MODELLING THIRTY FIVE YEARS OF COFFEE PRICES IN BRAZIL, GUATEMALA AND INDIA AND THE LAW OF ONE PRICE*

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ABSTRACT

The standard approach to modelling coffee prices ignores the impact that changes in government policies and market structures has on coffee prices. These changes have led to large structural breaks in coffee prices implying the standard estimates are biased. This paper models coffee prices in Brazil, Guatemala and India allowing for the structural breaks. The estimated model provides a consistent description of coffee prices and shows that liberalisation has benefited producers substantially in terms of a higher share of the world price of coffee. We also show that producers have benefited from higher real coffee prices following liberalisation.

Keywords: coffee prices, cointegration, coffee markets, liberalisation, coffee producers, transfer costs, law of one price
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1. INTRODUCTION

Prior to the 1990s unilateral and multilateral interventions in coffee markets were common. The broad objective of the interventions was macroeconomic stabilisation for the general welfare of the population and price stabilisation for the specific welfare of coffee producers.[1] The interventions took the form of export supply management through regulations or buffer stock schemes and in many cases the domestic market was also regulated through the administration of the prices received by producers.[2] In terms of producer welfare, the interventions are generally regarded as unsuccessful. The suspension of the International Coffee Agreement in 1989 and economic reforms in developing countries in the late 1980s resulted in most countries liberalising their coffee sector by replacing state-controlled marketing systems with markets run by private agents. The pace and scope of liberalisation varied across countries but has resulted in a more competitive international coffee market.[3]

The changes in coffee policies at both the domestic and international levels and the eventual liberalisation of coffee markets raise a number of issues when modelling coffee prices. For example, consider Graph 1 of terminal and producer prices for Brazilian, Guatemalan and Indian Arabica coffee.[4] There are four striking features common to these graphs. First, the gap between the terminal and producer prices of coffee varies considerably over time in all three countries. This gap can be thought of as an indirect measure of the costs of transferring

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1 Unless specified otherwise, 'coffee' means green (raw or un-roasted) beans and coffee prices imply prices of green beans. Coffee producers include growers and/or semi-processors, who sell their coffee as cherries, parchment or green beans. If producers sell their coffee as cherry or parchment, the prices are converted to green beans by using a 'green bean equivalent'.

2 For a brief description of coffee market interventions see Appendix 1.

3 For details concerning coffee market interventions see Raffaeli (1995), Gilbert (1996), McIntire and Varangis (1999), Jerome and Ogunkola (2000), Varangis et al. (2002), Winter-Nelson and Temu (2002), Krivonos (2004) and Boudreaux (2007).

4 The terminal price of coffee is the spot price of coffee as traded in international markets and the producer price of coffee is the cash price received at the 'gate' by producers. Details of the data are provided in Appendix 2.

coffee from the producer to the terminal markets. Between January 1973 and December 1989 the average transfer costs were around 85 (141 per cent of the average producer price), 45 (54 per cent), and 58 (72 per cent) US cents per pound of coffee for Brazil, Guatemala and India respectively. Following the liberalisation of coffee markets there has been a decline in transfer costs. Since January 1990 average transfer costs were around 18 (28 per cent), 32 (46 per cent) and 30 (42 per cent) US cents per pound of coffee for the three countries respectively. Such large reductions in transfer costs are unlikely to be explained by changes in the freight, handling and related costs alone. It is more likely the reductions are due to changes in the economic rents received by intermediaries and governments in the transfer process arising from the greater degree of vertical integration in coffee markets.[5]

The variation in the gap between coffee prices provides *prima facie* evidence that the 'law of one price' does not hold. The 'law' suggests that the prices of two identical goods in two separate markets will differ in equilibrium by the cost of transferring the goods between the markets. Importantly this implies that the two prices will evolve together and that the gap between the two prices in equilibrium will be constant. This 'law' is predicated on an unchanging economic environment which in the case of coffee markets is difficult to sustain. Changes in coffee market policies at the domestic and international levels will alter the economic environment and may lead to discrete changes in the gap between the two prices. Consequently, the changes that we observe in the gap between the two coffee prices may be due to either a change in the economic environment (i.e. changes in policy) or because the 'law' does not hold. Therefore, to empirically examine the 'law' we must control for the effects of changes in coffee market policies.

In recent years the extensive literature on the 'law of one price' has not provided unambiguous empirical evidence in support of the 'law', with the results depending on the level of aggregation of the data and the methods employed to 'test' the relationship between prices in different markets. For example, for commodity markets, the work of Ardeni (1989) and Baffes (1991) provide mixed evidence on accepting the 'law of one price' while Vataja (2000), Michael, Nobay and Peel (1994) and most recently Batista and de Silveira Filho (2010) provide evidence in support the 'law'. However, this literature mostly focuses on the

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[5] See Mohan (2007).

‘law’ in terms of exchange rate movements, distance between markets, shipping costs and price discrimination. We argue that the relationship between the prices of a commodity in two markets is also highly dependent on the prevailing international and national policies. This is especially important when long samples of data are examined and the intervention by governments is extensive and changing as in our case.

The second feature follows from the first. Large changes in transfer costs associated with changing government policies, regulations and market structure causes structural breaks in the producers’ share of the terminal price of coffee. The share is the ratio of the producer to the terminal price of coffee and is referred to in the paper as the coffee price ratio. These breaks are at times quite sudden and persistent as demonstrated in Graph 2 of the coffee price ratio for the three countries.

Third, the price of coffee received by producers at the beginning of the 21st century is much the same as it was in the 1970s suggesting a large fall in real terms. This fall in the real price of coffee is demonstrated in Table 1.[6]

If the terminal and producer prices of coffee are closely related then any modelling of the two prices must take into account the structural breaks in the coffee price ratio. If the breaks are not accounted for then estimating the model will result in biased and poor estimates that may lead to incorrect inferences. This paper, therefore, models the relationship between the terminal and producer prices of coffee in Brazil, Guatemala and India allowing for the breaks in the coffee price ratio. These three countries are chosen due to their variation in their coffee policies and market structures over time. We demonstrate that the modelling approach we adopt is successful in dealing with this variation.

There is now substantial work on identifying structural breaks in models with unknown dates. Perron (2006) reviews techniques that identify single breaks in models but for our purposes these techniques are too restrictive and so we consider techniques that identify multiple structural breaks with unknown break dates. We develop a two-step model with a

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[6] The real price of coffee in Table 1 is measured in terms of the United Nations (UN) index of unit values of exports. Similar results are obtained if the real price of coffee is measured in terms of the United States consumer price index (CPI).

methodology similar to that of Carter and Smith (2007). In the first step we employ the Bai and Perron (1998, 2003a, 2003b) (Bai-Perron) technique to indentify multiple breaks in the coffee price ratio. In the second step we estimate a VAR-ECM model of coffee prices conditioned on the identified breaks in the mean coffee price ratio. A major advantage of this approach is that the estimated error correction term is equivalent to the coffee price ratio. The structural breaks in the mean coffee price ratio identified in the first step are simultaneously the breaks in the mean of the error correction term. A further advantage of this approach is that we can examine directly the empirical relevance of the 'law of one price' after accounting for the influence of changing policies on coffee prices.

The next section sets out the standard approach to modelling coffee prices based on the 'law of one price' and cointegration analysis and explains the biases from not allowing for the breaks in the coffee price ratio. Section 3 reports the results of the estimated models allowing for these breaks. We find that the equilibrium, or 'long run', producers' share of the terminal price of coffee has increased in all three countries since coffee market liberalisation to around 0.85 in Brazil and India and 0.79 in Guatemala. Assuming that liberal markets led to these higher producer shares we demonstrate in Section 4 that the loss to producers from coffee market regulations and interventions over the years is substantial and that these losses are now almost non-existent following the liberalisation of coffee markets.

2. MODELLING COFFEE PRICES

The standard approach to modelling coffee prices can be motivated with reference to the Enke (1951), Samuelson (1952), Takayama and Judge (1971) spatial models of prices and the 'law of one price'.[7] These models argue that when two markets attain equilibrium prices the prices differ only by the costs of transferring the goods between the markets. The transfer costs include the shipping and storage costs associated with moving produce between markets along with the economic rents of intermediate agents in the supply chain. In this model, demand and supply shocks are fully transmitted between the two markets in equilibrium.

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[7] See also Stigler (1969), Stigler and Sherwin (1985), Ardeni (1989), Badiane and Shivley (1998), Baffes (1991), McNew (1996), Abdulai (2000), Fackler and Goodwin (2001) and Conforti and Rapsomanikas

The equilibrium in coffee prices between the terminal and producer markets can be represented in these models as:

$$P_{P,t} \;=\; P_{T,t} * U^{e} \qquad (1)$$

where $P_{P,t}$ and $P_{T,t}$ are the producer and terminal prices measured as price per unit of coffee respectively, U^{e} is the constant ratio that coffee prices in the two markets attain in equilibrium and the '*t*' subscript indicates the time period of the data. Note that even though the producer price of coffee is the subject of the equilibrium relationship in equation (1) it does not imply causation between the two prices which is conceptually bi-directional.

