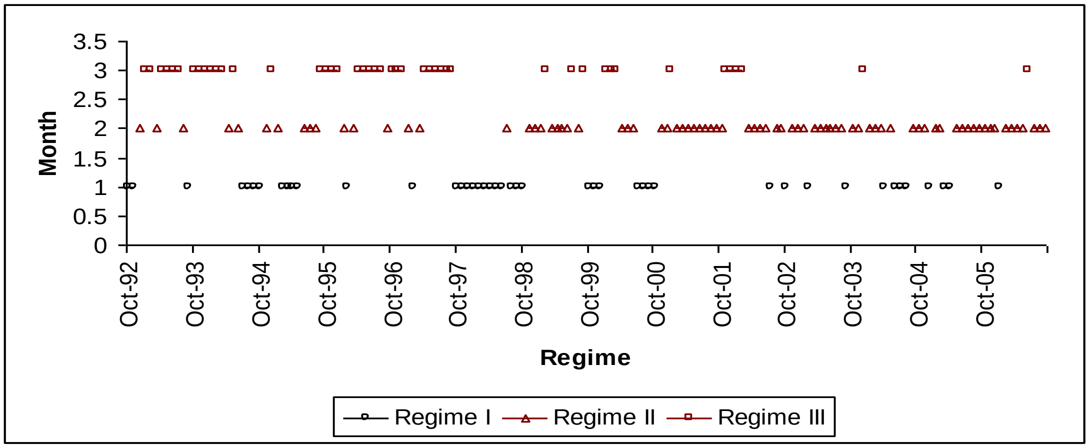

Figure 2: Regime Switching Estimates

Figure 2 investigates the degree to which deviations from equilibrium fall persistently within and outside the equilibrium band. It also gives information about time of switches between regimes which might assist in identifying the underlying causes. For the period between 1992 and 1998, for the majority of the cases, producers were paid higher than equilibrium price (see Appendix 1). However, for the period following that (i.e.1998 to 2006) Figure 1 and Appendix 1 show that producer price fell persistently within the equilibrium band. Does this mean that producers were paid fairly during this period compared with the period preceding it? The answer is no. This happened within the period what Daviron & Ponte (2005) called a period of unfair trade in a book they titled 'the paradox of coffee'. Unfair trade rules started influencing world price of coffee in 1980 which came in the form of agricultural protectionism in developed countries and market power of traders, processors and retailers. To answer the question, we divided the period 1998 to 2006 into two sub-periods based on Figure 1. The first correspond with a period of rapid decline in the international coffee prices (1998 to 2002) and the second with a period of recovery (2002 to 2006). In the first sub-period world price declined faster until it reached its trough in 2002 and local prices (producer and auction) responded to the change accordingly but with different paces - producer price fell at a rate lower than auction and world prices. In the second sub-period (a period of recovery), world price started to recover but it was only producer price that was able to recover to its pre 1998 level faster.

This asymmetric response of producer prices to world price might have caused a fall in the equilibrium price at a rate proportionately higher than producer price making deviations from equilibrium fall within the equilibrium (neutral) band. This asymmetry in price transmission could be the result of the higher demand that coffee commands in the domestic market. The country is not only important producers of coffee but also a major coffee consumer. On average, between 1960 and 2006, 48% of the coffee produced in the country was destined for domestic consumption. Coffee smuggling to neighboring countries might have also played its role. There were times when Ethiopia's none coffee producing neighbors (Eritrea, Dijibouti and the Sudan) were listed in the world trade statistic as coffee exporters. In 2006, Agricultural Market Supporting Department in the Ministry of Agriculture and Rural Development estimated that about 15% of the total coffee produced in the western part of the country (Wollega, Keffa and Illibabor) was smuggled illegally to neighboring countries.

Threshold Vector Error Correction (TVECM)

Table 5 gives results from the threshold vector error correction model. These results were used to measure the direction of causality i.e. whether it runs from world price and auction price to the producer price or vise versa. However, caution is needed on the way parameters should be interpreted. This is because their levels of significance are affected by the threshold values estimated and by our assumption of homogeneity in residuals. Care was taken to handle the latter by testing for homogeneity in errors and by making the necessary adjustments. As stated earlier, this is one of the many approaches which make this study different from earlier studies by Goodwin & Harper (2000) and others who merely assumed homoskedasticity in error variances. With regard to measuring the significance of parameter estimates, we followed Goodwin & Harper (2000). We considered as significant only those parameters with t-ratios closer to and exceeding two.

