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Volatility and Price Transmission from World Prices to the Ecuadorian Coffee Market

Andrés R. Jácome[a]*, Alberto Garrido[b]

[a]*PHD Student of the Technical University of Madrid (UPM). Avda. Puerta de Hierro Nº 2, CP. 28040, Madrid, Spain.*

[b]*Research Centre for the Management of Agricultural and Environmental Risks (CEIGRAM), Technical University of Madrid (UPM). C/ Senda del Rey 13, CP. 28040, Madrid, Spain.*

[a]*Email: andresrenato.jacome.gagnay@alumnos.upm.es*

[b]*Email: alberto.garrido@upm.es*

Abstract

Growers are the most vulnerable agents in price movements of agricultural commodities markets. The behaviors of margins do not usually evolve beneficially in an asymmetric price transmission (from world to domestic market) setting. Therefore, markets volatility affects the growers' benefits and decisions. The Ecuadorian coffee market operates in a competitive environment, but the government intervenes in the domestic market with sector policies and support programs. This paper evaluates the volatility exposure for the Ecuadorian coffee market and the asymmetric price transmission for the period 2001 - 2012. With an Autoregressive conditional heteroscedasticity model, we estimated the volatility for the two Ecuadorian coffee varieties: Arabica and Robusta. The volatility results showed the high level exposure of growers in the market. To test the asymmetric price transmission, we used the Han and Seo (2002) methodology. We evaluated the period 2001 – 2012 for the Arabica and Robusta coffee varieties, using International Coffee Organization and domestic prices. The results showed different adjustment speeds to the regimes in the long-run equilibrium. The government could implement policies and programs to mitigate the negative effects of world prices transmission and the exposure to volatility of growers.

Keywords: Ecuador; coffee market; volatility; asymmetric price transmission.

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* Corresponding author.

1. Introduction

Coffee is negotiated at global stock exchanges; whose prices provide a reference for the domestic market of coffee-producing countries. Any movement (increasing/ decreasing) of coffee prices in the world market affect the domestic prices in the physical markets around the world. Coffee prices in domestic markets of coffee producing-countries have been shown to be volatile [1, 2, 3]. This translates as uncertainty in the growers' benefits. Price fluctuations were a cause of poverty for growers and this situation was difficult to mitigate [4]. Growers constitute the part of the production chain that receives lower earnings in increasing price periods and are affected more rapidly by decreasing price periods [5, 6]. The asymmetry is determined by factors such as: market power, adjustment costs and menu costs [7]. Asymmetric price transmission gives rise to different adjustment speeds in positive or negative deviations to the long-run equilibrium. Ecuador is a coffee-exporting country. Official statistics showed that coffee is one of the largest exporting agricultural sectors. In 2012, Ecuador exported 261 million USD and produced 35,000 t [8]. Growers are located in most of the 23 provinces of the country. It was estimated that the coffee grower activity generated 105,000 employments in 2012 [9]. The Ecuadorian coffee market operates in a competitive environment. The government has implemented support programs for the growers since the end of 2011. From a global to domestic market perspective, do the Ecuadorian growers work in an asymmetric price environment? To answer this question, we used the [10] methodology for the period January 2001 – December 2012. First, we tested a cointegration relationship of monthly ICO prices (Other Milds for Arabica and Robusta) with the Ecuadorian prices for each coffee variety. Next, we estimated the threshold error correction model. With the results of this analysis, we expected to find an asymmetric price environment. Our results would be considered by policy makers in defining a policy to help growers benefit from world transmission prices. Moreover, we are interesting to know if Ecuadorian coffee growers work in a volatility prices environment. We estimated volatility with an Autoregressive conditional heteroscedasticity (ARCH) model for the two coffee varieties. Reference [11] reviewed volatility studies in coffee producing-countries and analyzed the effects of volatility in the growers´ exit decisions in the Ecuadorian market. The results of ARCH models showed the high exposure of growers in the Ecuadorian market and proved the need for a mechanism to be developed to mitigate price fluctuations. Therefore, it is important that the Ecuadorian government considers volatility when designing and implementing policies in the sector.The following section includes a literature review on price transmission analysis and its applications for agricultural products. Next, we present the methodology and data used in this paper to quantify volatility (ARCH model) and test asymmetric price transmission (TVECM). In the last part, we analyze and discuss the results of this study and carried out our final conclusion.

2. Material and Methods

2.1 Literature Review

The threshold cointegration concept was introduced by [12]. They proposed a two-step approach to evaluate the adjustment speed in the long-run equilibrium. Reference [13] introduce the momentum threshold autoregressive model (M-TAR), which helps to capture the asymmetry in the series. Reference [10] estimate a threshold vector error correction model (TVECM) for a bivariate case with a single cointegration vector and a threshold effect.