With $U^{e} < 1$ in equation (1) we can identify transfer costs, TC_t, associated with the movement of coffee between the two markets such that $TC_t = P_{T,t} - P_{P,t}$ which are also measured in price per unit of coffee. In the short run the equilibrium relationship (1) need not apply due to the incomplete transfer of information between markets and other rigidities. However, in the long run we expect this equilibrium relationship to hold if information is shared efficiently between markets and all agents make normal profits.[8]

An assumption of this model that is not often highlighted in the literature is that the transfer costs in equilibrium are a fixed ratio of both the terminal and producer prices of coffee. For example, transfer costs as a ratio to, or share of, the terminal price of coffee in equilibrium is:

$$\frac{TC_t}{P_{T,t}} = \frac{P_{T,t} - P_{P,t}}{P_{T,t}} = 1 - U^{e} \qquad (2)$$

(2005). The coffee model can be thought of as 'spatial' in terms of the geographic locations of producer and terminal coffee markets.

8 In the short run the coffee price ratio U_t may be greater than one implying that intermediaries make losses in the transfer of coffee between the two markets. However, this situation cannot continue in equilibrium as losses would lead agents to exit the market until intermediaries make 'normal' profits and $U^{e} < 1$.

Importantly, this implies that if the equilibrium in coffee prices is adequately described by this model then the statistical process of the transfer costs is the same as that of the two coffee prices in equilibrium. If this was not the case then when equilibrium coffee prices are attained in the two markets, transfer costs will not have returned to its equilibrium ratio in terms of the respective coffee prices. This implication is important for our modelling of coffee prices below.

The equilibrium relationship in (1) above has a straightforward time series interpretation in terms of a vector autoregressive-error correction model (VAR-ECM) of coffee prices. Consider the following error correction representation of a two variable VAR of order k:

$$\Delta x_t = \delta + \alpha\beta' x_{t-1} + \sum_{i=1}^{k-1} \Pi_i \Delta x_{t-i} + \varepsilon_t \tag{3}$$

where lower case variables are in natural logarithms, $x_t = \begin{pmatrix} p_P \\ p_T \end{pmatrix}_t$, $\alpha = \begin{pmatrix} \alpha_{11} & \alpha_{12} \\ \alpha_{21} & \alpha_{22} \end{pmatrix}$ is a matrix of equilibrium speed of adjustment coefficients, β is a matrix containing the equilibrium vectors $\begin{pmatrix} 1 & \beta_{12} \\ 1 & \beta_{22} \end{pmatrix}$, Π_i is a matrix of short-run coefficients and Δ represents the change in the variable such that $\Delta x_t = x_t - x_{t-1}$.

The error correction representation argues that the producer and terminal prices of coffee move together and coffee prices converge on the equilibrium relationship. Changes in coffee prices depend on the deviation from the equilibrium relationship and the speed of adjustment (i.e. the error correction mechanism) along with lagged changes in the prices of coffee.

The standard approach to estimating the VAR-ECM of coffee prices proceeds within a cointegration framework.[9] If coffee prices, p_P and p_T are cointegrated, the matrices α and β must be of reduced rank and in our case equal to one. No cointegration implies a rank of

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9 For example see Rapsomanikas *et al.* (2004), Fortenbery and Zapta (2004), Krivonos (2004) and Alizadeh and Nomikos (2005).

zero and full rank implies the levels of both prices are stationary. This is an issue of some relevance with what follows below.

Assuming cointegration:

$$\beta' x_t = p_{P,t} + \beta p_{T,t} = z_t \qquad (4)$$

where z_t is a stationary process.[10] Furthermore, if $\beta = -1$ then the long-run cointegrating vector can be interpreted as the equilibrium relationship of equation (1) where:

$$p_{P,t} - p_{T,t} = u_t \qquad (5)$$

and the error correction mechanism is now equivalent to the coffee price ratio, u_t.

Note the models in equations (1) and (5) display long-run homogeneity which is equivalent to accepting the 'law of one price'. This means that a 1 per cent increase in one coffee price leads to a 1 per cent increase in the other price in the long run so that transfer costs as a proportion of either the terminal or the producer price are unchanged. This also implies that transfer costs have increased by 1 per cent in the long run. With trending price and cost variables β needs to equal - 1 so that a persistent change in the level of coffee prices does not lead to a persistent change in the gap between the two prices in equation (3). In other words, $\beta = -1$ means that a change in the level of prices leaves the coffee price ratio unchanged in the long run and transfer costs have increased in line with prices.

Two important assumptions concerning the equilibrium relationship (5) and the VAR-ECM analysis are that the coffee price ratio, u_t, converges on a constant value, u^e, in equilibrium and that u_t is a stationary process with a constant mean equal to u^e. Looking closely at Graph 2 we can see discrete shifts in the mean of the coffee price ratio. These visual shifts in the ratio can be tested formally by applying the Bai and Perron (1998, 2003a, 2003b)

[10] See also Johansen (1988, 1991, 1995).

technique for identifying multiple structural breaks in the mean coffee price ratio, u_t.[11] The Bai-Perron technique identifies 11, 8 and 10 discrete shifts in the mean of the coffee price ratio for Brazil, Guatemala and India and these are shown in Graph 2 as horizontal thin lines.

It appears, therefore, that the two important assumptions are not valid. This suggests there is a time dimension to the mean coffee price ratio and therefore the equilibrium coffee price ratio should be written in a more general form that contains a trend, t, and n shift dummies D_i:

$$p_{P,t} + \beta_1 \; p_{T,t} + \beta_2 t + \sum_{i=1}^{n} \delta_i D_i = \omega_t \qquad (6)$$

The inclusion of the trend is to capture a systematic divergence between the equilibrium terminal and producer prices. This would occur if transfer costs evolved differently to coffee prices over the longer term. Transfer costs may be driven by factors such as wages, productivity and energy costs which may not affect to the same extent the prices of homogeneous agricultural products like coffee. The shift dummies represent discrete structural breaks in the mean of the coffee price ratio in response to changing domestic and international coffee market policies.

If estimation of the model proceeds assuming that the mean ratio of coffee prices is time *invariant* as implicitly (or explicitly) assumed in the standard cointegration literature then the estimates of the equilibrium coefficients, β, and the adjustment coefficients in equation (3) will be poor and biased if the coffee price ratio, u_t, is non-stationary. The direction of the bias in β depends on whether the coffee price ratio is on average increasing or decreasing over the period. The adjustment coefficients will be biased downwards if the shifts in the mean coffee price ratio are not accounted for. From the perspective of the estimated model it will appear that the coffee price ratio is taking a long time (i.e. the speed of adjustment is low) to return to the equilibrium coffee price ratio following a change in the mean coffee price ratio in the data. Consequently, how we model the coffee price ratio may affect our estimates in important ways.

[11] See Appendix 3 for details of the Bai-Perron estimates of the structural breaks in the coffee price ratio.

Finally, estimating the VAR-ECM allows us to (i) formally test for the presence of cointegration; (ii) test whether long-run homogeneity and the 'law of one price' is a valid restriction; and (iii) estimate the speed of adjustment back to the long-run relationship and in so doing identify whether producer prices, terminal prices, or both adjust when prices are away from the long-run cointegrating relationship.

3. ESTIMATING A VAR-ECM OF COFFEE PRICES

3.1 The Data

The models are estimated using the monthly average International Coffee Organization (ICO) Indicator Price for Arabica coffee as a measure of terminal prices and the monthly average producer price for Arabica coffee in Brazil, Guatemala and India for the period January 1973 to October 2007. All price data are in nominal terms and measure a monthly average price in US$ per pound.[12] In analysing the data we should keep in mind the factors that could influence the evolution of coffee prices. The period 1973 to 1989 coincides with the operation of the International Coffee Agreement for regulating the market through export quotas.[13] Under the Agreement, export-quotas were allocated to exporting countries and they were changed according to changes in world coffee prices. However, the Agreement did not always operate as there was failure to reach any agreement among participating countries between 1977 and 1980 (Raffaeli, 1995). The Agreement was finally suspended in 1989.

Coffee prices are also subject to the influences of domestic policies through local taxes, export levies and subsidies, value added taxes, the setting of coffee grading standards, foreign exchange regulations and the provision of credit. Governments through their parastatal coffee organisations also regulated domestic coffee markets by administering producer prices as well as controlling the production and marketing of coffee.[14] The period from 1990 is marked by the liberalisation of the coffee trade at the international level with the abolition of all systems for regulating the coffee market and at the national level through the progressive

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12 Further details concerning the data are provided in Appendix 1.

13 Its stated aim was to achieve price stabilisation, increase revenue from coffee and adjust production in line with demand.

14 For further details see Appendix 1.

dismantling of the monopolies of the coffee marketing boards in most coffee producing countries.

3.2 Standard Cointegration Model of Coffee prices

Univariate unit root tests reported in Table 2 reject the null hypothesis of a unit root in the data of both coffee price series for all three countries. However, we proceed under the assumption that the price data are integrated because of the low power of unit root tests, the need to maintain comparison with the standard literature and for the sake of consistency with our own results that we present below.

