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COFFEE COMMODITY CHAIN

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ABSTRACT:

To explain the value added along the coffee commodity chain we propose and estimate a theoretical model of the coffee commodity chain. The theoretical model consists of four markets and five agents in the coffee commodity chain and predicts that prices in the coffee commodity chain move together but are also influenced by income, technology and production. A vector error correction model is used to test the theoretical predictions. In addition to the theoretical conclusions the empirical model confirms the beneficial role of the International Coffee Agreement and the importance of the level of production in determining coffee prices.

Key words: global commodity chain, vector error correction model, coffee, value added
JEL classifications: O01, F02, Q110, C320, F230, F14

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Coffee Commodity Chain

1. Introduction

Between being grown and picked by a farmer in a developing country and being consumed, most often in a developed country, coffee passes through many sets of hands. Inspired by the global commodity chain literature we here propose a theoretical and an empirical model of the coffee commodity chain.

We want to find out what determines the value added at each stage of the commodity chain. The question touches upon the distribution of income among agents and countries in the commodity chain, the prevailing market structure at each stage of the production process, trade, bargaining power and other factors influencing the commodity chain. Figure 1 provides a graphical representation of the value chain for coffee in Brazil, Colombia and the US.

[Figure 1]

Value added at the various stages of the chain is the difference between input and output price. For Brazil and Colombia *producer's share* is producer price and *processing and transport* is export price minus producer price. For Brazil *international processing and transport* is the difference between import price of Brazilian coffee in US and the export price in Brazil and *processing in US* is the US retail price minus the import price of Brazilian coffee in the US. For Colombia *processing in US and transport* is the difference between the US retail price and the Colombian export unit value.

Regarding weight-loss due to roasting, green coffee is the commodity at all stages of the chain until it reaches the consumer. We follow one pound of green coffee along the commodity chain and multiply the retail price by 0.8 since coffee looses 20% of the weight in roasting (Daviron and Ponte, 2005, p. 242, n. 5).

Figure 1 shows that the share of value added acquired by Brazil and Colombia has decreased after 1948. Behind this observation lies that the share to producers has decreased in Colombia but remained roughly constant in Brazil while the shares to domestic processing and transport have decreased in both countries, in particular after 1990. What we attempt to explain by this analysis are the decreasing shares of income to producing countries and the disappearing margins to exporters.

The framework of this analysis is global commodity chains, terms of trade literature and price transmission literature. Commodity chains for coffee are described by Talbot (1997; 2002) and Ponte (2002). Commodity chain analysis focuses on the good along the nodes of the chain, and looks at the flow of the good through the commodity chain, the transactions which take place along the chain, the geographical location of the chain, the agents involved in the chain, and the rules governing the chain (Talbot, 2002).

North-South trade and growth literature is relevant in the analysis of commodity chains to model the terms of trade between North and South. Darity and Davis (2005) argue that in the study of uneven development the North-South trade and growth literature provides insights which have been neglected by the later literature of new growth theory and new trade theory. This has encouraged us to apply North-South models to the coffee value chain. The theoretical model derived in section 2 builds on Bloch and Sapsford (2000) who model primary commodities used as inputs in the production of manufacturing. Where Bloch and Sapsford (2000) take an aggregate view of primary commodities and manufactures, we here focus on coffee and hereby take an approach similar to Boratav (2001) who examines terms of trade for individual commodities. And just like Bloch, Dockery, and Sapsford (2004) we analyse the effect of mark-up on wages and commodity prices on the final consumer prices.

Price transmission literature such as Hazell, Jaramillo, and Williamson (1990), Mundlak and Larson (1992), Baffes and Gardner (2003), Krivonos (2004), Morisset (1998) and Weldegebriel (2004) also offer a framework to analyse prices of commodities at different nodes of the commodity chain. This part of the literature views producer and retail prices as determined by world prices. In Bloch and Sapsford (2000) the price of manufactures, which is a good higher up in the value chain if it is interpreted as roasted coffee, is a function of the price of primary products because primary products are inputs in the production of manufactures. In the transmission literature it is assumed that the price formation happens in the world market and that market forces allow prices movements to trickle down to producers and consumers. The price trickles down because of trade, price signals and arbitrage.

The causality between world prices and producer prices is therefore opposite in the terms of trade literature and the price transmission literature. The contradiction is created because the value chain literature focuses on the flow of goods while the transmission literature focuses on the flow of information and market signals. We can look at the problem in multiple time frames. In the long run, prices may be determined by economic fundamentals and can be modelled according to the terms of trade literature. In the short run the price may be a result of the global market situation and the transmission literature is applicable. We here propose a theoretical model which builds on the terms of trade literature but the same time accommodates features from the price transmission literature.

The choice of countries in the empirical model poses the main limitation of the empirical analysis. Coffee is consumed in all countries across the world and production statistics are available for 71 countries[1]. Though an analysis comprising all consuming and producing countries is possible, the approach here is to only look at a few countries. The countries for analysis in this study are the largest producer, Brazil, the largest consumer, US, and Colombia as a country which depends heavily on coffee.[2]

In the following, the theoretical model is presented in section 2. The empirical model, data and preliminary data analysis are presented in section 3 and section 4 reports the results. The theoretical hypotheses and empirical results are evaluated in section 5, which concludes.

2. Theoretical Model

The commodity chain, which spans from producers to consumers, is modelled in the form of the prices at each node of the chain. The model builds on Bloch and Sapsford (2000), but instead of primary commodities and manufactures, we here follow the same commodity along the chain and the commodity is an input in the production at the next stage of the chain.

The producer and intermediary one (often the exporter) meet in market one where the producer price is determined. In market two intermediary one sells the commodity to intermediary two (often the importer) for the export price. In market three intermediary two sells the commodity to intermediary three (often the roaster) for the import price. Finally in market four intermediary three sells the commodity to the consumer and receives the retail price. The model has this set of agents to reflect what price data is available at the various stages of the supply chain.

Except for intermediary three, each agent takes the price and quantity produced in other markets as given. This assumption makes the markets separable. Intermediary three determines the price in market four by mark-up and we hereby follow Bloch and Sapsford (2000) in the assumption of different market structures in developing and developed countries. The assumption of imperfect competition in market four reflects the high concentration in the coffee roasting sector as described by Talbot (1997).

The commodity is produced by the farmer according to the production function

$$G = Ae^{\alpha_0 t} L_G^{\alpha_1} T^{\alpha_2} \varepsilon_G . \quad (1)$$

Where, in the case of coffee, G is green coffee, L_G is the labour input in coffee production, T the number of coffee trees and ε_G is a random disturbance term, such as weather. t is time and represents technological progress in the production techniques. α_0, α_1 and α_2 are elasticities of inputs and technology. The number of trees is assumed to be fixed in the short term and is therefore not a variable input.