These studies are fundamental when analyzing the asymmetric price transmission in many markets[1].

Agricultural applications

Several studies have analyzed the effects of price transmission in the agricultural sector in different countries. These studies evaluated the impact of changes in agricultural policies, market reforms, external shocks and supply chains in the national market. Reference [14] analyze price transmission for dairy products from the farm to retail levels in Spain, finding that the asymmetry has little economic impact. Reference [15] investigate the asymmetric price transmission in the lamb chain in Spain. The results demonstrate a perfect integration in the long-run, but the retail sector maintains the benefits due to the market power in the short run. Reference [16] investigate the long-run relationship between vegetable oil and fossil oil prices for the period 2005-2007 and find that rapeseed oil is exposed to external shocks determined by political scenarios in the European Union. Reference [17] conducts an analysis for tomatoes and cauliflowers in the European market. He suggests that perishable products were sensitive to market crises and recommended governmental actions during those periods. Reference [18] estimate a short and long-run price transmission for 100 food commodities classified in 5 categories in USA. The conclusion of the analysis highlights the strength of price linkages and their reduction in the time.

Application for the coffee sector

Reference [19] use an aggregate model of oligopolistic interaction for the Netherlands for the period 1992-1996 to explain the incomplete transmission of prices from coffee bean to consumers. Reference [20] find evidence of two cointegration relationships for different types of coffee and slow adjustment to the equilibrium in increasing price periods. Reference [5] analyze the liberalization of the Ethiopian coffee market: they observe that there was a strong relationship within the sector between growers, wholesalers and export prices during the post-reform period. However, negative price movements affect the grower's sale price quickly. Reference [21] study the export quota system (EQS) and post-EQS for three importing coffee countries. The analysis shows asymmetric result variations for the international coffee prices: positive for USA and negative for France and Germany. Reference [6] uses threshold cointegration models to evaluate the liberalization of the market in El Salvador, India and Colombia, and find growers as the most affected in the post-reform periods. Reference [22] use a momentum-based threshold cointegration and threshold error correction models to examine the market reforms in Tanzania (government intervention) and Zambia (market liberalization). The findings show that Zambian prices responded rapidly to transmission of world price movements. Reference [23] examine world transmission in Ugandan coffee prices from 1988 to 2010: their research suggests the importance of the indicator ICO price and future prices in the growers' decisions, enabling them to obtain the best prices.

2.2 Methodology

We first tested the stationarity of the coffee prices series. We used the Augmented Dicker-Fuller test to determine whether the series had a unit root in levels and first differences. All series were evaluated with a

[1] To review volatility studies about coffee-producing countries, it is recommended to review the Jacome & Garrido (2017) study.

constant (equation 1) and constant and trend (equation 2). The number of lag of the dependent variable is selected according to the Akaike Information Criteria (AIC).

$$\Delta P_t = \beta_1 + \delta P_{t-1} + \alpha \Delta P_{t-1} + u_t \quad (1)$$

$$\Delta P_t = \beta_1 + \beta_2\, t + \delta P_{t-1} + \alpha \Delta P_{t-1} + u_t \quad (2)$$

To quantify the volatility, we used the ARCH model for Ecuadorian coffee (Robusta and Arabica). With the results of the ADF augmented test (equation 1 and 2), we model an Autoregressive Integrated Moving Average (ARIMA) process as follows:

$$Y_t = \propto_0 + \sum_p^{p\ max} \emptyset_p\, y_{t-p} + \sum_q^{q\ max} \emptyset_q\, \varepsilon_{t-q} + \sum_n^{n\ max} \eta_n\, D_t \quad (3)$$

Where $\propto_0$ is the constant, y_{t-p} is the (AR) autoregressive term corresponding to the use of the lagged value (p), ε_{t-q} contains the (MA) moving average term with a lagged value (q) and D_t is the order of the differencing the series. This process is modelled according to the Box-Jenkins methodology. First, we determined the (I) differencing order of the series for it to be stationary. Next, we determined the values of p (AR) and q (MA) of the ARIMA process. We used the Akaike Information Criteria to select the lagged values (p and q).