Tests of the number of cointegrating vectors in the standard model that does not include breaks in the cointegrating vector are reported as Model 1 in Table 3. At the 5 per cent level, the conclusion for Brazil is that coffee prices are not cointegrated while for Guatemala and India we accept the hypothesis of one cointegrating vector between the producer and terminal prices of coffee. These conclusions concerning the number of cointegrating vectors are supported by the estimates of the VAR-ECM for the three countries reported in Table 4.

While there is some variation in the estimates there is a strong pattern in the results of the standard models. A trend is significant for all three countries suggesting that there has been a trend increase in the producer price of coffee relative to terminal prices over the period examined. The estimated models for Brazil and India appear to be relatively poor representations of the dynamics of the coffee prices with largely insignificant adjustment coefficients for Brazil and small for India. The results for Guatemala are the best behaved where we accept both one cointegrating vector and the long-run homogeneity restriction that $\beta = -1$ with the adjustment coefficients moderately large and significant. Consequently, with the possible exception of Guatemala, we might conclude that a VAR-ECM is a relatively poor representation of the dynamics of coffee prices.

The inconclusive nature of these results are consistent with the view that structural breaks are an important feature of the price series being modelled and therefore need to be taken into account in order to develop a more accurate description of the system generating coffee prices.

3.3 Modelling the structural breaks in the coffee price ratio

Breaks in the coffee price ratio are due to breaks in the component coffee price series. However, simultaneous breaks of equal magnitude will not affect the ratio. That is, the coffee price ratio will break if either the breaks in the price series occur at different points of time or when occurring simultaneously they are of different magnitudes. While there may be numerous events that impact simultaneously on both price series the discussion above focuses on changes to policy and market structure that impact on the coffee price ratio. This has implications for the method used to identify the breaks in the ratio.

There are two broad ways to proceed. The first is the one-step procedure of Qu and Perron (2007) that identifies multiple structural breaks in estimated systems of equations. This approach restricts the breaks to occurring at the same time in all equations of the system and therefore can only detect breaks in the ratio when they occur in the component series simultaneously but with different magnitudes. It may also identify simultaneous breaks of similar magnitude but these would not lead to breaks in the coffee price ratio.

Consequently, our preferred approach focuses on identifying breaks in the mean coffee price ratio directly by applying the Bai and Perron (1998) algorithm. The identified breaks are those reported in the Appendix 3 and shown in Graph 2. Repeating the cointegration analysis incorporating the breaks leads to the results reported in Table 5. The breaks are introduced as level shifts in the cointegrating relationship which account for the level shifts in the mean coffee price ratio evident in Graph 2.

The inclusion of the shift dummies leads to the rejection of the trend in the cointegration space at the 5 per cent level. This implies the shift dummies dominate the trend as a proxy for the shifts in the long-run coffee price ratio over the period.[15] The shift dummies are highly significant and we now easily accept $\beta = -1$ for all three countries at the 5 per cent level implying we simultaneously accept the 'law of one price' in relation to terminal and

[15] Over the full sample the mean coffee price ratio increases and this results in a positive estimated trend in the standard model (see Graph 2). However, the structural breaks in Model 2 better represent the evolution of the mean coffee price ratio resulting in the trend becoming insignificant.

producer coffee prices. The error correction mechanisms are also strongly significant with large adjustment coefficients.

However, the inclusion of the dummies leads us to conclude from the Trace tests reported in Table 3 that the long-run matrix is of full rank for Brazil and Guatemala. This implies coffee prices are stationary processes once we adjust for structural breaks. If this were indeed the case then coffee prices cannot cointegrate and the VAR-ECM framework is invalid.

We therefore consider the results for Brazil and Guatemala from the perspective of a stationary system rather than an integrated one. To this end we estimate an error correction model of coffee prices using seemingly unrelated regression (SUR) for both countries. For comparison the model is parameterised identically to the VAR-ECM models reported in Table 5. The results for the most parsimonious models are reported in Table 6. Several points may be noted. First, the estimated adjustment coefficients on the error correction terms are highly significant with estimated values of - 0.24 and - 0.41 for Brazil and Guatemala respectively. These estimates are identical to two decimal places to the estimated adjustment coefficients in the integrated system reported in Table 5. Second, for both countries the error correction term appears only in the producer price equation implying that terminal prices are weakly exogenous for the parameters of interest in the producer price equation.[16] Third, looking at the terminal price equation shows that terminal prices in differences for both countries are stationary first order autoregressive processes with estimated parameters of 0.20 and 0.29 for Brazil and Guatemala respectively. This means of course that the level of terminal prices is integrated of order one which in turn generates producer prices as integrated of order one processes via the error correction mechanism.

In summary, all this implies that the SUR estimates are consistent with the levels of producer and terminal prices being integrated of order one processes. Furthermore, the significance of the error correction terms implies these two coffee prices are cointegrated. Together this demonstrates that our results from both approaches support each other and provide evidence of well behaved cointegrated systems once breaks in the coffee price ratio are taken into

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[16] This also implies that single equation estimation of the producer price equation would yield similar coefficient estimates. We have verified this and details are available on request.

account. Consequently, finding a rank of two in the Trace test for Brazil and Guatemala appears to be due to the low power of the test or an over rejection caused by the critical values being too small in the face of numerous structural breaks in the data.

Therefore our results for all three countries conform with the theoretical spatial model of prices and the expected behaviour of coffee prices. For example, the terminal and producer prices of coffee move very closely together as demonstrated by accepting the restriction that $\beta = -1$ and the existence of a powerful error correction mechanism in all three countries. Consequently, these results strongly favour the 'law of one price' once we adjust for the breaks in the mean of the coffee price ratio which are presumably due to changing coffee market policies. The large adjustment coefficients reported in Tables 5 and 6 imply that deviations from the long-run coffee price ratio are relatively small and transitory. Following a shock to the coffee price ratio, half of the adjustment to the long-run equilibrium occurs in around 2 ½ months for Brazil and 1 month for Guatemala and India.[17] This can be seen in Graph 2 where the estimated long-run coffee price ratios are equivalent to the horizontal thin lines and deviations in, u_t, from the long-run ratio are mostly small and short lived.

Finally, it appears that modelling the discrete shifts in the coffee price ratio as structural breaks plays an important role in explaining the behaviour of coffee prices and the associated changing shares in the terminal prices going to producers. Extending the standard analysis to include the breaks improves our understanding of the behaviour of coffee prices significantly.

4. COST TO PRODUCERS OF COFFEE MARKET REGULATION

The long-run equilibrium coffee price ratio is particularly useful for examining the impact of government policies and changing market structures on the coffee market as it abstracts from short-run variations and shocks to the ratio. Since the liberalisation of coffee markets the long-run coffee price ratio has increased to around 0.85 for Brazil and India and 0.79 for Guatemala in the most recent period.[18] Assuming the most recent long-run ratios reflect the

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[17] The adjustment speeds are calculated from simulations based on the estimates in Table 6.

[18] The slightly lower figure for Guatemala may reflect idiosyncratic or fundamental market reasons.

'efficient' market outcome then we can estimate the loss to producers by examining the extent to which the ratio has deviated from the efficient outcome.

The dashed and the black lines in Graph 3 show the annual value of coffee production measured at terminal and producer prices respectively for each of the three countries. The grey line is what coffee producers would have received according to the efficient outcome throughout the period.[19] The gap between the grey and black lines is the nominal loss to producers relative to the efficient outcome which is shown as the solid thin line in Graph 4.[20] Graph 4 also shows this loss in real terms measured in 2007 prices.

We observe that producers suffered losses in all three countries during the 1970s and early 1980s. In 2007 prices, the real losses to producers peak at around US$7 billion in the early 1980s for Brazil and around US$0.45 billion for Guatemala and India in the mid 1970s. The losses trail off to negligible levels in the most recent periods following liberalisation in all three countries indicating that market interventions over the years have not been in the overall interest of producers.

Note that these measures of loss are in respect to the producers alone and not necessarily to the country as a whole. The loss, or a part of the loss, may simply represent a transfer from the producer to either the government or intermediaries in the transfer process.

5. Are Producers Better Off?

Are producers better off following the liberalisation of coffee markets? To answer this question we consider three interrelated issues since the liberalisation of the coffee markets. First, what has happened to the producer price of coffee? Second, what has happened to the quantity of coffee produced? And finally, what has happened to the share of the terminal price of coffee that goes to the producer?

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19 Calculated as: $Q_t \bullet P_{T,t} \bullet U^e_{2007}$ where Q_t is the production of coffee and U^e_{2007} is the long-run coffee price ratio in 2007 for each country. This calculation assumes that production and the terminal price of coffee are independent of the efficient coffee price ratio.

20 The loss to producers is calculated as: $Q_t \bullet P_{T,t} \bullet \left[U^e_{2007} - U_t\right]$.

The common expectation from coffee market interventions was that they would result in an increase in the producer price of coffee. If this were the case then the producer price of coffee should have fared better during the period of interventions than after liberalisation. This is not supported by Table 1. In the seventeen years prior to liberalisation, producer coffee price inflation is only half that of the 'world' inflation rate of 6.6 per cent as measured by the UN index of unit values of exports or the United States CPI. Producer prices increased by 3.3, 1.0 and 2.3 per cent per annum in Brazil, Guatemala and India but in real terms they fell over the period prior to liberalisation by 42, 60 and 50 per cent respectively.