Exporters constitute the demand side in market one. They have the production function:

$$X = Be^{\beta_0 t} L_X^{\beta_1} G^{\beta_2} \varepsilon_X , \tag{2}$$

where *X*, in the case of coffee, is green coffee packed, sorted and graded and located in the producing country. L_X is the labour input necessary to export the product. It should be noted that green coffee, which is the output produced by the farmer according to the production function (1), is an input in the exporter's production function. As before, *t* represents technological progress and β_0, β_1, and β_2 are elasticities of inputs and technology. The shocks, ε_X, may represent strikes or other random shocks to the production process.

The production functions for importers and roasters are defined in a similar manner with coffee from the previous part of the chain as an input.

$$M = De^{\gamma_0 t} L_M^{\gamma_1} X^{\gamma_2} \varepsilon_M \tag{3}$$

$$R = Fe^{\delta_0 t} L_R^{\delta_1} M^{\delta_2} \varepsilon_R \tag{4}$$

Equation (3) is the production function for importers and equation (4) is the production function for roasters. M is green packed and sorted coffee imported into the consuming country. *R* is roasted and ground coffee sold in retail. The importer employs labour L_M and the roaster employs labour L_R.

The factor prices are as follows. The price of L_G is the wage rate in agriculture, w_G; the price of L_X is the wage paid by exporters, w_X. The price of L_M is w_M and the price of L_R is w_R. Coffee at stage *J* of processing has price p_J, e.g. *G* has the price p_G.

It is assumed that all inputs have positive but diminishing marginal products in all four production functions: $1 > \alpha_1 > 0$, $1 > \alpha_2 > 0$, $1 > \beta_1 > 0$, $1 > \beta_2 > 0$, $1 > \gamma_1 > 0$, $1 > \gamma_2 > 0$,

$1 > \delta_1 > 0$ and $1 > \delta_2 > 0$. It is also assumed that inputs together do not give rise to increasing returns to scale: $\alpha_1 + \alpha_2 < 1$, $\beta_1 + \beta_2 < 1$, $\gamma_1 + \gamma_2 < 1$ and $\delta_1 + \delta_2 < 1$.

2.1 Price Determination in Market One

In market one we assume perfect competition and the price paid to farmers, p_G, is determined by equilibrium in the market with demand and supply for green coffee. Supply is determined by profit-maximising coffee farmers and demand by profit-maximising exporters.

Profit maximisation gives the supply function:

$$p_G = w_G \alpha_1^{-1} \left[A e^{\alpha_0 t} T_G^{\alpha_2} \varepsilon_G \right]^{-1/\alpha_1} G^{(1-\alpha_1)/\alpha_1}. \quad (5)$$

The optimal amount of coffee demanded by the exporter who profit maximises is:

$$G = \left[\left(p_X B e^{\beta_0 t} \varepsilon_X \right) p_G^{\beta_1 - 1} \beta_2^{1-\beta_1} w_X^{-\beta_1} \beta_1^{\beta_1} \right]^{1/(1-\beta_1-\beta_2)}. \quad (6)$$

The equilibrium price in market one is derived by equating supply given by equation (5) and demand in equation (6):

$$\ln(p_G) = a_0 + a_1 \ln(p_X) + a_2 \ln(w_G) + a_3 \ln(w_X) + a_4 \ln(T) + a_5 t + \mu_G \quad (7)$$

Where

$$a_0 = \phi \alpha_1 (1-\beta_1-\beta_2) \ln\left(\alpha_1^{-1} A^{-1/\alpha_1} \left(B \beta_2^{1-\beta_1} \beta_1^{\beta_1} \right)^{(1-\alpha_1)/[\alpha_1(1-\beta_1-\beta_2)]} \right),\ a_0 > 0 \quad (8)$$

$$a_1 = \phi(1-\alpha_1),\ a_1 > 0 \quad (9)$$

$$a_2 = \phi \alpha_1 (1-\beta_1-\beta_2),\ a_2 > 0 \quad (10)$$

$$a_3 = -\phi \beta_1 (1-\alpha_1),\ a_3 < 0 \quad (11)$$

$$a_4 = -\phi \alpha_2 (1-\beta_1-\beta_2),\ a_4 < 0 \quad (12)$$

$$a_5 = \phi\left(\beta_0 (1-\alpha_1) - \alpha_0 (1-\beta_1-\beta_2) \right) \quad (13)$$

$$\dot{\mu}_G = \phi\left((1-\alpha_1) \ln(\varepsilon_X) - (1-\beta_1-\beta_2) \ln(\varepsilon_G) \right) \quad (14)$$

$$\phi = \left(1 - \beta_1 - \alpha_1\beta_2\right)^{-1} \tag{15}$$

The coefficients will be interpreted in section 2.5 below together with the rest of the coefficients of the model.

2.2 Price Determination in Market Two

In market two exporters sell to importers. The price is again determined by equilibrium between demand and supply. Supply is determined by profit maximisation by exporters and demand by profit-maximising importers.

Supply in market two by the exporter is calculated from what amount of coffee is demanded in market one:

$$X = \left[Be^{\beta_0 t} p_X^{\beta_1+\beta_2} \varepsilon_X p_G^{-\beta_2} \beta_2^{\beta_2} w_X^{-\beta_1} \beta_1^{\beta_1}\right]^{1/(1-\beta_1-\beta_2)} \tag{16}$$

The demand function by importers is derived by profit maximisation in a similar manner to the derivation of the demand function for exporters above. Making use of the symmetry of the production functions, the demand function is similar to (6). The price in market two is determined by equating demand and supply:

$$\ln(p_X) = b_0 + b_1 \ln(p_G) + b_2 \ln(p_M) + b_3 \ln(w_X) + b_4 \ln(w_M) + b_5 t + \mu_X \tag{17}$$

where the b's are:

$$b_0 = \varphi\left[(\gamma_1+\gamma_2-1)\ln\left(B\beta_2^{\beta_2}\beta_1^{\beta_1}\right) + (\beta_1+\beta_2-1)\ln\left(\gamma_2^{\gamma_1-1}\gamma_1^{-\gamma_1}D^{-1}\right)\right],\ b_0 > 0 \tag{18}$$

$$b_1 = -\varphi\beta_2(\gamma_1+\gamma_2-1),\ b_1 > 0 \tag{19}$$

$$b_2 = \varphi(1-\beta_1-\beta_2),\ b_2 > 0 \tag{20}$$

$$b_3 = \varphi\beta_1(1-\gamma_1-\gamma_2),\ b_3 > 0 \tag{21}$$

$$b_4 = -\varphi\gamma_1(1-\beta_1-\beta_2),\ b_4 < 0 \tag{22}$$

$$b_5 = \varphi\left[\beta_0(\gamma_1+\gamma_2-1) + \gamma_0(1-\beta_1-\beta_2)\right] \tag{23}$$

$$\mu_X = \varphi\left(\left(\gamma_1 + \gamma_2 - 1\right)\ln(\varepsilon_X) + \left(1 - \beta_1 - \beta_2\right)\ln(\varepsilon_M)\right) \tag{24}$$

$$\varphi = \left(1 - \gamma_1 - \gamma_2(\beta_1 + \beta_2)\right)^{-1} > 0 \tag{25}$$