The next step is the evaluation of ARCH process, we estimated the following process:

$$Y_t = \propto_0 + \sum_p^{p\ max} \emptyset_p\, y_{t-p} + \sum_q^{q\ max} \emptyset_q\, \varepsilon_{t-q} + \sum_n^{n\ max} \eta_n\, D_t \quad \text{and}$$

$$\sigma^2{}_t = \propto_1 + \sum_{i=1}^{q} \propto_i\ \varepsilon^2{}_{t-i} \quad (4)$$

Where $\sigma^2{}_t$ is the conditional variance, $\propto_1$ is the constant, $\propto_i$ (i=1...q) are the estimated coefficients of the squared error terms and $\varepsilon^2{}_{t-q}$ are the lagged (q) values of the squared error terms. With equation 4, we estimated the conditional variance for each Ecuadorian coffee series and selected the lagged (q) values with the AIC criteria information. The ARIMA and ARCH models are estimated through the EViews program. To estimate the price transmission, we used the Johansen cointegration test to validate the long-run relationship from world prices to domestic prices. The Johansen approach begins with a vector autoregressive model as:

$$Z_t = A_1 Z_{t-1} + \cdots \ldots A_k Z_{t-k} + \varepsilon_t \quad (5)$$

and it is reformulated in a vector error model:

$$\Delta Z_t = \sum_{i=1}^{k-1} \Gamma_i\ \Delta Z_{t-i} + \prod Z_{t-k} + \varepsilon_t \quad (6)$$

Where Z_t is a vector of non-stationarity series, A are the different matrices of parameters, k is the lag of variables, ε_t is the error term, following a i.i.d. process with mean 0 and normal distribution. The Johansen test examined the Π matrix and is interpreted as long-run relationship, and Γ_i is the measure of short-run adjustment.

With the results of the cointegration test, we observed the existence of a cointegration relationship between Ecuadorian and world prices and continued with the estimation of TVECM. [10] proposed a Threshold Vector Error Correction Model with two regimes, which can be treated as a non-linear VECM of order l + 1 in the following form:

$$\Delta X_t = \begin{cases} A'_1 X_{t-1}(\beta) + u_t & \text{if } w_{t-1}(\beta) \leq \Upsilon \quad regime\ 1 \\ A'_2 X_{t-1}(\beta) + u_t & \text{if } w_{t-1}(\beta) > \Upsilon \quad regime\ 2 \end{cases} \tag{7}$$

with:

$$X_{t-1}(\beta) = \begin{Bmatrix} 1 \\ w_{t-1}(\beta) \\ \Delta X_{t-1} \\ \Delta X_{t-2} \\ . \\ . \\ \Delta X_{t-l} \end{Bmatrix} \tag{8}$$

Where X_t is a p-dimensional time series of I (1). It is cointegrated with one (p x 1) cointegrating vector β. w_t (β) = $\beta' X_t$ is the error correction term (ECT). The coefficients matrices of A_1 and A_2 describe the dynamics in each regime. Υ is the threshold parameter values and u_t is the error term that is assumes a covariance matrix $\Sigma = \mathrm{E}(u_t u'_t)$. The parameters (β, A and Σ) are estimated by maximum likelihood under the assumption that the error (u_t) are i.i.d Gaussian.

The values of w_{t-1} below or above the threshold value (Υ) allow the coefficients to switch between the regimes 1 and 2. The estimated values of $w_{t-1}$of the regime 1 and 2 show the adjustment speed of the series toward the equilibrium.

Reference [10] developed two heteroskedastic-consistent SupLM tests to evaluate the null hypothesis of linear cointegration (i.e., there is no threshold effect), against the alternative of threshold cointegration. These two SupLM tests use a parametric bootstrap method to estimate asymptotic critical values with the respective p-values. The first test is used when the true cointegration vector β is known a priori and denoted as:

$$\sup LM^0 = \sup LM\left(\beta_0, \Upsilon\right) \tag{9}$$

$$\gamma_L \leq \gamma \leq \gamma_U$$

The second test is used when the true cointegration vector $\tilde{\beta}$ is unknown and denoted as:

$$\sup LM = \sup LM\left(\tilde{\beta}, \Upsilon\right) \tag{10}$$

$$\gamma_L \leq \gamma \leq \gamma_U$$

In these tests, $[\gamma_L, \gamma_U]$ are the search region set so that γ_L is the π_0 percentile of $\widetilde{W}_{t-1}$ and γ_U is the (1-π_0)

percentile. We followed [24] suggestion to set the π_0 between 0.05 and 0.15. The ADF test and Johansen cointegration test are estimated through the EViews program. In the case of TVECM and SupLM test, we used the package tsDyn in the R program[2].

2.3 Data

For this analysis, we selected monthly coffee prices for the period January 2001 to December 2012. World prices were taken from the International Coffee Organization data, these prices are in nominal terms and expressed in USD/lb. For Arabica coffee, the data is taken from the category Other Milds. For Robusta coffee, we selected the only existing category. In the case of Ecuadorian prices, we used the information published by the COFENAC. For Robusta coffee, data is related to grower prices in the province of Orellana. For the Arabica coffee, the prices used are the intermediate level prices of the Loja province. Both monthly data series are measured in nominal terms and expressed in USD/lbs.