In contrast, during the period 1990 to 2007 when coffee markets witnessed the phase of liberalisation, producer prices increased by 3.6, 3.5, and 2.9 per cent per annum in Brazil, Guatemala and India compared with 'world' inflation of less than 1 per cent per annum as measured by the UN index of unit values of exports. This means that the producer price of coffee increased by around 60, 55 and 40 per cent in real terms after liberalisation.[21] Coffee prices therefore did not match the growth in 'world' prices during the years of coffee market interventions up to 1990 but increased by more than 'world' prices after the liberalisation of coffee markets.

The data also shows there has been a large increase in coffee production following liberalisation in all three countries. Average coffee production in the seventeen years after 1990 is 1.3, 1.3 and 1.8 times the coffee production in the seventeen years prior to 1990 in Brazil, Guatemala and India respectively (ICO, 2007). There may be many reasons for this increase in production. However, a part of the increase may be attributed to the removal of restrictions that were imposed on the production of coffee prior to liberalisation and to the added incentive after liberalisation for producers to supply better quality coffee which, in turn, has helped the growth in the consumption of coffee worldwide. In any case, as far as producers are concerned they have gained both in terms of prices and production following liberalisation. Finally, the empirical analysis above demonstrates that the long-run coffee price ratio has increased systematically since liberalisation of coffee markets in all three

[21] In the period 1990 to 2007 United States CPI deviates from the UN index of unit values of exports (see Table 1). However, if we use United States CPI as a measure of world inflation we find that producer prices still increase in real terms by around 15, 13 and 2 per cent respectively.

countries. This increase means that liberalisation has improved the returns to producers by reducing the net transfer costs throughout the coffee supply chain.

Therefore, the answer to the question of whether producers are better off since liberalisation appears to be unambiguously yes. Producers have benefited from a higher real price of coffee, higher coffee production, and a higher share of the terminal price of coffee.

6. CONCLUSION

This paper argues that to understand the dynamics of coffee prices we need to allow for structural breaks in the long-run coffee price ratio due to changes in government policies and market structure and that to simply undertake a cointegration analysis is inadequate. For example, estimating the model without allowing for the shifts in the long-run coffee price ratio (see Table 4) suggests that (i) a long-run cointegrating relationship between the two coffee prices exists only for Brazil where long-run homogeneity is rejected; and (ii) the speed of adjustment back to the long-run relationship is very slow.

However, estimating the model allowing for the shifts in the coffee price ratio as reported in Table 5 provides estimates that are consistent with our understanding of coffee markets. First, terminal and producer prices move closely together in the long run. Second, shocks to the relationship between the two coffee prices are eradicated very quickly. Third, liberalisation of the coffee markets has coincided with large increases in the coffee price ratio, that is the producers' share of the terminal price of coffee. In Brazil, the long-run share has risen from 0.6254 in the late 1980s to 0.8461 in the most recent period up to October 2007. Over the same period the long-run share to producers has increased from 0.6325 to 0.7896 for Guatemala and from 0.5485 to 0.8494 for India.

The systematic increase in the long-run producers' share of terminal coffee prices over the last seventeen years has greatly benefited the producers in these three coffee producing countries. The combination of the increase in the long-run producers share and the increase in the real price of coffee after liberalisation suggest that the benefit to producers in 2007 is around 3.63, 0.31 and 0.43 $US billion.[22] This can be compared with the actual payments to coffee producers of 4.63, 0.47 and 0.65 $US billion in 2007.

Lately there have been calls for a return to coffee market interventions on the grounds that the liberalisation of coffee markets has not improved the plight of producers. For example, ActionAid (2008) and South Centre (2008) argue that the real producer price of coffee is lower in 2007 than it was thirty years ago and it has not increased in line with the real retail price of coffee.[23] Furthermore, Sarris (2002) argues that the increase in the variance in the price of coffee due to liberalisation could mean that large and unexpected negative price shocks might result in some producers going out of business. This may well be the case and the international community and policy planners could do a lot more for producers. However, this paper demonstrates that producers have benefited significantly since liberalisation and that returning to interventions of the kind that existed prior to liberalisation would not be in the interest of producers.

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22 The total benefit to producers in 2007 is calculated as: $\left[Q_{2007} \bullet P_{T,2007} \bullet U^{e}_{2007}\right] - \left[Q_{2007} \bullet \frac{P_{T,2007}}{1+x} \bullet U^{e}_{1989}\right]$ where x is the benefit in terms of a higher real terminal prices of coffee calculated as in footnote 22. The first component of the calculation is what the producer actually received in 2007. The second component is what the producer would receive if the real terminal price was lower, $\frac{P_{T,2007}}{1+x}$, and they only received the 1989 equilibrium producers share, U^{e}_{1989}. The difference between the two components is the benefit to producers from higher real coffee prices and a higher equilibrium share of terminal prices. This measure of the benefit assumes that the quantity of coffee produced is unaffected by the real price of coffee or the coffee price ratio.

23 The fall in real prices over the past 30 years is consistent with our findings. However, as shown in Section 5 producers have benefited from increases in real prices over the past 17 years during the liberalisation phase.

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APPENDIX 1: REGULATION OF COFFEE MARKETS

International Regulation

1940: Inter-American Coffee Agreement. Export quotas to the United States were set for 14 Latin American countries. It is thought that prices doubled in response to the quotas.

1956-58: Brazil and Colombia jointly decided to limit their total exports. Between 1959 and 1962 further producers joined Brazil and Colombia to limit their exports.

1962-89: Formal system of multilateral interventions in coffee markets started with the signing of the United Nations sponsored first International Coffee Agreement (ICA) in 1962 by the major coffee exporting and importing countries and administered by the International Coffee Organization (ICO). The ICA allocated export quotas that were adjusted according to the changes in world prices. Quotas were reduced (increased) when coffee prices fell below (above) a particular level. The ICA was undermined by some member countries distributing their exports at lower prices through non-member countries and the inability to agree on quotas. Quotas were operational between October 1963 - December 1973, October 1980 - March 1986, and November 1987 - July 1989 (ICO, 1989). The Agreement was suspended in 1989.

May, 2000: 14 members of the Association of Coffee Producing Countries (ACPC) and five non-ACPC members introduced a price support scheme. Under the plan, up to 20 per cent of exports were to be held off the market when the 15-day ICO composite indicator price falls below 95 cents/lb and only released when prices are above US$1.05/lb. A similar scheme was tried for short periods in 1993 and 1995. The scheme had little or no impact on coffee price and was abandoned soon after implementation.

Domestic Regulation

Coffee exporting countries regulated the production and marketing of coffee both before and during the ICA period. Regulation took the form of producers having to sell their produce to the coffee or commodity marketing board at an administered price. At times producers also were required to obtain a license for the production of coffee. The suspension of the ICA and the shift in the late 1980s and early 1990s away from intervening in markets led to the replacing of state-controlled marketing systems with markets run by private agents.

The domestic regulation of coffee in India was carried out by the Coffee Board of India under which all producer's coffee was pooled and auctioned by the Coffee Board for the domestic and export markets. Exporters and international buyers were not permitted to buy coffee directly from producers. The producers were paid a guaranteed price fixed by the Coffee Board from time to time. The price was supposed to be fixed on the basis of auction prices after taking into consideration the marketing costs of the Coffee Board. However prices were often adjusted with considerable lag due to bureaucratic delays and other considerations. The liberalisation of coffee marketing was phased in over a period of four years starting in 1992/93 when producers were allowed to directly market up to 30 percent of the produce in the internal market. This was gradually increased and by 1996 the Coffee Board's involvement in marketing had been completely removed and producers were free to market their produce as they chose.

In Brazil, the Instituto Brasileiro do Café (IBC) was responsible for the domestic regulation of coffee. Its coffee marketing functions were similar to that of the Indian Coffee Board. The only difference being that IBC changed producer prices promptly to changes in the auction prices. Since 1990 coffee marketing has been totally liberalised and run by the private sector. The state's involvement is now limited to the funding of research and the provision of credit to the coffee sector. Coffee strategy is developed by the Conselho Deliberativo da Política do Café (CDPC) which is composed of representatives of the Government and private coffee sector. Prior to 1997, a transport tax was levied when coffee crossed a provincial boundary.

Guatemala had no state run commodity or coffee board and the interests of the sector were represented by a coffee producers' association, Asociación Nacional de Café (ANACAFE). The ANACAFE imposed market controls mostly in compliance with the ICA export quotas which were abolished following the ending of the ICA. The ANACAFE acts as the coffee sectors representative in government negotiations and providing policy advice and is funded by a levy of around one per cent on all coffee exports.