2.3 Price Determination in Market Three

In market three, intermediary three purchases green coffee from intermediary two, or in the example of Brazil, the roasters purchase the coffee from the importers and produce roasted coffee according to the production function (3). The roasters' demand and the importers' supply are again given by profit maximisation. Given the similar production functions for roasters and importers, the derivations of the equilibrium price are as for market two. The equilibrium price is (expected signs in parentheses under the coefficients):

$$\ln(p_M) = \underset{+}{c_0} + \underset{+}{c_1}\ln(p_X) + \underset{+}{c_2}\ln(p_R) + \underset{+}{c_3}\ln(w_M) + \underset{-}{c_4}\ln(w_R) + \underset{+/-}{c_5}\,t + \mu_M \tag{26}$$

The signs of the coefficients are determined in a similar way as in market two since the market set-ups are identical.

2.4 Price Determination in Market Four

In market four the price is not determined by supply and demand, but rather by a mark-up on the unit cost function because of imperfect competition. This is one of the conclusions by Prebisch (1950) and Singer (1950) which Bloch and Sapsford (2000) also model. The price is determined by:

$$p_R = m\left[\frac{L_R w_R}{R} + \frac{p_M M}{R}\right] \tag{27}$$

Where m is the mark-up. To derive p_R the cost-minimising demands for labour and green coffee are derived and inserted into (27) which gives the price of roasted coffee:

$$\ln(p_R) = d_0 + d_1\ln(R) + d_2\ln(p_M) + d_3\ln(w_R) + d_4\ln(m) + d_5 t + \mu_R \tag{28}$$

where

$$d_0 = (\delta_1+\delta_2)^{-1}\ln(B) + \delta_1\left(\delta_1+\delta_2\right)^{-1}\ln\left(\delta_2\delta_1^{-1}\right) + \delta_2\left(\delta_1+\delta_2\right)^{-1}\ln\left(\beta_1\beta_2^{-1}\right),\ d_0 > 0 \quad (29)$$

$$d_1 = \left(\delta_1+\delta_2\right)^{-1}\left(1-\delta_1-\delta_2\right),\ d_1 > 0 \quad (30)$$

$$d_2 = \left(\delta_1+\delta_2\right)^{-1}\delta_2,\ d_2 > 0 \text{ and } d_3 = \delta_1\left(\delta_1+\delta_2\right)^{-1},\ d_3 > 0 \quad (31)$$

$$d_5 = -\delta_0\left(\delta_1+\delta_2\right)^{-1} < 0,\ d_5 < 0 \quad (32)$$

$$\mu_R = -\left(\delta_1+\delta_2\right)^{-1}\ln(\varepsilon_R) \quad (33)$$

2.5 Hypotheses

Before commencing to estimate the system of the four equations, equation (7), (17), (26) and (28), it is necessary to address data limitations. To test the four equations for the coffee market it is necessary to have wages in coffee farming, wages in the coffee-exporting sector, wages in the coffee-importing sector and wages in the coffee-roasting sector. These wage data are not available and the wages in producing countries, w_G and w_X, will be approximated with the gross domestic product (GDP) per capita in producing countries, y_P. Wages in the importing sector and the roasting sector in the consuming country, w_M and w_R, are approximated with the GDP per capita for a consuming country, y_C.

In addition to data on wages, data on coffee trees limit the empirical analysis since data for coffee trees or acreage are not available for the desired timeframe of the analysis. The quantity of coffee trees enters equation (7) and coffee production enters equation (28). Both variables are in the empirical model represented by world coffee production.

The alterations to the theoretical model, give the following four equations:

$$p_G = \underset{+}{a_0} + \underset{+}{a_1}\, p_X + \underset{+/-}{a_2^*}\, y_P + \underset{-}{a_4}\, q + \underset{+/-}{a_5}\, t + \mu_G \quad (34)$$

$$p_X = \underset{+}{b_0} + \underset{+}{b_1}\, p_G + \underset{+}{b_2}\, p_M + \underset{+}{b_3}\, y_P + \underset{-}{b_4}\, y_C + \underset{+/-}{b_5}\, t + \mu_X \tag{35}$$

$$p_M = \underset{+}{c_0} + \underset{+}{c_1}\, p_X + \underset{+}{c_2}\, p_R + \underset{+/-}{c_3^*}\, y_C + \underset{+/-}{c_5}\, t + \mu_M \tag{36}$$

$$p_R = \underset{+}{d_0} + \underset{+}{d_1}\, q + \underset{+}{d_2}\, p_M + \underset{+}{d_3}\, y_C + \underset{1}{d_4}\, m + \underset{-}{d_5}\, t + \mu_R \tag{37}$$

The expected signs of the parameters are indicated under the respective parameters; +/– indicate that the sign is uncertain from the adjusted theoretical model. World production is q, and the coefficients on income in market one and three are defined as:

$$a_2^* = a_2 + a_3 = \phi^{-1}\left(\alpha_1(1-\beta_2) - \beta_1\right) \tag{38}$$

$$c_3^* = c_3 + c_4 = \left[\gamma_1(1-\delta_2) - \delta_1(1-\gamma_2)\right]\left(1-\gamma_1-\gamma_2(\beta_1+\beta_2)\right)^{-1} \tag{39}$$

The coffee commodity chain model consists of the four simultaneous equations in equation (34) to (37) from which hypotheses can be derived.

Firstly, it is apparent that all prices are positively correlated. An increase in the price of coffee in market *i–1* (increased input price) shifts the supply curve in market *i* left since it increases marginal costs and the equilibrium price is higher and the quantity traded lower. An increase in the price of coffee in market *i+1* increases the supply in market *i+1* and hereby the demand for coffee in market *i* and increases the price in market *i*.