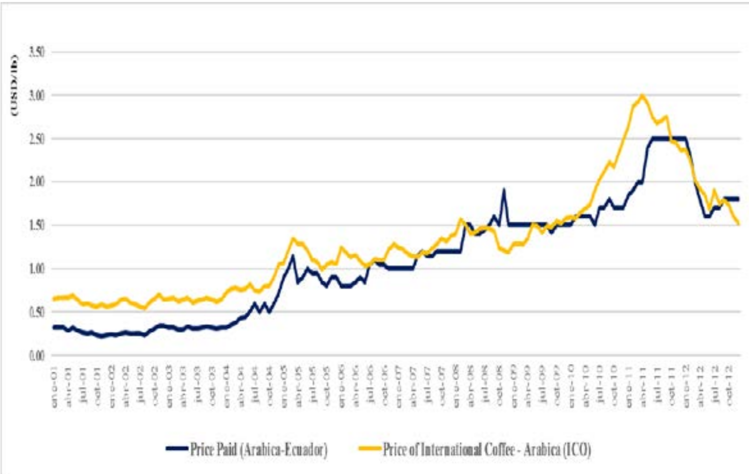

Figure 1: Prices of Arabic coffee in the world market (ICO) and Ecuador

Source: ICO (2016), COFENAC (2013)

Figure 1 shows the Arabica prices' series. Looking at the global price, we found an average of 1.30 USD/lb., a minimum of 0.54 USD/lb. for august 2002 and a maximum of 3 USD/lb. for April 2011. In the Ecuadorian market, we saw an average price of 1.09 USD/lb., a minimum price of 0.22 USD/lb. in November 2001 and a maximum price of 2.50 USD/lb. for the period June 2011 – January 2012.

For the Robusta sector, figure 2 outlines the series for the analyzed period. In the global market, the average price was 0.57 USD/lb. The minimum price was 0.23 USD/lb. registered in October 2002 and January 2003 and a maximum price of 1.22 USD/lb. in March 2008. The domestic price had an average of 0.57 USD/lb. and a minimum price of 0.08 USD/lb. in the period October 2001 - February 2002 and a maximum price of 1.08 USD/lb. in November 2011.

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[2] The tsDyn package was developed by Antonio Di Narzo, Jose Aznarte and Matthieu Stigler.

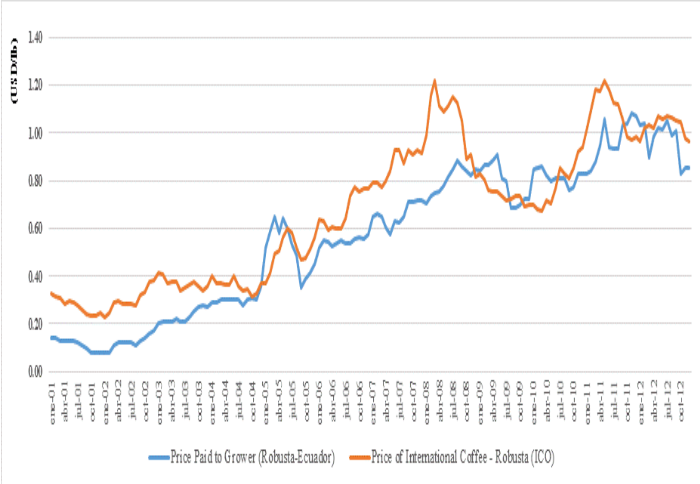

Figure 2: Prices of Robusta coffee in the world market (ICO) and Ecuador

Source: ICO (2016), COFENAC (2013)

The coffee series showed a period of decreasing prices for the years 2001 – 2002. The reason behind this was the oversupply in the world market caused by the Vietnamese expansion and the Brazilian harvesting crops [25]. Since 2004, the coffee prices followed an increasing tendency. It is explained by crop diseases and low production in the main coffee-producing countries: this affected the balance between demand and supply in the world market [26, 27]. Moreover, high prices of the mid-2011 are similar to prices of 34 years ago, but they experimented a slight reduction in 2012 [4]. Factors such as production, consumption and stock movements determine the price behavior in the world market [4].

To estimate the returns, we used the following formula: $Y_t = \log(P_t/P_{t-1})$ for each coffee price series, where P_t is the price at month t and P_{t-1} is the price at previous month.

Table 1: Summary statistic for monthly returns

	Robusta		**Arabica**	
Statistic	Pw	Pecu	Pw	Pecu
Mean	0.008	0.013	0.006	0.012
Median	0.003	0.004	0.009	0.000
Maximum	0.183	0.368	0.161	0.237
Minimum	-0.172	-0.336	-0.148	-0.302
Std. Dev.	0.061	0.083	0.058	0.086
Skewness	0.308	0.151	0.149	-0.011
Kurtosis	3.368	7.922	2.822	4.571
Observations	142	142	142	142

Table 1 provides the summary statistics for the returns of each series. We observed that domestic prices have a slightly higher mean average than international prices in both markets (Arabica and Robusta). Moreover, domestic returns are more volatile than international returns, as shown by the values of standard deviations in table 1 (0.082 for Robusta and 0.085 for Arabica).