APPENDIX 2: THE DATA

Variable	*Mnemonic*	*Details*
Producer price of coffee	P_P	is the cash (gate) price received for Arabica coffee by coffee producers. They are the dollar equivalents, that is, prices in local currency converted to US$ at the contemporaneous exchange rates to arrive at a monthly average producer price in US cents per pound. Although there may be many grades traded for Arabica coffee, most producing countries calculate a weighted average price of the major grades, major being determined on the basis of coffee traded in quantitative terms. The producer prices were obtained from the ICO database and the Coffee Boards of the respective countries.
Terminal price of coffee	P_T	is the ICO Indicator Price for Arabica coffee calculated by weighting the ex-dock prices on the international markets in New York, Bermen and Hamburg markets in US cents per pound. The prices are available on daily and monthly basis from the ICO database.
Coffee price ratio	U	is the producer price divided by the terminal price of coffee. It is equivalent to the producers' share of the terminal price of coffee.
United States CPI		refers to the all urban consumer price index (old base) downloaded 25 August 2008 from the United States Department of Labor.
UN index of unit values of exports		refers to the United Nations index of unit values of exports of manufactured goods from developed market economies. It is used to convert values/unit values from current to constant terms. Downloaded on 25 August 2008 from the United Nations Conference on Trade and Development.
Coffee production		is the annual data of total production of coffee by coffee exporting countries available from the ICO database.

Note: Lower case variables in the paper are the natural logarithms of the upper case variables. All data is available at www.BillRussell.info.

APPENDIX 3 IDENTIFYING BREAKS IN THE MEAN RATIO OF COFFEE PRICES

The Bai and Perron (1998, 2003a, 2003b) approach minimises the sum of the squared residuals to identify the dates of k breaks in the natural logarithm of the ratio of the producer price of coffee to the terminal price of coffee and, thereby, identify $k+1$ shifts in the coffee price ratio. The estimated model is:

$$u_t = \gamma_{k+1} + \tau_t \qquad \text{(A3.1)}$$

where u_t is measured as $p_{P,t} - p_{T,t}$ and $p_{P,t}$ and $p_{T,t}$ are the natural logarithms of the producer and terminal prices of coffee respectively for Brazil, Guatemala and India. The terms γ_{k+1} are a series of $k+1$ constants that estimate the mean coffee price ratio in each of the $k+1$ regimes and τ_t is a random error. The minimum size between breaks is assumed to be 24 months and the final model is chosen using the Bayesian Information Criterion.

The technique identifies 11, 8 and 10 breaks in the coffee price ratio for Brazil, Guatemala and India implying that there are 12, 9 and 11 mean coffee price ratios respectively in each country over the past 35 years. The estimated dates of the shifts in the coffee price ratio are reported in the table below. The breaks were estimated in RATS 7.2 using the baiperron.src and multiplebreaks.src procedures written by Tom Doan and available at www.Estima.com.

Table A3: Estimated Dates of the Shifts in the Mean Coffee Price Ratio

Brazil	Guatemala	India
January 1973 to November 1974	January 1973 to May 1975	January 1973 to February 1976
December 1974 to February 1977	June 1975 to November 1979	March 1976 to May 1978
March 1977 to July 1979	December 1979 to August 1983	June 1978 to May 1980
August 1979 to July 1981	October 1983 to April 1986	June 1980 to August 1982
August 1981 to November 1984	May 1986 to April 1988	September 1982 to November 1986
December 1984 to March 1987	May 1988 to March 1993	December 1986 to May 1989
April 1987 to March 1989	April 1993 to March 1995	June 1989 to March 1992
April 1989 to November 1991	April 1995 to January 1998	April 1992 to March 1984
December 1991 to July 1996	February 1998 to October 2007	April 1994 to August 1996
August 1996 to October 2000		September 1996 to October 2004
November 2000 to November 2002		November 2004 to October 2007
December 2002 to October 2007		

Table 1: Nominal and Real Coffee Prices

Brazil

	Nominal Values			Real Value		
	Producer Price	*Terminal Price*	*Transfer Costs*	*Producer Price*	*Terminal Price*	*Transfer Costs*
1973	31.02	69.20	38.19	1	1	1
1990	55.58	82.97	29.39	0.5832	0.4048	0.2599
2007	98.23	111.66	13.44	0.9273	0.4725	0.1030
			Percentage Change			
1973 – 1990	72.7 (3.3)	19.9 (1.1)	- 23.0 (- 1.5)	- 41.7 (- 3.1)	- 59.5 (- 5.2)	- 74.0 (- 7.6)
1990 – 2007	83.3 (3.6)	34.6 (1.8)	- 54.3 (-4.5)	59.0 (2.8)	16.7 (0.9)	- 60.7 (- 5.3)
1973 – 2007	216.7 (3.4)	61.4 (1.4)	- 64.8 (- 3.0)	- 7.3 (- 0.2)	- 52.8 (- 2.2)	- 89.7 (- 6.5)

Guatemala

	Nominal Values			Real Value		
	Producer Price	*Terminal Price*	*Transfer Costs*	*Producer Price*	*Terminal Price*	*Transfer Costs*
1973	46.03	62.30	16.27	1	1	1
1990	54.58	89.46	34.87	0.4004	0.4848	0.7235
2007	98.09	123.55	25.46	0.6240	0.5807	0.4581
			Percentage Change			
1973 – 1990	18.6 (1.0)	43.6 (2.2)	114.3 (4.6)	- 60.0 (- 5.2)	- 51.5 (- 4.2)	- 27.6 (- 1.9)
1990 – 2007	79.7 (3.5)	38.1 (1.9)	- 27.0 (- 1.8)	55.9 (2.6)	19.8 (1.1)	- 36.7 (- 2.7)
1973 – 2007	113.1 (2.3)	98.3 (2.0)	56.5 (1.3)	- 37.6 (- 1.4)	- 41.9 (- 1.6)	- 54.2 (- 2.3)

India

	Nominal Values			Real Value		
	Producer Price	*Terminal Price*	*Transfer Costs*	*Producer Price*	*Terminal Price*	*Transfer Costs*
1973	45.37	62.30	16.93	1	1	1
1990	66.75	89.46	22.70	0.4968	0.4848	0.4527
2007	108.34	123.55	15.21	0.6992	0.5807	0.2630
			Percentage Change			
1973 – 1990	47.1 (2.3)	43.6 (2.2)	34.1 (1.7)	- 50.3 (- 4.0)	- 51.5 (- 4.2)	- 54.7 (- 4.6)
1990 – 2007	62.3 (2.9)	38.1 (1.9)	- 33.0 (- 2.3)	40.8 (2.0)	19.8 (1.1)	- 41.9 (- 3.1)
1973 – 2007	138.8 (2.6)	98.3 (2.0)	- 10.2 (- 0.3)	- 30.1 (- 1.0)	- 41.9 (- 1.6)	- 73.7 (- 3.9)

Notes: Figures in brackets are the compounded annualised percentage change. Real values are calculated with reference to the UN index of unit values of exports. Annual values are averages of the monthly values. Nominal values are in US cents per pound. Transfer costs are the difference between the terminal and producer price. The table on the right shows the percentage changes in the UN index of unit values of exports and the United States CPI.

	Unit Values of Exports	*US CPI*
	Percentage Change	
1973 – 1990	196.2 (6.6)	194.1 (6.6)
1990 – 2007	15.3 (0.8)	58.7 (2.8)
1973 – 2007	241.5 (3.7)	366.6 (4.6)

Table 2: ADF Univariate Unit Root Tests

Series	Original Data		De-meaned Data	
Brazil	Test Statistic	Probability Value	Test Statistic	Probability Value
Producer Price	- 3.48	0.0089	- 4.33	0.0005
Terminal Price	- 2.91	0.0454	- 4.02	0.0014
Ratio of Coffee Prices	- 3.33* #	0.0634	- 7.57#	0.0000
Guatemala				
Producer Price	- 3.01	0.0350	- 4.33	0.0005
Terminal Price	- 2.91	0.0454	- 4.02	0.0014
Ratio of Coffee Prices	- 6.10*	0.0000	- 11.61	0.0000
India				
Producer Price	- 3.00	0.0361	- 3.84#	0.0027
Terminal Price	- 2.91	0.0454	- 4.62	0.0001
Ratio of Coffee Prices	- 5.71*	0.0000	- 10.00	0.0000

Notes: Reported are the augmented Dickey-Fuller unit root test statistics and the associated probability values. ADF 5 per cent critical values with a constant is – 2.87 and with trend and constant -3.43. The data are in natural logarithms. De-meaned data is the original data adjusted for the shifts in mean as identified by the Bai-Perron technique for each country (see Appendix 2). * indicates a significant trend in the unit root test. In all other cases the trend is insignificant and excluded prior to inference. A lag length of one was chosen on the basis of SIC in all cases except when zero as indicated by #. The ratio of coffee prices is the natural logarithm of the producer price divided by the terminal price of coffee.