Secondly, the coefficients on national incomes have mixed signs. They depend on the input elasticities of labour at different nodes of the chain. If the input elasticity of labour in coffee growing (importing) is relatively large compared to the input elasticity of labour in coffee exporting (roasting) then a_2^* (c_3^*) will be positive. It may be assumed that production processes are relatively more labour-intensive early in the commodity chain because of less reliance on capital. In market two the coefficient on producer income is positive because it is an input price for exporters. In contrast consumer income is an input price for importers and decreases the export price. The coefficient on income, d_3, in market four expresses a mark-up, and is positive. Overall coefficients on national incomes are expected to pull coffee prices up, only with the exception of the income in the consuming country which is assumed to depress the export price of coffee.

Thirdly, coffee production has a positive impact on the retail price, but a negative impact on the producer price. It is expected that the effect of output is largest on the producer price because prices paid to producers are primarily influenced by conditions in the coffee market while the retail prices in consuming countries are outcomes of many factors, such as market structures, wages and technology. In a system with all four equations the coefficient on production is therefore expected to be negative.

Fourth, the effects of technological change on the prices in markets one, two and three are uncertain, and negative for the retail price in market four. If it is assumed that production methods become more technologically progressive the higher up they are in the chain, the coefficients on the time trend will be positive in market one, two and three.

Constants a_0, b_0, c_0 and d_0, are positive but do not have any economic interpretation. μ_G, μ_X, μ_M and μ_R are random shocks with expected value zero. μ_G, μ_X and μ_M are linear combinations of shocks to production in two markets. Therefore, the residuals generated by estimation of equations (34), (35), (36) and (37) are not independent of each other. Furthermore, any given price in the commodity chain depends on the prices at the previous and next stage of the chain. The four equations are hence simultaneous, and the econometric model accommodates for this.

3. Econometric Model and Preliminary Data Analysis

Annual data from 1948 to 2004 are employed to estimate the theoretical model. An empirical analysis of the commodity chain for coffee from a single origin in a time series framework is not possible due to data limitations. Instead eight price series are used. These are producer and export prices in Brazil and Colombia, import price of Brazilian coffee into the US, import unit value of (all) coffee in the US, the world price and the US retail price of coffee.

Given the non-stationarity of the time series used to estimate the model, a vector error correction model (VECM) is appropriate. A VECM captures long-run paths of the series in the cointegrating vectors and short-run dynamics in the error correction equations. It is formulated as:

$$\Delta\mathbf{y}_t = \alpha\beta'\mathbf{y}_t + \Gamma_1\Delta\mathbf{y}_{t-1} + \cdots + \Gamma_{p-1}\Delta\mathbf{y}_{t-p+1} + \mathbf{u}_t, \qquad (40)$$

where $\mathbf{y}_t = \left(p_t^{G,B}, p_t^{G,C}, p_t^{X,B}, p_t^{X,C}, p_t^{M,B}, p_t^{W}, p_t^{M,US}, p_t^{R}, y_t\right)'$, α is the loading vector of coefficients on error correction terms, β is the coefficient vector for the cointegrating vector, Γ_j is the coefficient matrix on lag *j* and $\mathbf{u}_t$ is the vector of error terms. $p_t^{G,j}$ and $p_t^{X,j}$ are respectively the producer and the export price in country *j*, where *B* is Brazil and *C* is Colombia. $p_t^{M,US-B}$ is the import price of Brazilian coffee in the US, $p_t^{M,US}$ is the import price of (all) coffee in the US, p_t^{W} is the world price and $p_t^{R,US}$ is the retail price in the US. y_t is relative income between consuming and producing countries and is used to avoid that the rank of $\mathbf{\Pi} = \alpha\beta'$ is not higher than the number of truly endogenous variables.

According to the theoretical model national incomes have an impact on coffee prices, but coffee prices do not have an impact on national incomes. This is though not true for Brazil and Colombia for parts of the sample. Today Brazil and Colombia no longer rely heavily on export earnings from coffee (ICO, 2003) but historically this is not the case, and this analysis covers 1948-2004. Therefore, y_t is treated as an endogenous variable.

Sources for prices are as in Figure 1 above. World production of coffee is included as an exogenous variable. Source are Departamento Nacional do Café (1938, 1939/40), Deaton and Laroque (2003) and FAOSTAT online (2007). Real GDP are from Maddison (2007) and GGDC (2005) and the US CPI from BLS (2005a) has been used to reach nominal GDP.

To determine the stationarity properties of the series, unit root tests are carried out. It is pointed out by Morisset (1998) and Krivonos (2004) that coffee price responses may be asymmetric and we follow Enders and Granger (1998) and conduct unit root tests for variables which possibly adjust asymmetrically. The results are outlined in Table 1.

[Table 1]

All variables in Table 1 are expressed in natural logarithms. Lag-length is determined by the Akaike Information Criterium (AIC) and inclusion of a trend is decided from visual inspection of the series and the decision noted under "Trend" where "y" indicates that a trend is included and "n" that it is not. The F-statistic for the hypothesis that the series has a unit root shall be held up against the Enders and Granger (1998) critical value of 7.07 when a trend and a constant are included in the regression and 5.14 when only a constant is included.

The results in Table 1 show that all series but world production have one unit root and hence are non-stationary and integrated of order one. The test statistic for the stationarity of world production is close to the 5% critical value by Enders and Granger (1998), so depending on significance level the series could also have been concluded to be non-stationary. It is not important to correctly identify the stationarity properties of world production, since the series is not an endogenous variable in the VECM and furthermore, it enters the model in first differences. No series adjusts asymmetrically according to this analysis, and asymmetries are disregarded when formulating the empirical model.

Due to the possible impact from the International Coffee Agreement (ICA) a dummy variable, which takes the value one in the years the agreement was in place (1962 to 1989), is included. The ICA dummy is included in the short-run regressions because the ICA had an impact only on prices in the short run. In the long run quotas were adjusted to meet market forces on supply and demand, but in the short run quotas stabilised coffee prices.

4. Results

Before estimating the VECM in equation (40) the lag-length and the rank of the VECM are determined. Schwartz Information Criteria points at one lag and the AIC and the Hannan-Quinn Criteria point towards four. In the estimation process the model was first estimated with one lag and tests of the residuals indicated no problems regarding normality. There was no need to expand the number of lags and the model reported here has one lag.