3. Results

Table 2 shows the results of the Augmented Dickey Fuller tests for Robusta and Arabica coffee prices: one with constant and a second one with constant and trend. The lags of the dependent variable were selected according to the Akaike Information Criteria. The results showed that the both series are stationary in first differences and first integration.

Table 2: Augmented Dickey Fuller test results

	Level		First Differences	
	Constant	Constant and Trend	Constant	Constant and Trend
Log Price Paid to Ecuadorian Grower (Robusta)	-1.686	-1.068	-9.607**	-6.070**
Log Price World ICO (Robusta)	-1.112	-2.066	-9.542**	-9.516**
Log Price Paid to Ecuadorian Grower (Arabica)	-0.95	-1.75	-12.96**	-12.93**
Log Price World ICO (Arabica)	-1.16	-1.71	-10.07**	-10.06**

Note: ** denote significance at the 5% significance levels.

To estimate the volatility in the Ecuadorian coffee, we performed the Box-Jenkins methodology and chose p, d and q values for the process with the Akaike information criteria. Table 3 presents the values of p (AR terms), d (differentiated series) and q (Ma terms) of each ARIMA process.

Table 3: Values of p, d and q for ARIMA process in Ecuadorian coffee series

Ecuadorian coffee	**p**	**d**	**q**
Robusta	0	1	2, 6 y 10 *
Arabica	0	1	12, 29 y 31 **

Note: ** and * denote significance at the 5% and 10% significance levels

Source: Own Elaboration

From table 3, we observed the following: the absence of AR terms for both coffee series, d takes the value of 1 for both processes, indicating that the series is differenced once to be stationary. For MA terms, we found 2, 6 and 10 for Robusta and 12, 29 and 31 for Arabica. The estimated coefficients can be evaluated for their statistical significance with a 10% for Robusta and 5% for Arabica[3].

Table 4: Regression results of ARCH model for Ecuadorian coffee

Robusta				
Mean Equation				
Variable	**Coefficient**	**Std. Error**	**z-Statistic**	**Prob.**
C	0.012382	0.007137	1.734875	0.0828*
MA(2)	0.138146	0.080959	1.706367	0.0879*
MA(10)	0.190335	0.076192	2.498086	0.0125**
MA(6)	-0.147286	0.057609	-2.556639	0.0106**
Variance Equation				
C	0.004423	0.000499	8.872025	0.0000**
ε^2_{t-1}	0.171429	0.060007	2.856819	0.0043**
Arabica				
Mean Equation				
Variable	**Coefficient**	**Std. Error**	**z-Statistic**	**Prob.**
C	0.016879	0.003181	5.306505	0.0000**
MA(12)	-0.261248	0.051833	-5.040209	0.0000**
MA(29)	-0.381524	0.065541	-5.821174	0.0000**
MA(31)	-0.278866	0.059330	-4.700279	0.0000**
Variance Equation				
C	0.003508	0.000678	5.171318	0.0000**
ε^2_{t-1}	0.170171	0.090545	1.879398	0.0602*

Note: ** and * denote significance at the 5% and 10% significance levels

Source: Own Elaboration

Table 4 showed the ARCH model for each coffee variety. For Robusta, we denoted the significance of estimated coefficients with a confidence level of 5% and 10% for the mean average (ARIMA process) and variance (ARCH process) equation. In the case of Arabica, we observed the same success described previously. With these results, we observed the effect of past innovations (ε^2_{t-1} term) in variance for each coffee variety. Figures 4 and 5 show the level volatility present in the Ecuadorian coffee market for both varieties. It is important to note periods of high volatility (2001 – 2002) and (2004 – 2005) for Robusta coffee. Since 2006, the level of volatility is reduced when compared to previous years. For the Arabica market, we observed the same pattern for the periods (2002 – 2003) and (2004 – 2005), but a different behavior (periods with high volatility) for the rest of the analyzed period. These facts are presented by the international price movements, which affect

[3] We tested seasonal fluctuations with dummy variables (monthly) and not to found significance in two coffee varieties process.

domestic markets as described in the previous section. Coffee production is the principal market factor that affects the volatility, the weather is an exogenous factor that carries periods with a short or over production in coffee-producing countries, and this fact carries speculative factors in the price in the coffee market [4].