Table 3: Testing for the Number of Cointegrating Vectors

	Brazil			Guatemala			India		
H_0: r =	Trace	$CV_{5\%}$	p-value	Trace	$CV_{5\%}$	p-value	Trace	$CV_{5\%}$	p-value
Model 1 – Standard Cointegration Model without Breaks									
0	23.8590	25.7310	0.0862	48.4878	25.7310	0.0000	44.6153	25.7310	0.0000
1	8.3049	12.4478	0.2345	8.5179	12.4478	0.2183	6.8484	12.4478	0.3709
Model 2 – Bai-Perron Break Adjusted Estimates									
0	94.8161	55.1580	0.0000	149.7019	42.5595	0.0000	139.3038	50.5940	0.0000
1	26.3182	19.6200	0.0060	40.3706	15.0355	0.0000	17.9809	18.1718	0.0556

Notes: The maximum number of cointegration vectors is given by r. Trace and the p-value are the Bartlett small sample adjusted values of the Trace test statistics and associated probability value respectively. $CV_{5\%}$ is the 5 per cent critical value of the Trace test. In Models 2 and 3, the inclusion of the shift dummies in the cointegration space affect the distribution of the test statistics in such a way as to reject cointegration too often i.e. the dummies increase the value of the Trace statistic relative to the critical value. In these models the simulated critical values of the Trace statistic are reported based on the actual finite sample behaviour of the data.

Table 4: VAR Error Correction Model of Coffee Prices
Model 1 – Standard Cointegration Model without Breaks

BRAZIL

	Long-run Coefficients			Adjustment Coefficients	
	p_P	p_T	Trend	Δp_P	Δp_T
Unrestricted	1.0000	- 0.7010 (- 4.7)	- 0.1828 (- 3.1)	- 0.0630 (- 3.0)	- 0.0044 (- 0.3)
Restricted	1.0000	- 1.0000	- 0.0048 (- 4.3)	- 0.0351 (-1.6)	0.0199 (1.2)

TLRR = 0.2875, TT = 0.1513, LM_1 = 0.2688, LM_2 = 0.4058. Normality = 0.0000. Stationarity: p_P = 0.0883, p_T = 0.0121. Exclusion: p_P = 0.0121, p_T = 0.0883, Trend = 0.0830. Exogeneity: p_P = 0.0494, p_T = 0.8594.

GUATEMALA

	Long-run Coefficients			Adjustment Coefficients	
	p_P	p_T	Trend	Δp_P	Δp_T
Unrestricted	1.0000	- 0.9571 (- 13.9)	- 0.0495 (-2.2)	- 0.2022 (- 6.0)	0.0218 (1.0)
Restricted	1.0000	- 1.0000	- 0.0528 (- 2.3)	- 0.1935 (- 5.9)	0.0268 (1.3)

TLRR = 0.6281, TT = 0.0564, LM1 = 0. 1204, LM2 = 0. 0683. Normality = 0.0000. Stationarity: p_P = 0.0000, p_T = 0.0000. Exclusion: p_P = 0.0000, p_T = 0.0000, Trend = 0.0381. Exogeneity: p_P = 0.0000, p_T = 0.3724.

INDIA

	Long-run Coefficients			Adjustment Coefficients	
	p_P	p_T	Trend	Δp_P	Δp_T
Unrestricted	1.0000	- 0.7783 (- 12.0)	- 0.0514 (- 2.4)	- 0.0913 (- 4.0)	0.0864 (3.7)
Restricted	1.0000	- 1.0000	- 0.3474 (- 2.4)	- 0.0508 (- 2.8)	0.0788 (4.3)

TLRR = 0.0316, TT = 0.0364, LM_1 = 0.3603, LM_2 = 0.5283. Normality = 0.0000. Stationarity: p_P = 0.0000, p_T = 0.0000. Exclusion: p_P = 0.0000, p_T = 0.0000, Trend = 0.0226. Exogeneity: p_P = 0.0003, p_T = 0.0009.

Notes: Reported as ( ) are t-statistics. The trend is multiplied by 100. The models and statistics are estimated with two lags of the core variables and an effective sample of 416 monthly observations for the period January 1973 to October 2007. The number of lags was chosen by a likelihood ratio test for lag reduction. TLRR and TT are the finite sample Bartlett corrected probability values of the test of the long-run cointegrating restriction that $\beta = 1$ and the likelihood ratio exclusion test of the estimated trend. LM_1 and LM_2 are the probability values of the Lagrange Multiplier tests of no serial correlation in the errors of lags 1 and 2 respectively. Normality is the probability value of the Doornik-Hansen test for normal errors. Stationarity, Exclusion and Exogeneity are the probability values of the likelihood ratio tests that p_P and p_T (and trend if applicable) are stationary, can be excluded from the cointegrating space and/or weakly exogenous respectively. Estimated with CATS 2.0.

Table 5: VAR Error Correction Model of Coffee Prices – Johansen Estimates
Model 2 – Bai-Perron Break Adjusted

BRAZIL

	Long-run Coefficients		**Adjustment Coefficients**	
	p_P	p_T	Δp_P	Δp_T
Unrestricted	1.0000	- 0.9058 (- 17.2)	- 0.2652 (- 6.7)	- 0.0338 (-1.1)
Restricted	1.0000	- 1.0000	- 0.2420 (-5.9)	- 0.0036 (- 0.1)

TLRR = 0.2085, LM_1 = 0.5148, LM_2 = 0.0577. Normality = 0.0000. Stationarity: p_P = 0.0000, p_T = 0.0000. Exclusion: p_P = 0.0000, p_T = 0.0000. Exogeneity: p_P = 0.0000, p_T = 0.3981.

Dec' 1974	- 0.2449 (- 2.8)	Aug' 1979	0.2806 (3.3)	Dec' 1984	- 0.5702 (- 7.6)	April 1989	- 0.5049 (- 6.1)	Aug' 1996	- 0.0645 (- 1.1)	Dec' 2002	- 0.2014 (-2.8)
March 1977	0.3939 (4.8)	Aug' 1981	- 0.1225 (- 1.5)	April 1987	0.4842 (5.7)	Dec' 1991	- 0.2544 (- 3.8)	Nov' 2000	0.1965 (2.6)		

GUATEMALA

	Long-run Coefficients		**Adjustment Coefficients**	
	p_P	p_T	Δp_P	Δp_T
Unrestricted	1.0000	- 0.9189 (- 23.8)	- 0.4547 (- 10.2)	- 0.0578 (- 1.9)
Restricted	1.0000	- 1.0000	- 0.4117 (- 9.4)	0.0852 (2.9)

TLRR = 0.1309, LM1 = 0.0001, LM2 = 0.6317. Normality = 0.0000. Stationarity: p_P = 0.0000, p_T = 0.0000. Exclusion: p_P = 0.0000, p_T = 0.0000. Exogeneity: p_P = 0.0000, p_T = 0.1319.

June 1975	0.2924 (5.4)	Oct' 1983	- 0.3316 (- 6.1)	May 1988	0.0607 (1.1)	April 1995	- 0.1062 (- 1.7)
Dec' 1979	- 0.1562 (- 3.3)	May 1986	0.3101 (4.8)	April 1993	0.1043 (1.8)	Feb' 1998	- 0.1693 (-2.8)

INDIA

	Long-run Coefficients		**Adjustment Coefficients**	
	p_P	p_T	Δp_P	Δp_T
Unrestricted	1.0000	- 1.0391 (- 24.1)	- 0.1699 (- 5.8)	0.2250 (7.8)
Restricted	1.0000	- 1.0000	- 0.1813 (- 6.0)	0.2243 (7.5)

TLRR = 0.4704, LM_1 = 0.0083, LM_2 = 0.0777. Normality = 0.0000. Normality = 0.0000. Stationarity: p_P = 0.0000, p_T = 0.0000. Exclusion: p_P = 0.0000, p_T = 0.0000. Exogeneity: p_P = 0.0000, p_T = 0.0000.

Mar' 1976	0.5463 (10.5)	June 1980	- 0.1491 (- 2.6)	Dec' 1986	- 0.2019 (- 4.3)	April 1992	- 0.1102 (- 2.0)	Sept' 1996	- 0.2669 (- 6.2)
June 1978	- 0.2231 (- 3.9)	Sept' 1982	0.2442 (5.0)	June 1989	- 0.1842 (- 3.6)	April 1994	0.4594 (8.1)	Nov' 2004	- 0.2021 (- 5.1)