With one lag Johansens's cointegration test gives the following rank of the VECM:

[Table 2]

Using the trace test, the hypothesis of rank one cannot be rejected, and from the maximum-eigenvalue test the hypothesis of no cointegration cannot be rejected. The test statistics are close to the 5% critical values which makes the decision regarding the rank of the matrix equivocal. The trace statistic for the hypothesis of one or less cointegrating vectors is close to the critical value, but the test statistic for the hypothesis of rank three or less is clearly rejected. Therefore, according to the trace statistic there are one or two cointegrating vectors. Looking at the maximum-eigenvalue statistic, the test statistics and 5% critical values are relatively close until the hypothesis of three or less cointegrating vectors. Again, rank up to two is acceptable according to the test statistics. A model with two cointegrating vectors is preferred because this indicates seven trends among the nine variables and some variables share trends.

4.1 Long-Run Equilibrium

The preferred model has the following two estimated cointegrating vectors:

$$p_t^W = \underset{(2.95)}{0.24} p_t^{M,US-B} + \underset{(2.22)}{0.24} p_t^{X,C} + \underset{(2.61)}{0.15} p_t^{X,B} + \underset{(4.01)}{0.18} p_t^{R,US} - \underset{(3.58)}{0.05} p_t^{G,B} + \underset{(6.35)}{0.34} p_t^{G,C} - \underset{(2.86)}{0.28} y_t - \underset{(3.76)}{0.00} t + 0.43 \quad (41)$$

$$p_t^{G,C} = -\underset{(5.05)}{0.23} p_t^{M,US} + \underset{(0.70)}{0.10} p_t^{M,US-B} + \underset{(5.71)}{1.05} p_t^{X,C} + \underset{(5.09)}{0.91} y_t + \underset{(4.51)}{0.01} t + 1.97 \quad (42)$$

t-statistics are in parentheses under the parameter estimates. The first cointegrating vector, CIV1, in equation (41) represents the long-run equilibrium in the world market. The second cointegrating vector, CIV2, in equation (42) represents the long-run equilibrium between the two Colombian prices.

The two cointegrating vectors are found by commencing with a general model with one cointegrating vector and all nine endogenous variables in this cointegrating vector. Insignificant variables in the cointegrating vector are removed sequentially. It is clear that the US import unit value is not significant in CIV1 and it is moved out to a second cointegrating vector. Other variables were included in CIV2 if they obtain significant coefficients in CIV2 or exhibit significant error correction.

According to the first cointegrating vector, CIV1, six prices move together in the long run, and one moves opposite to this group. The world price, the import price of Brazilian coffee in the US, the export price in Brazil, the export unit value in Colombia, the US retail price and the Colombian producer price all move together in the long run. Five of the prices have roughly the same influence on the common path, but the world price, to which CIV1 is normalised, dominates through a higher coefficient (one). The Brazilian producer price moves in opposite direction to these six prices, but has a small coefficient in equation (41). The prediction of the theoretical model is that all prices should move together. Therefore, the coefficient on the Brazilian producer price contradicts the model, but the coefficient is small.

The second cointegrating vector, CIV2, shows Colombian prices (producer and export price) and the import price of Brazilian coffee in the US move together in the long run. It is clear that the two Colombian prices dominate the movements of the group of prices since the Colombian export price obtains an estimated coefficient above one and CIV2 is normalised to the Colombian producer price. The import price of Brazilian coffee into the US is the least influential in the group since its estimated coefficient is 0.10 and hence a tenth of the estimated coefficient on the Colombian prices. The import unit value of (all) coffee into the US enters CIV2 with a negative coefficient indicating that the Colombian prices and the import unit value of coffee in the US move in opposite directions to each other in the long run. As the Brazilian producer price in CIV1, this poses a challenge to the theoretical model which predicts that all prices should move together. However, the US import price and the Colombian producer price are far from each other in the coffee commodity chain and the coefficient is less than a quarter of the coefficient on the Colombian export unit value. Therefore, this coefficient, like the Brazilian producer price in CIV1 above, does not mean that the theoretical model is rejected, and prices are found to generally co-move in the long run.

The coefficients on relative income are significant in both cointegrating vectors but have different signs. When relative income decreases, the six prices in CIV1 increase. In contrast, the three prices which co-move in CIV2 decrease. The effect of relative income on coffee prices in the long run are hence not clear from looking at the cointegration vectors.

Technological progress, here modelled as a time trend, obtains estimated coefficients in the cointegrating vectors of the same sign as relative income. Technological progress hence moves the two groups of prices in different directions. Alternatively, if something else than technological progress is the reason for the coefficients on the time trend, something else makes the two groups of prices diverge over time. Over time the six prices in CIV1, which are close to the world market, move closer together. Opposite to this, the Colombian producer price moves away from the path of other prices in CIV2.

4.2 Short-Run Dynamics

The short-run structures show how the series adjust towards the long-run equilibria, and how the endogenous variables respond to shocks in exogenous variables. Error correction towards the two long-run equilibria happens according to the estimates in Table 3.

[Table 3]

Whether a variable error corrects and restores the long-run equilibrium between prices in a cointegrating vector is determined by looking at its sign in the cointegrating vector (the sign of β) and its sign in the loading matrix (the sign of α). If the combined sign is negative, the variable works towards restoring equilibrium.

The two export prices, $p_t^{X,C}$ and $p_t^{X,B}$, and the import price of Brazilian coffee into the US, $p_t^{M,US-B}$, are the only variables which significantly adjust to disequilibrium between the variables in CIV1. These three prices work to restore an equilibrium which is dominated by the world price. The world price in contrast moves further away from the equilibrium when a shock has created disequilibrium.

The import price of Brazilian coffee into the US and the Colombian export price significantly adjust to disequilibrium between the prices in CIV2. Though the import price of Brazilian coffee into the US was not significant in determining the second long-run equilibrium (CIV2), it significantly works to restore it. The estimated parameters on the error correction term in the equations for the import unit value in the US, the Colombian producer price and relative income are not different from zero. This suggests that these variables do not work to restore the long-run relationship described by CIV2. The Colombian producer price is an important determinant of the equilibrium described by CIV2, but it does not adjust to restore this equilibrium. It thus influences other prices, but is itself not influenced by other prices.

Relative income does not adjust to disequilibrium between the variables in CIV1 but its error correction towards the equilibrium described by CIV2 is significant on the 10% level. Relative income therefore works in part to restore the equilibrium between (among others) the Colombian prices in CIV2. This could show that any endogeneity of relative income is due to the importance of coffee prices for national income in Colombia.

In addition to the error correction terms, the short-run equations include exogeneous variables. The four exogenous variables in the VECM are a constant (*c*), the dummy for the International Coffee Agreement (*ICA*) and the current and lagged first difference of world production of coffee, $d(q_t)$ and $d(q_{t-1})$. The estimated coefficients on the exogeneous variables in the short-run regressions are presented in Table 4.