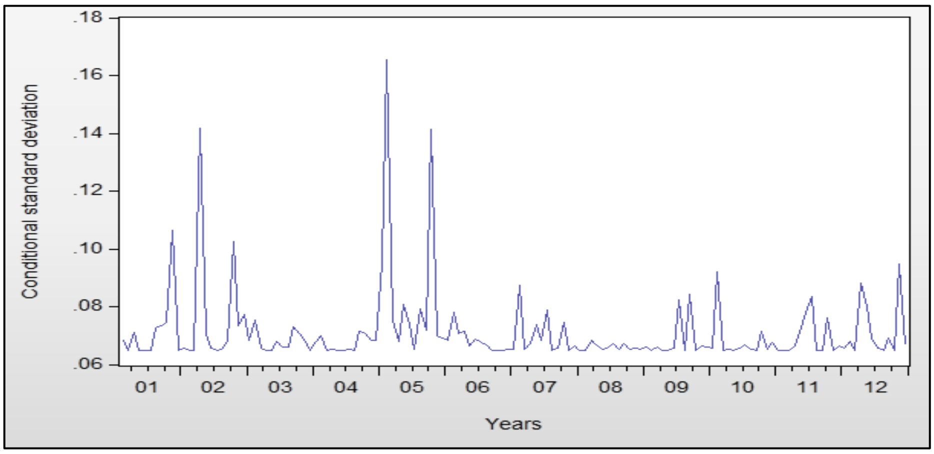

Figure 3: Volatility for Robusta coffee in Ecuador

Source: Own estimation

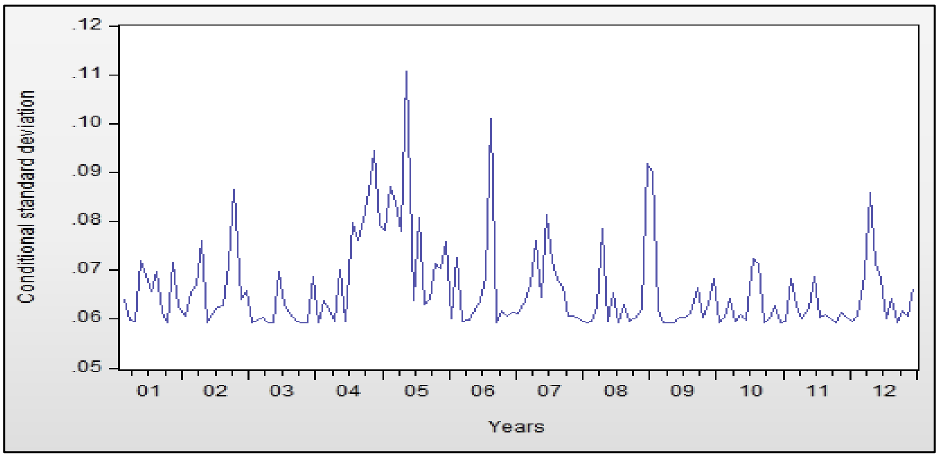

Figure 4: Volatility for Arabica coffee in Ecuador

Source: Own estimation

For the asymmetry price transmission, we worked with the results of table 2. Next, we performed the Johansen cointegration test to evaluate the cointegration relationship of world prices and Ecuadorian prices per variety. Lastly, we estimated the (TVECM) threshold vector error correction model for Robusta and Arabica coffee.

We used the Johansen cointegration test to evaluate the existence of a long-run relationship between World coffee and Ecuadorian coffee prices. Table 5 shows the results of the test for the international-domestic relationship. The results explained a long-run relationship between world and Ecuadorian prices for both coffee varieties.

Table 5: Johansen cointegration test results

Robusta (Ecuador-Word Price)				
Hypothesized no. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.210779	5.719963	1.549471	0.0000
At most 1 *	0.162874	2.453378	3.841466	0.0000
Arabica (Ecuador-Word Price)				
Hypothesized no. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.200111	5.205288	1.232090	0.0000
At most 1 *	0.142653	2.123985	4.129906	0.0000

Trace test indicates 2 cointegration equations at the 5% level

* Denote the rejection of the null hypothesis at the 5% level

** MacKinnon and his colleagues. (1999) p-values.

Source: Own Elaboration

Now, with the existence of a cointegration relationship, we estimated the TVECM for Robusta and Arabica coffee. The estimated of TVECM model for Robusta is presented below (Eicker-White standard errors are reported between brackets):