In general, we found dynamic interrelationships between auction price and lagged price differences of producer price and world prices. But we found the interrelationship between producer price and world price to be weak. As shown by Table 5, producer price is affected by world price only indirectly through auction price. Therefore, the results imply that direction of causality flows from world prices to auction price and then to producer price. Adjustment coefficients computed also support findings already discussed- auction prices are more responsive to shocks than producer prices are. In addition, in accordance with a priori expectation, the adjustment coefficient computed for the equilibrium band is lower in magnitude as well as level of significance than similar coefficients computed for the same outside of the equilibrium bands (see auction equation). This indicate that adjustments are not uniform i.e. shocks greater than threshold values result in greater responses than smaller shocks.

Table 5: Threshold Vector Error-Correction Model Parameter Estimates

Variables		Producer (P_t)	Auction (A_t)
Regime I	Intercept	-0.001 (0.0078)	0.037* (0.004)
	dP_{t-1}	-0.278 (0.144)	-0.091 (0.073)
	dA_{t-1}	0.110 (0.198)	0.261* (0.100)
	$d\textit{fob}_{t-1}$	-0.013 (0.318)	0.065 (0.161)
	ε_{t-1}	0.001 (0.0133)	0.053* (0.007)
Regime II	Intercept	0.005 (0.005)	-0.001 (0.002)
	dP_{t-1}	-0.202 (0.120)	0.060 (0.061)
	dA_{t-1}	0.683* (0.213)	0.083 (0.107)
	$d\textit{fob}_{t-1}$	-0.169	0.113

		(0.180)	(0.091)
	ε_{t-1}	-0.016 (0.028)	0.032* (0.014)
Regime III	Intercept	0.002 (0.008)	-0.032* (0.004)
	dP_{t-1}	-0.006 (0.170)	0.102 (0.086)
	dA_{t-1}	-0.100 (0.222)	0.204* (0.112)
	$d\mathit{fob}_{t-1}$	0.107 (0.248)	-0.229* (0.125)
	ε_{t-1}	-0.015 (0.0137)	0.048* (0.007)

Impulse Response Function

Impulse response estimates give information about dynamic interrelationships between prices in different markets and also the asymmetric nature of price transmissions. It is calculated in this study using a nonlinear impulse response function of Potter (1995). According to Potter, responses are defined on the basis of the actual data ($z_t, z_{t-1},...$) and a shock (υ) as follows:

[8] $$I_{t+k}(v, Z_{t-1}, Z_{t-2},...) = E[Z_{t+k} / Z_t = z_t + v,\ Z_{t-1} = z_{t-1},...] - E[Z_{t+k} / Z_t = z_t, Z_{t-1} = z_{t-1},...]$$

In general, as shown by Figures 3.1 and 3.2 (for the 158th and 50th observations respectively) responses are asymmetric (to note differences in scale see Appendix 2 for additional information). Auction price responds differently to one-half standard deviation positive and negative shocks to world prices. This divergence in responses could be attributed to the presence of a strong demand for coffee in the local market. Consistent with results from TVECM, auction prices are found to be more responsive than producer prices to shocks to world price. Results further indicated that shocks cause permanent adjustment.

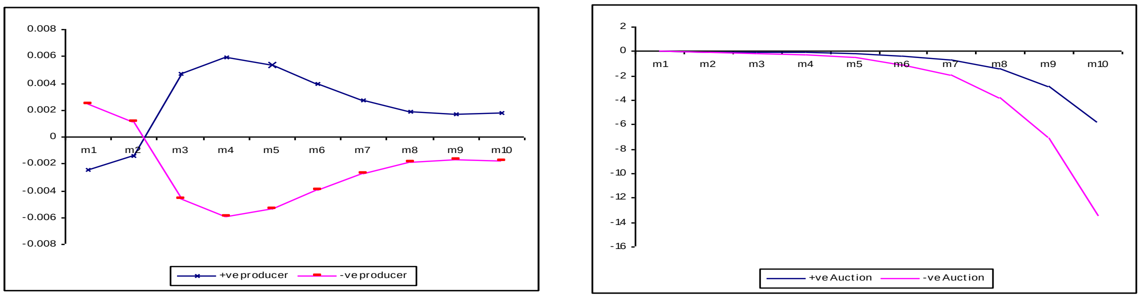

Figure 3.1: Nonlinear Impulse Response of producer (left) and auction (right) prices to shocks at world price at 168th observation