[Table 4]

None of the estimated constants in the short-run equations for prices are significantly different from zero. This suggests that time trends have been captured in the cointegrating vectors, but it is noticeable that the constant is positive and has high t-statistics in the equations for the price of coffee imported into the US and the retail price in the US. This indicates that the prices, which have increased in an unexplained way, are prices in the US and that value added is largest further up in the coffee commodity chain. The constant is also positive with a high t-statistic in the short-run equation for the Colombian producer price. This could indicate that the attempts by the Federación Nacional de Cafeteros de Colombia[3] (FNC) to influence the prices of Colombian coffee have been successful.

The estimated coefficient on the ICA dummy is positive in the equation for relative income and in six equations for prices but negative in two equations for prices. However, it is never significant. The ICA increased six of the eight prices and it should be pointed out that the most significant, though not significant even at the 10% level, increases are for export prices and the import price of Brazilian coffee into the US. It was not producers which gained from ICA but rather exporters and importers of Brazilian coffee. So, there is weak evidence that while exporters benefited from the agreement the producers did not; the effects of the commodity agreement did not trickle down and reach them.

First differences of world production and lagged world production enter with negative and significant signs in all regressions but one. This stresses the importance of production in determining prices in the short run. This is predicted by the theoretical model; increased production lowers price regardless of where in the chain the price is situated.

4.3 Weak Exogeneity

Tests of weak exogeneity are carried out to further test the driving forces in the system. A weakly exogenous variable has an impact on the long-run path of the variables of the system, but is not itself influenced by the variables in the system. The results from likelihood ratio tests are given in Table 5.

[Table 5]

In Table 5 the test statistics for the world price, the import unit value into the US, the Colombian export unit price, the US retail price and the two producer prices are lower than the 5% critical value, and the null hypothesis can not be rejected for these variables. These six prices are hence weakly exogenous. Agents at the ends of the chain, retailers, importers and producers, are hence not responding to deviations from the long-run equilibrium relationships between prices. As such, they are somewhat isolated from the world market. This is not surprising since the price transmission literature asserts that the price determination happens in the world. Further up and down the chain other factors, such as market set-ups, intervention and incomes determine the prices.

The hypothesis of weakly exogenous relative income is clearly rejected, indicating that it is correct to model income as endogenous in the system as discussed above. Also, the likelihood ratio test shows that the causality between prices and relative income is uncertain. Coffee prices and national incomes in Brazil and Colombia are interrelated. Coffee prices are important determinants of income in Brazil and Colombia, but national incomes also determine coffee prices.

Regarding relative income it is clear that the results are equivocal. The coefficients in the cointegrating vectors obtained different signs and it may or may not be weakly exogenous according to the error correction coefficients and weak exogeneity tests. The final set of results which can shed light on the effect which relative income has on prices, is impulse response functions. They were estimated for the VECM and show that relative income has a negative impact on all eight coffee prices and hence that a decreasing income gap between producing and consuming countries increases coffee prices.

5. Discussion

Regarding the central question of what determines the value added at each stage of the commodity chain, it can be concluded that the prices definitely determine each other, and that from outside the system of prices quantity has a large impact, but only in the short run. In the long run, relative income has an effect on all prices, and a closing income gap between producers and consumers increases prices. In addition, prices move in response to changes in technological progress.

In this concluding section four overall conclusions are drawn. The first is of how the prices influence each other. The second is of how relative income impacts prices. The third is of how production influences prices. And last how the time trend, which represents technology, influences prices.

It is of utmost importance to determine which prices are detached from the chain. The theoretical model predicts positive correlation between the prices and this is generally found in the empirical model both by long-run co-movements and by adjustments to restore the long-run equilibria in the short run.

Both CIV1 and CIV2 show co-movement among prices, but the VECM is estimated with two cointegrating vectors. This indicates that there may be a break in the coffee commodity chain since one group of prices moves together in one manner while the other group moves in a different manner in the long run. The world market prices in CIV1 move together but the Colombian prices in CIV2 do not follow their movement, and the Colombian prices may be detached from other prices, possibly due to FNC. Since the Brazilian producer price is not significant in CIV2 and moves against the other prices in CIV1 it can be said to also be detached from the value chain.

The error correction properties of the system and the weak exogeneity tests show that prices in the middle of the chain work to restore the two long-run equilibria. The prices at the ends of the chain, the producer prices and the retail price, and the dominating world price do not error correct. The lack of error correction by the prices at the ends of the chain indicates that they are not influenced by the long-run paths and points at breaks in the coffee commodity chain.

The empirical results suggest that the world market is characterized by close linkages between prices but retail price and producer prices are less integrated with other prices. This finding may support the arguments made by the price transmission literature. The limited trickle down of price signals to producer prices confirm the findings of Fitter and Kaplinsky (2001) and Ponte (2002) who argue that surplus created along the chain falls on agents further up the chain, and not on producers. The discussion of intervention and integration in the transmission literature (Baffes and Gardner, 2003; Hazell et al, 1990; Krivonos, 2004; Mundlak and Larson, 1992) explain why the Colombian producer price and export price, which have experienced considerable intervention by FNC, are detached from other prices.

It is not possible to reach an unequivocal conclusion regarding the impact of relative income by looking at the cointegrating vectors, short-run dynamics or weak exogeneity tests. It is concluded that decreasing income gap increases prices in the world market, whereas it decreases the Colombian producer price.

The negative relationship between relative income and all eight prices found by the impulse response functions confirms the expected signs of the coefficients on income in market one and two. The negative relationship between relative income and prices extends to market three. However, since income in consuming countries occurs in the numerator of relative income, relative income should obtain a positive coefficient if the hypothesis of decreasing importance of labour along the coffee commodity chain is confirmed. A negative c_3^* in equation (36) suggests that the roasting sector relies *more* on labour than the importing sector, in light of the discussion of equation (35) above.

Income's significance in the determination of producer prices, both in the theoretical and the empirical model, offers support for the terms of trade literature, where prices are determined by underlying macroeconomic factors. Relative income also helps explain divergence of producer and retail prices as these prices reflect relative overall economic performance of producer countries compared to consuming countries.

The theoretical model predicts that there is a negative relationship between prices and production. This is fully supported by the empirical model. The negative and significant coefficients on the differences of world production show that it could be the supply curves which shift outwards and create the decreasing prices.