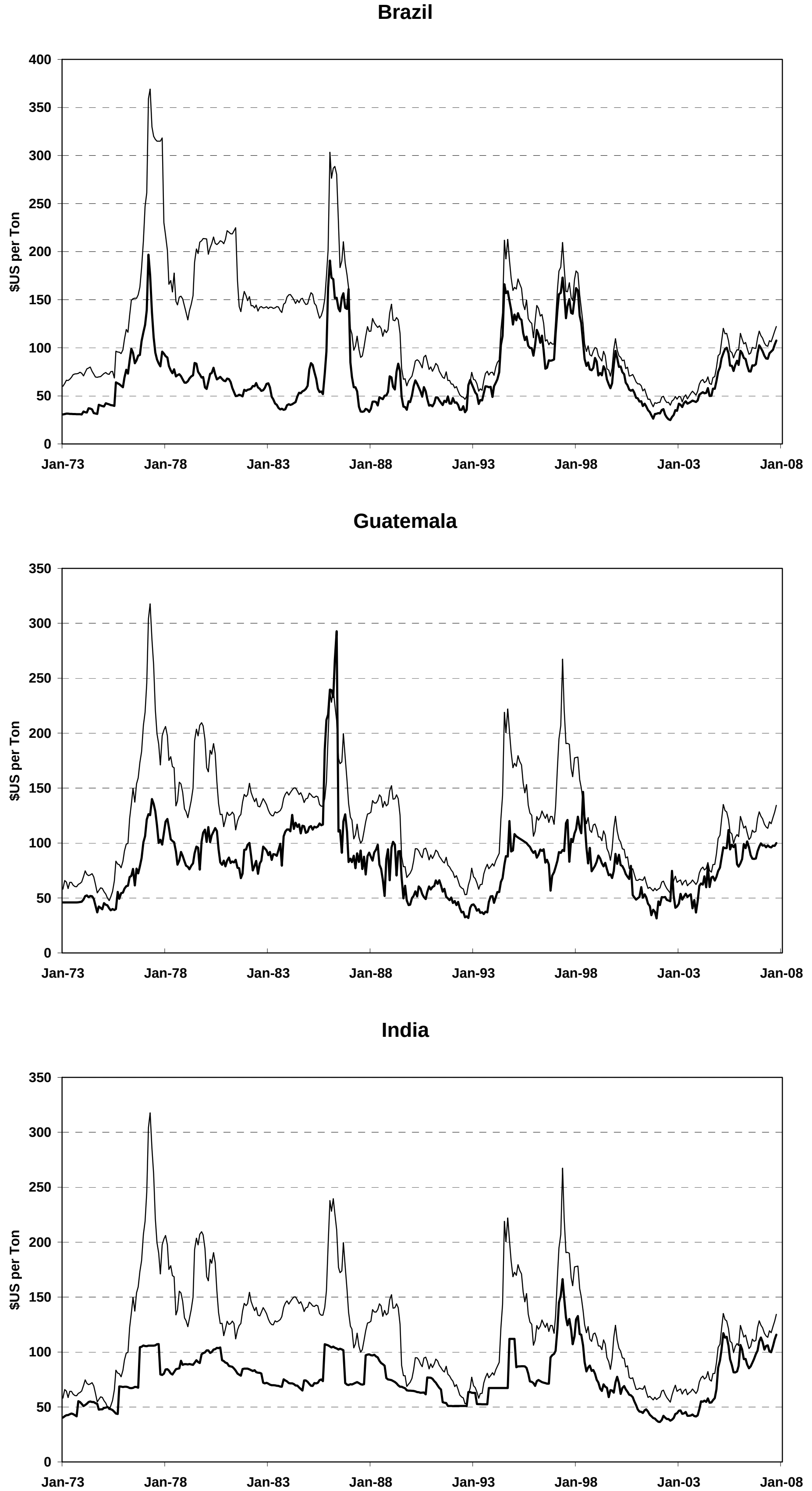
Notes: Lower panel for each country is the estimated cointegration shift dummies in the restricted model. For further details see the notes to Table 4, 5 and 6.

Table 6: Error Correction Model of Coffee Prices – SUR Estimates
Model 2 – Bai-Perron Break Adjusted

	Brazil		**Guatemala**	
Equation	Producer Prices	Terminal Prices	Producer Prices	Terminal Prices
Dependent variable	$\Delta p_{P,t}$	$\Delta p_{T,t}$	$\Delta p_{P,t}$	$\Delta p_{T,t}$
ecm_{t-1}	- 0.2420 (- 5.6)		- 0.4091 (- 5.7)	
$\Delta p_{P,t-1}$	0.2068 (4.5)		- 0.1288 (- 2.5)	
$\Delta p_{T,t-1}$		0.2005 (4.2)	0.2195 (2.6)	0.2895 (4.4)
Constant	- 0.1841 (- 4.9)	0.0013 (0.3)	- 0.1273 (- 5.3)	0.0012 (0.3)
$D2_t$	0.0603 (2.7)		- 0.1076 (- 4.4)	
$D3_t$	- 0.0323 (- 1.5)		- 0.0554 (- 3.1)	
$D4_t$	- 0.1026 (- 4.0)		0.0929 (3.9)	
$D5_t$	- 0.0725 (- 3.2)		- 0.0392 (- 1.0)	
$D6_t$	0.0602 (2.0)		- 0.0724 (- 3.5)	
$D7_t$	- 0.0488 (- 2.1)		- 0.913 (- 3.2)	
$D8_t$	0.0728 (2.8)		- 0.0682 (- 2.7)	
$D9_t$	0.1312 (4.2)		0.0272 (1.9)	
$D10_t$	0.1451 (4.6)			
$D11_t$	0.0984 (3.7)			
$D12_t$	0.1470 (4.7)			
		Diagnostics		
DW	1.84	1.97	2.01	2.02
LM(1) LM(4)	[0.0717] [0.0576]	[0.5803] [0.1725]	[0.2572] [0.2877]	[0.9658] [0.3715]
ADF	- 9.76	- 9.14	- 8.65	- 9.98
		F-Test		
JET	[0.0808]		[0.1219]	

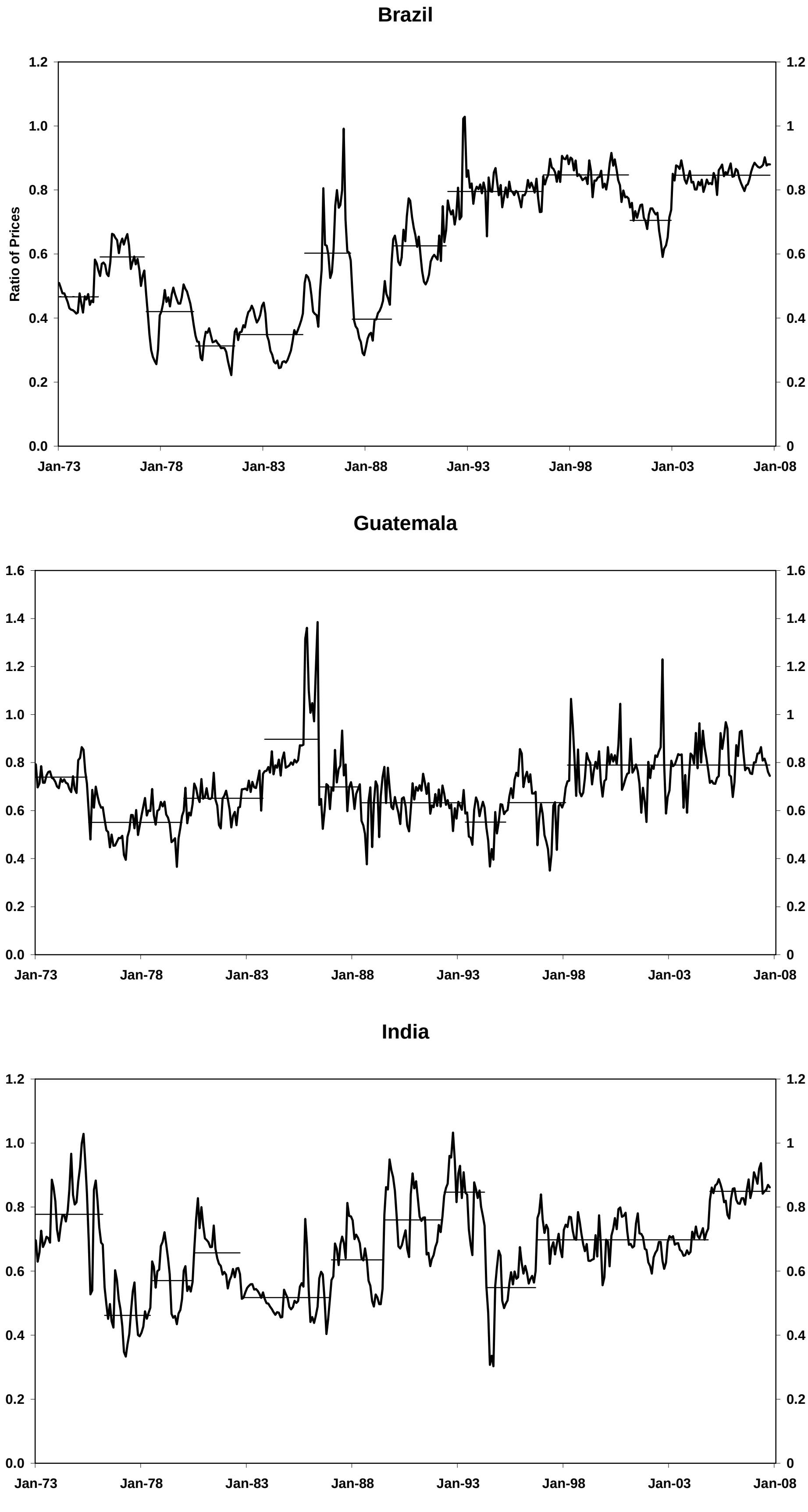
All models estimated with SUR estimator. [ ] reported as probability values. Original model contains the error correction term, ecm_{t-1}, one lag of the difference in producer prices and terminal prices, a constant and dummies. The error correction term is calculated as: $ecm_t = p_{P,t} - p_{T,t}$. DW is the Durban-Watson test statistic, LM(1) and LM(4) are the Lagrange multiplier test probability values of the first and fourth order autocorrelation of the residuals, ADF is the no intercept and no trend ADF test of the residuals where the 1%, 5% and 10% critical values are - 2.576, - 1.941 and - 1.616 respectively. JET is the probability value of the joint exclusion test that the error correction term, lagged producer price inflation and dummies are all zero in the terminal price equation for Brazil and Guatemala and lagged terminal price inflation for Brazil is zero.