$$\Delta\text{Pecu} = \begin{cases} -0.1768 \; - 0.8543w_{t-1} - 1.2775\Delta Pecu_{t-1} + 0.0978\;\Delta Pw_{t-1} + u_{1t}, \;\; w_{t-1} \leq -0.0947, \\ (0.0054) \quad (0.0484) \qquad\quad (0.00002) \qquad\qquad (0.8271) \\ 0.0091 - \; 0.6220w_{t-1} - 0.1010\Delta Pecu_{t-1} \; + 0.2467\Delta Pw_{t-1} + u_{2t}, \qquad w_{t-1} > -0.0947. \\ (0.1978) \quad (6.1\;x\;10^{-8}) \qquad\quad (0.2172) \qquad\qquad (0.0069) \end{cases}$$

$$\Delta Pw = \begin{cases} -0.0705 \; - 0.5236w_{t-1} + 0.0740\Delta Pecu_{t-1} - 0.2236\Delta Pw_{t-1} + u_{1t}, \; w_{t-1} \leq -0.0947, \\ (0.2215) \quad (0.1856) \qquad\quad (0.7839) \qquad\qquad (0.5866) \\ 0.0108 - 0.3930w_{t-1} + 0.1021\Delta Pecu_{t-1} - 0.3431\Delta Pw_{t-1} + \; u_{2t}, \qquad w_{t-1} > -0.0947. \\ (0.0963) \quad (0.0001) \qquad\quad (0.1744) \qquad\qquad (0.00005) \end{cases}$$

The lag length (*l*=1) of the TVECM was selected according to the Akaike information criteria (AIC). The estimated threshold is Y = - 0.0947. The estimated value of β is equal to -0.15. The first regime included 8.5% of the observations when w_{t-1} (Error Correction Term - ECT) is ≤ - 0.0947 (this regime is considered as the unusual regime). The second regime incorporated 91.5% of the observations when w_{t-1} is > - 0.0947 (this regime is considered the usual regime). Next, we carried out the [10] Sup LM test of estimated β, the result (*p*-value = 0.01) supported a threshold cointegration relationship at 1% level of confidence.

In the ΔPw equations, we found that the (- 0.5236) ECT coefficient in the unusual regime was not statistically significant. On the other hand, the usual regime showed significance at 1%. Moreover, the (0.0740 and 0.1021)

$\Delta Pecu_{t-1}$ estimated coefficients were not significant in either regime. In the case of $\Delta Pecu$ equations results, the ECTs estimated coefficients were statistically significant in both regimes. The - 0.8543 ($\Delta Pecu$ ECT coefficient) showed a fast adjustment to the long-run equilibrium in the unusual regime. Similar behavior is presented in the usual regime with a -0.6220 ECT coefficient result. Therefore, we can see a strong adjustment in the unusual regime and a moderate adjustment in the usual regime. It means that the Ecuadorian price converges in different magnitudes towards the long-run equilibrium.

For the Arabica model, we have the following specification (Eicker-White standard errors are reported between brackets):

$$\Delta \text{Pecu} = \begin{Bmatrix} 0.0118 - 1.0628 w_{t-1} - 0.0923 \Delta Pecu_{t-1} - 0.0834\, \Delta Pw_{t-1} + u_{1t}, & w_{t-1} \leq 0.0678, \\ (0.1570) \quad (0.000) \qquad (0.3597) \qquad (0.4719) & \\ -0.0111 - 0.8593 w_{t-1} - 0.1714 \Delta Pecu_{t-1} + 0.0726 \Delta Pw_{t-1} + u_{2t}, & w_{t-1} > 0.0678. \\ (0.7938) \quad (0.0297) \qquad (0.4358) \qquad (0.8031) & \end{Bmatrix}$$

$$\Delta Pw = \begin{Bmatrix} 0.0067 + 0.10566 w_{t-1} - 0.1670 \Delta Pecu_{t-1} - 0.0834 \Delta Pw_{t-1} + u_{1t}, & w_{t-1} \leq 0.0678, \\ (0.2603) \quad (0.4217) \qquad (0.0218) \qquad (0.0000) & \\ -0.1358 + 0.7120 w_{t-1} + 0.0156 \Delta Pecu_{t-1} - 0.2223 \Delta Pw_{t-1} + u_{2t}, & w_{t-1} > 0.0678. \\ (0.0000) \quad (0.0122) \qquad (0.9209) \qquad (0.2876) & \end{Bmatrix}$$

We selected the lag = 1 according with the Akaike information criteria. The estimated threshold value is Y = 0.0678. The β estimated value is 0.399. The first regime included 81.6% of the observations when w_{t-1} is ≤ 0.0678 (this regime is considered as the usual regime). The second regime (unusual) incorporated the 18.4% of the observations (w_{t-1} takes values > 0.0678). We performed the Hansen and Seo (2002) Sup LM test of β estimated, the p-value = 0.09 is significant at 10% level; it means the existence of a threshold cointegration relationship. For the ΔPw equations, the (0.1056) ECT coefficient in the usual regime was not statistically significant, the unusual regime showed a value of 0.7120 with a significance of 1%. The (-0.1670 and 0.0156) $\Delta Pecu_{t-1}$ estimated coefficients' results were not significant in both regimes. For Ecuador ($\Delta Pecu$) equations, the ECTs estimated coefficients were statistically significant in both regimes at 1% and 5% levels. The $\Delta Pecu$ ECT coefficient takes the values of -1.0628 for the usual regime and -0.8593 for the unusual regime. We observed different magnitude in the adjustment to converge toward the long-run equilibrium (the usual regime converges faster than unusual regime).