According to the theoretical model the sign on the time trend (technological progress) is unknown and depends on whether the supplier or the demander in a given market experiences the most significant technological innovations. The negative sign of the estimated coefficient on the time trend in CIV1 shows that the prices in CIV1 move closer together over time than what is explained by relative income. Technological progress can be the explanation for this. A negative sign indicates that the technological progress is largest for the supplying parties in markets one, two and three and/or the negative sign of d_5 is confirmed. The latter case is particularly neat since CIV2, which holds a positive time trend, does not contain the US retail price, and the different signs of the time trend in the cointegrating vectors are not conflicting. They are not conflicting because in CIV1, which describes all four markets, d_5 causes a negative time trend. In CIV2, which describes market one, two and three, a_5, b_5 and c_5 represent relatively bigger technological progress by demanders which creates a positive time trend.

A positive time trend could occur in market one, two and three in the theoretical model if the technological progress is largest for the demanding parties in these three markets. This development is not unlikely in the coffee commodity chain if agents along the chain become more able to improve their production methods (technological progress) because they become wealthier either through market power and/or the value they add to coffee. This hypothesis can however not be tested with the data used for this analysis, but touches on the discussion in Ponte (2002).

Therefore, the positive time trend in CIV2 could be capturing technological progress or some factor not included in the model that coincides with the passing of time. Market power and bargaining power are examples of unmodelled variables in the VECM.

The almost significant positive constants in the regressions of US prices show that US import and retail prices tend to increase more than other prices. This could capture the mark-up, *m* in (37). The negative constant in the short-run regression for the Brazilian export price could be caused by the coffee commodity chain being a trader-driven commodity chain, as argued by Talbot (2002), where international traders trade large amounts of coffee with very little margin. Looking at the value chain for Brazil in Figure 1 confirms this, since the value added at the exporting stage, which is denoted *processing and transport in Brazil*, reduces to almost zero after 1990. It is no coincidence that this is the year after the breakdown of ICA, and it is also argued by Ponte (2002) that this event changed the power relations along the coffee commodity chain.

The empirical model gives some insight into issues which are not explicitly modelled in the theoretical model. The theoretical model did not predict which prices would be dominating and which would be adjusting to movements in other prices. However, it is found that the world price is dominating and the export prices are responding. Boratav (2001) found that the ratio between world price and export unit value was stable, and the analysis here can extend the conclusion by suggesting that the export prices follow the world price.

If the aim is to create a more equal income distribution among agents in the global coffee commodity, this analysis offers some insights of policies to achieve this. Income levels in coffee-producing countries are important determinants of the coffee prices and low national incomes pull coffee prices down even though the retail and import price in consuming countries might increase. Unless the general income level in producing countries increases increased income in consuming countries will not trickle down to the coffee farmers. Alternatively the structure of the chain can be changed and an income distribution more favourable for coffee farmers could be achieved.

At the international level the International Coffee Agreement increased coffee prices, but more so export and import prices than producer prices. If the aim is to benefit those in the global coffee commodity chain who has the least – the farmers – an international agreement is hence not the most efficient tool. Improved technology for farmers and increases bargaining power are other factors which would redistribute value within the commodity chain.

Producer and retail prices which are detached from the world market, technological progress mainly by demanding parties in the chain and increasing mark-ups (or market or bargaining power) in consuming countries are all findings which support the idea by Darity and Davis (2005) to bring Karl Marx back into the picture. Though international commodity agreements, producer cartels and attempts to change the structures of the centre and periphery are not policies currently in vogue, it may be useful to keep them in mind when engaging in the world coffee market.

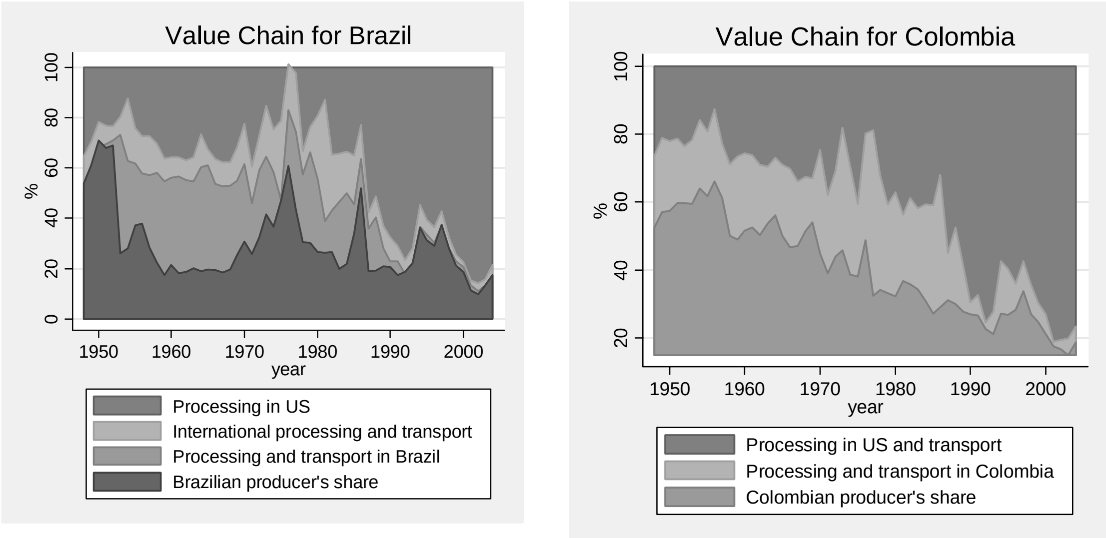

Fig. 1. *Distribution of the Coffee Dollar along the Commodity Chain.*

Sources: Brazilian and Colombian producer prices: FAO (various years), FAOSTAT (2006) and ICO (2005). Export and import unit values: FAOSTAT online (2006) and U.S. Department of Commerce: Bureau of the Census (1989). Wholesale prices for Brazil: IFS (various years). US Retail prices: BLS (2005b).