Graph 1: Terminal and Producer Prices for Arabica Coffee



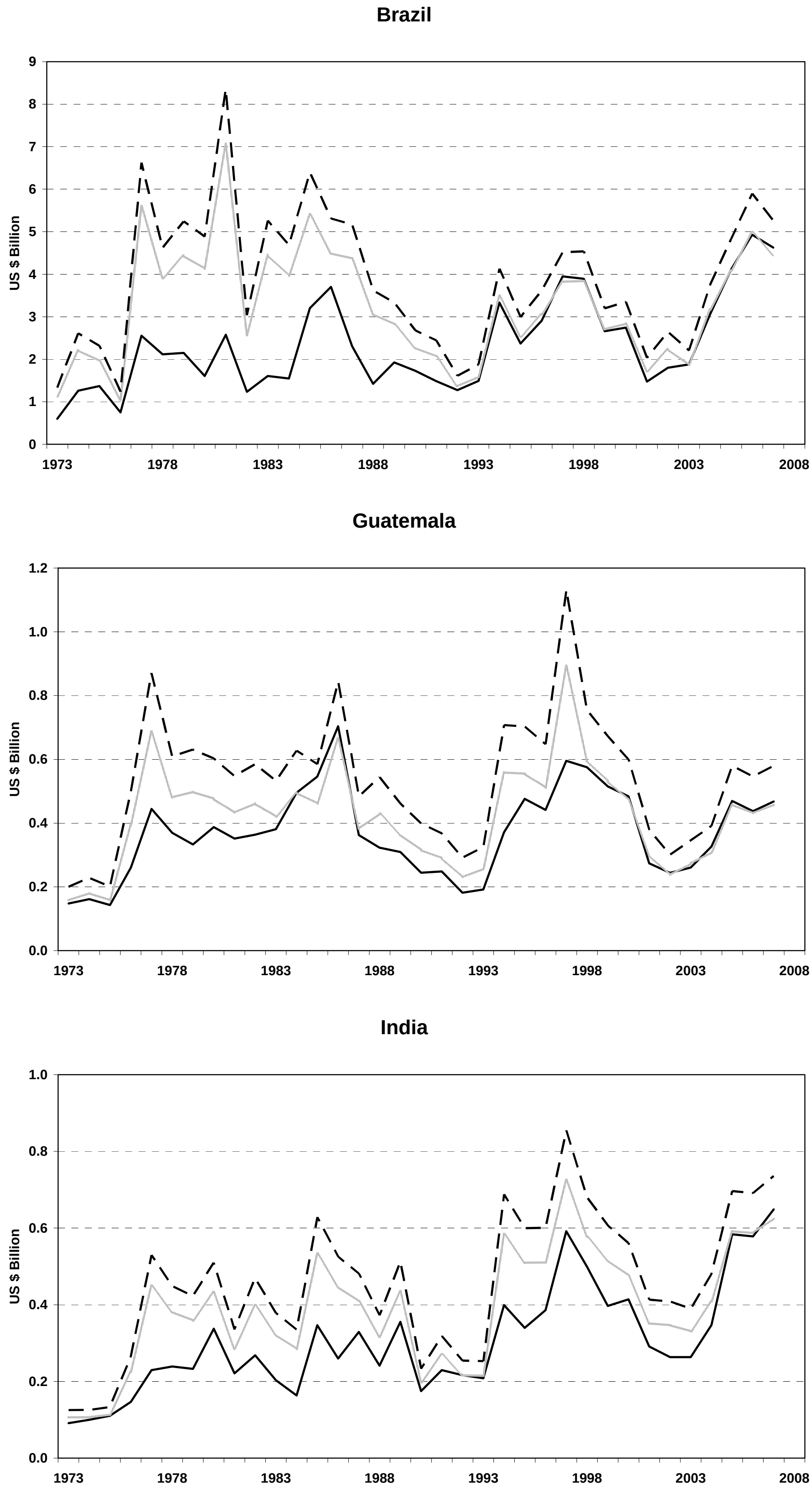
Note: Thin and thick lines are the terminal and producer prices of coffee respectively.

Graph 2: Ratio of the Producer Price to the Terminal Price of Coffee



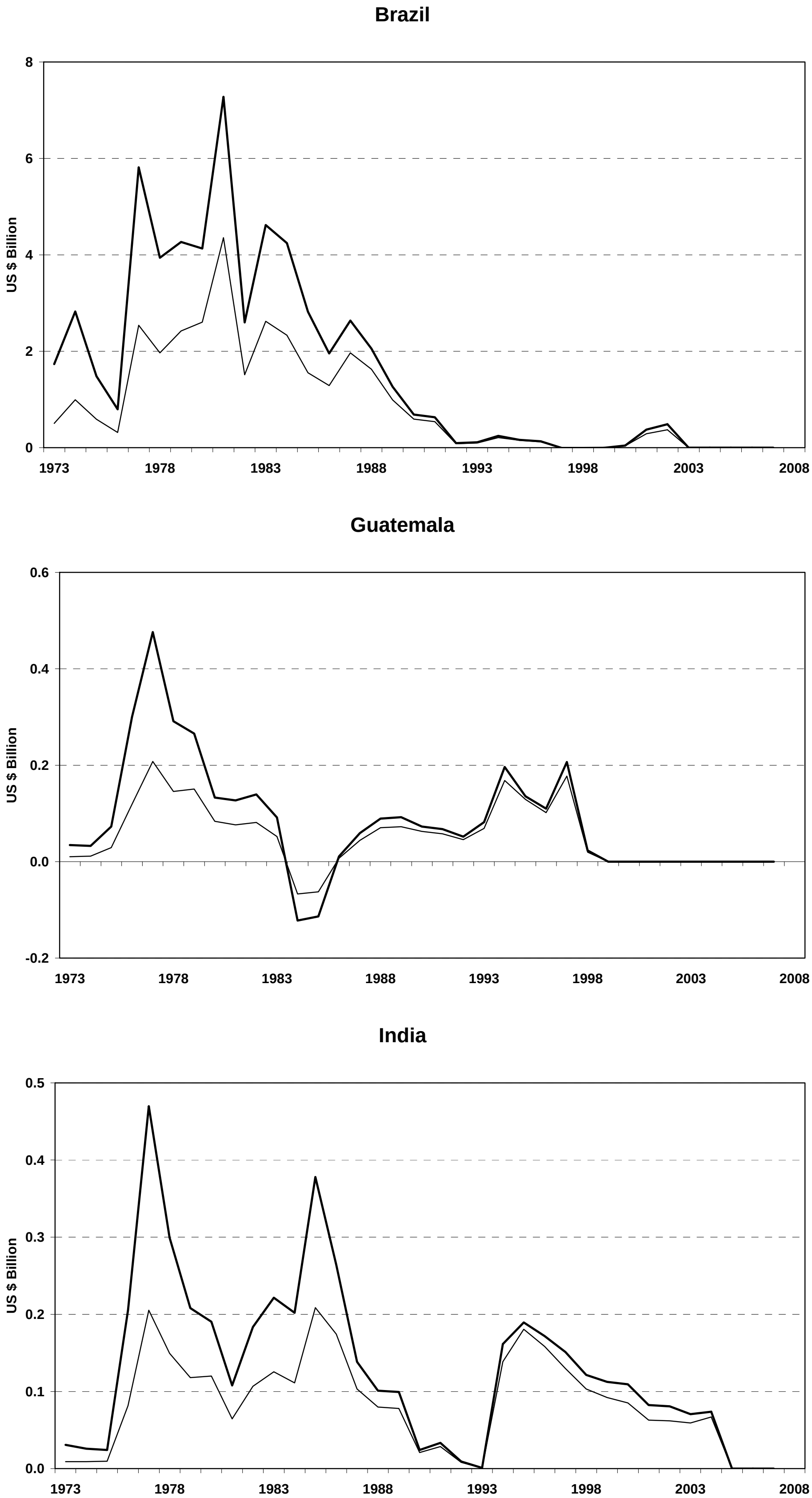
Note: Thick line is the ratio of the producer to the terminal price of coffee. The horizontal thin lines are the mean coffee price ratio as estimated by the Bai-Perron technique.

Graph 3: Value of Coffee Production



Note: The black, grey and dashed lines are the actual value of production to producers, the value of production according to the 'efficient' market outcome, and the value of production at terminal prices respectively.

Graph 4: Nominal and Real Losses of Coffee Producers



Note: The thin and thick lines are the nominal and real values (in 2007 prices) of the loss to producers. Real values are in terms of the UN index of unit values of exports.