4. Conclusion

4.1. Discussion

The assessment of volatility of the Robusta and Arabica coffee markets in Ecuador showed the level of exposure faced by the sector. Our results are in accordance with other coffee volatility studies showing similar levels of price volatility faced by growers and firms [1, 2, 3, 28, 29]. Their studies show that growers are the most affected by the volatility in the market. In our study, most periods of high volatility were 2001 – 2002 and 2004 - 2005 for Robusta coffee. We observed a reduction of volatile behavior since 2006 for the same coffee variety. A similar pattern is found in the study by [2].

In Arabica coffee, we observed the same periods of high volatility described for Robusta coffee, but a different behavior is presented since 2006 (high volatility periods). We observed similar results in [1, 29] studies. However, we noticed a different behavior in [2] study for 2006 – 2010 period, which showed low periods of volatility in the domestic market. Our study reveals that Arabica coffee prices are more volatile than Robusta coffee prices since 2006. The importance of taking the concept of volatility into consideration in investment decisions is evaluated by [11], which showed that volatility was a critical factor that pushes growers to leave the activity in Ecuador. This finding could give more information to policy makers in the design of program for growers.

The cointegration results showed an asymmetry in the Ecuadorian coffee (Robusta and Arabica) sector. The different adjustment speeds found in the regimes confirm the existence of asymmetric transmission in the coffee sector. Our results corroborate findings from others studies on asymmetric price transmission. Market drivers (market liberalization) have been studied in other coffee-producing countries like Colombia, El Salvador, India, Tanzania, Zambia and Ethiopia. The main conclusion is that growers are the most affected part of the production chain in low price periods [5, 6, 22]. Our study indicates that Arabica prices converge faster than Robusta prices in the long-run equilibrium. This is represented by the magnitude value of ECT estimated coefficients. The Ecuadorian coffee market operates in a free competitive environment, but the presence of asymmetry in the market is detrimental for growers and their incomes, and sustainability of the activity in the long-run.

4.2. Conclusion

The world market of coffee creates an uncertain and volatile environment. Growers are the most affected agents in the chain of production because of the transmission of the prices and volatility effects. Upstream agents transmit low prices rapidly to growers. However, in increasing price periods, the economic agents do not react in the same way with regards to the growers [6, 22].

This reality is known as asymmetry. It happens when there are different adjustment speeds in price movements in the long-run equilibrium. Market power, adjustment costs and menu cost are the factors that influence the existence of asymmetry in the market [7]. Ecuadorian coffee participants work in a free competitive market. It is regulated by the government. Over the last years, growers decided to leave the sector because of low production and financial unprofitability. This has raised concerns in the Ecuadorian government and motivated it to create a support program to reactivate the sector since the end of 2011. However, all these efforts should go along with a fair competitive market to achieve the desired success. In the case of an asymmetric market, incentives for growers are diminished; policy makers should determine it and correct it. This paper aimed to quantify the volatility of Robusta and Arabica coffee in Ecuador and evaluate the existence of asymmetric price transmission from world prices to Ecuadorian prices for both coffee varieties. We used the data from ICO and COFENAC for the period January 2001 – December 2012. We used an ARCH model to quantify the volatility in the sector and estimated a threshold vector error correction model (TVECM) with the [10] methodology for both coffee varieties to validate the existence of asymmetric price transmission. The results confirmed the asymmetry in the prices for the Robusta and Arabica varieties. This is explained by different adjustment speeds when converging towards the long-run equilibrium in the two regimes for both coffee varieties. Additionally, we found faster adjustment speeds for Arabica than for Robusta coffee. Moreover, we quantified the volatility for the two coffee varieties. This study found high periods of volatility for both coffee varieties. Since 2006, the volatility in Robusta coffee has been reduced considerably. However, we observed a different behavior in Arabica coffee (high volatility periods). [11] showed that volatile and uncertain environments drive growers out of the sector. Therefore, it is important to consider this when making investment decisions in the sector. As coffee growers work in a volatile and asymmetric environment, the government should work on a policy and program that protects growers from the distortion of the market, from which they are the most vulnerable agents. This policy would promote a fair and competitive environment for growers producing either of the two coffee varieties as well as an incentive to maintain it.

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