Table 1. *Asymmetric Unit Root Tests*

Series	Analysis of Series in Levels					Analysis of Series in 1st Differences				Conclusions
	Trend	Lags	Unit Root	Asymmetric Adjustment	Bartlett's White Noise	Lags	Unit Root	Asymmetric Adjustment	Bartlett's White Noise	
			1.80	0.19	0.99			0.97	0.97	
$p^{G,B}$	n	1	0	1	8	0	29.849	5	3	I(1) symm
$p^{G,C}$			0.19	0.59	0.95			0.98	0.87	
	n	1	5	8	4	0	26.732	0	3	I(1) symm
$p^{X,B}$			2.62	0.19	0.33	0		0.52	0.89	
	n	1	1	3	1	#	28.028	4	3	I(1) symm
$p^{X,C}$			1.31	0.92	0.48			0.42	0.69	
	n	1	4	1	3	0	28.842	2	0	I(1) symm
p^{W}			0.15	0.66	0.78			0.22	0.90	
	n	1	2	6	3	0	32.509	9	1	I(1) symm
$p^{M,B\text{-}US}$			1.21	0.65	0.55			0.55	0.89	
	n	1	4	6	6	0	27.076	5	1	I(1) symm
$p^{M,US}$			0.53	0.31	0.99			0.93	0.92	
	n	1	6	0	5	0	29.196	5	8	I(1) symm
$p^{R,US}$			0.32	0.99	0.99	0		0.75	0.60	
	y	4	2	5	4	#	25.499	1	1	I(1) symm
q		0	8.87	0.37	0.07					
	y	#	3	1	8	.	.	.	.	I(0) symm
y	n	3	0.00	0.99	0.99	1	26.032	0.38	0.00	I(1) symm

5	5	4	##		1	6

"Unit Root" contains the F-statistic for the hypothesis that the series has a unit root.

"Asymmetric Adjustment" contains the p-value for the hypothesis of symmetry.

"Bartlett's White Noise" contains the p-value from Bartlett's periodogram-based test for white noise. The null is that the error terms are white noise.

# indicates that the lag-length selected by AIC did not result in white noise residuals and increasing the lag-length did not amend the problem and the lag-length was hence decreased until the indicated number of lags.

indicates that residuals from the regressions with the first difference of relative income fail Bartlett's periodogram-based test for white noise regardless of variations of the number of lags and the lag-length is chosen by AIC.

Table 2. *Rank for VECM(1) with nominal prices and relative income*

	Trace Test			Maximum-Eigenvalue Test		
Hypothesized No. of CE(s)	Test Statistic	5% Critical Value	Prob.*	Test Statistic	5% Critical Value	Prob.*
None	232.686	228.298	0.031	49.706	62.752	0.486
At most 1	182.980	187.470	0.083	46.246	56.705	0.367
At most 2	136.734	150.559	0.230	36.528	50.600	0.617
At most 3	100.206	117.708	0.372	31.817	44.497	0.570
At most 4	68.389	88.804	0.570	21.460	38.331	0.885
At most 5	46.929	63.876	0.556	19.020	32.118	0.728
At most 6	27.909	42.915	0.628	13.839	25.823	0.736
At most 7	14.070	25.872	0.652	8.642	19.387	0.761
At most 8	5.428	12.518	0.536	5.428	12.518	0.536

Trace test indicates 1 cointegrating equation at the 5% level. Max-eigenvalue test indicates no cointegration at the 5% level.

* MacKinnon-Haug-Michelis (1999) p-values.

Table 3. *Error Correction Parameters*

		p^{W}	$p^{M, US}$	$p^{M,US-}$	$p^{X,C}$	$p^{X,B}$	$p^{R,US}$	$p^{G,B}$	$p^{G,C}$	y
CIV1	α	2.04	0.52	3.68	2.33	4.20	0.99	1.73	0.96	-0.16
		(1.64)	(0.44)	(2.92)	(2.09)	(3.04)	(1.59)	(0.94)	(1.11)	(0.97)
	EC	N		Y	Y	Y	Y	N	Y	Y
CIV2	α	0.99	0.07	1.47	1.01	1.55	0.31	0.69	-0.01	0.13
		(1.73)	(0.14)	(2.54)	(1.96)	(2.44)	(1.08)	(0.81)	(0.04)	(1.75)
	EC		N	Y	Y				Y	Y

t-statistics are given in parentheses under parameter estimates.

'*α*' refers to α in (40) and is the estimated parameter on the error correction term.

'EC' shows whether the variable exhibits error correction (Y) or not (N).

Table 4. *Coefficients on Exogenous Variables in the Short-Run Regressions*

	p^{W}	$p^{M, US}$	$p^{M,US-}$	$p^{X,C}$	$p^{X,B}$	$p^{R,US}$	$p^{G,B}$	$p^{G,C}$	y
c	0.01	0.07	-0.01	0.01	-0.01	0.04	0.01	0.07	-0.01
	(0.11)	(1.15)	(0.21)	(0.10)	(0.13)	(1.36)	(0.16)	(1.65)	(1.51)
ICA	0.11	-0.03	0.15	0.10	0.14	0.04	0.11	-0.03	0.02
	(1.13)	(0.29)	(1.61)	(1.24)	(1.38)	(0.75)	(0.81)	(0.48)	(1.34)
$d(q_t)$	-1.21	-1.01	-1.23	-1.12	-1.25	-0.66	-1.35	-1.16	0.03
	(3.48)	(3.11)	(3.51)	(3.60)	(3.24)	(3.79)	(2.62)	(4.82)	(0.60)
$d(q_{t-1})$	-0.92	-0.93	-1.04	-0.75	-0.87	-0.51	-0.84	-0.83	0.04
	(2.74)	(2.96)	(3.06)	(2.50)	(2.34)	(3.06)	(1.69)	(3.61)	(0.79)

t-statistics are given in parentheses under the parameter estimates. c is the constant, *ICA* the dummy for years the International Coffee Agreement was in place, q_t is the natural logarithm of world production.

Table 5. *Likelihood Ratio Tests for Weak Exogeneity*

Model		LogL	λ_{LR}	Critical value, 2 d.f.
Unrestricted model		583.365		
Restricted model	p^{W} is exogenous	581.883	2.962	5.991
	$p^{M,US}$ is exogenous	583.249	0.230	
	$p^{M,US\text{-}B}$ is exogenous	579.380	7.969*	
	$p^{X,C}$ is exogenous	581.364	4.001	
	$p^{X,B}$ is exogenous	580.307	6.116*	
	$p^{R,US}$ is exogenous	582.301	2.127	
	$p^{G,B}$ is exogenous	582.835	1.059	
	$p^{G,C}$ is exogenous	582.122	2.485	
	ry is exogenous	576.575	13.579*	

$\lambda_{LR}=2[LogL_U - LogL_R]$, $LogL_U$ is the loglikelihood of the unrestricted model, $LogL_R$ is the loglikelihood of the restricted model. λ_{LR} is χ^2-distributed with two degrees of freedom.

* indicates that the null hypothesis can not be rejected, hence weak exogeneity is not present, the critical level is 5%

Notes

1 FAOSTAT shows production statistics for 71 countries in 2004 on 2 August 2006

2 In Colombia coffee dominated the primary commodity exports with 48% of total primary commodity exports between 1991 and 1999 (Cashin, Cespedes and Sahay, 2004).

3 For information on the Colombian price stabilization scheme, see FNC (2007).

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