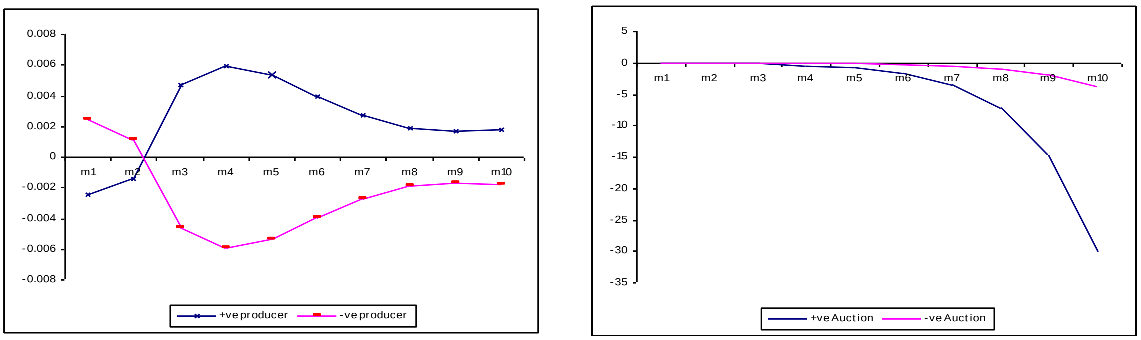

Figure 3.2: Nonlinear Impulse Response of producer (left) and auction (right) prices to shocks at world price at 50th observation

Conclusion

We analyzed interrelationships and transmissions among producer, auction and world markets. We criticized previous study on the topic done for Ethiopia on methodological grounds. In addition, we extended technique developed by Hansen (1999), originally developed within a threshold autoregressive (TAR) context, to test for the presence of threshold-like responses, to handle heteroskedasticity in error variances and to decide on the number of regimes that best characterizes the responses. Some of the methods applied in this study, tackle specification and thus inferential biases that applied studies in the field have overlooked to date. Available applied studies which made use of $TVECM$ merely assumed constant error variance, without validating their assumptions; and they fitted a $TVECM_3$, ignoring the possibility of fitting other alternative $TVECM$ models.

We found the following results from the model specification exercise. Firstly, all price variables were *I(1)* and they exhibited long run relationships. Secondly, nonlinearity tests suggested threshold type adjustments. Thirdly, we tested for heteroskedasticity which detected a problem in the $TVECM_1$. Fourthly, we corrected for heteroskedasticity problem and run simulations with 2000 replications to decide on the number of thresholds in the $TVECM$. Finally, we settled with a $TVECM_3$, which helped us answer some of the questions we raised in section one of this paper- the degree to which prices are transmitted from the world to producer prices.

The exercise gave the following salient findings. Firstly, producer price fell persistently within the equilibrium band between 1998 and 2006. This was attributed to asymmetries in price transmissions and adjustments a finding supported by the estimated three-regime threshold vector error correction model and by the impulse response function. Secondly, we found unidirectional transmission of shocks from world to auction and then to producer price. In general, we found producer prices to be less responsive to changes in the world prices (positive or negative) than auction prices. This could be attributed to the increased use of the domestic market as a major outlet by coffee suppliers at times of lower world prices.

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Appendix 1: Regime Switching (%) of observations falling in regimes I, II and III

Year	Regime I	Regime II	Regime III
1993	8	17	75
1994	33	25	42
1995	33	33	34
1996	8	25	67
1997	33	17	50
1998	75	25	0
1999	25	50	25
2000	33	42	25
2001	0	75	25
2002	17	67	16
2003	17	75	8
2004	42	58	0
2005	17	83	0
2006	11	78	11
Average	26	47	27

Appendix 2: Nonlinear Impulse Response

	168th observation				50th observation			
Month after shock	Producer price		Auction price		Producer Price		Auction price	
	+ve	-ve	+ve	-ve	+ve	-ve	+ve	-ve
m1	-0.002	0.002	-0.004	0.0043	-0.002	0.0024	-0.004	0.004
m2	-0.001	0.001	-0.028	-0.119	-0.001	0.001	-0.135	-0.022
m3	0.005	-0.005	-0.026	-0.151	0.005	-0.005	-0.160	-0.036
m4	0.006	-0.006	-0.080	-0.355	0.006	-0.006	-0.424	-0.073
m5	0.005	-0.005	-0.154	-0.643	0.005	-0.005	-0.805	-0.131
m6	0.004	-0.004	-0.337	-1.293	0.004	-0.004	-1.711	-0.256
m7	0.003	-0.003	-0.682	-2.507	0.003	-0.003	-3.475	-0.497
m8	0.002	-0.002	-1.41	-4.940	0.002	-0.002	-7.165	-0.978
m9	0.002	-0.002	-2.88	-9.681	0.002	-0.002	-14.672	-1.919
m10	0.002	-0.002	-5.917	-19.014	0.002	-0.002	-30.124	-3.768