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7 Commodity Export Prices and the Real Exchange Rate in Developing Countries: Coffee in Colombia

Sebastian Edwards

7.1 Introduction

Changes in commodity export prices generally have an important effect on real exchange rate behavior. Under most conditions a commodity export boom results in a real appreciation of the domestic currency, with the extent of this appreciation depending on, among other things, whether the public perceives the change in export prices as being temporary or permanent. Most recent work on the interaction between commodity export prices and real exchange rates has focused on the long-run real effects of changes in export prices, analyzing how resource-based export booms will affect the real exchange rate, wages, employment, and output in the long run.[1] Changes in commodity export prices can also have important short-run monetary effects, however, effects that spill over to the real exchange rate. A resource-based export boom, for example, typically results in a balance-of-payments surplus and an accumulation of international reserves. If this increase in reserves is not fully sterilized, the monetary base will increase, and inflation will likely result. This increase in the price level will in general be one of the mechanisms through which the real appreciation actually takes place. It is possible, however, that the short-run increase in the rate of inflation exceeds what is required to bring about the equilibrium real appreciation generated by the export boom; in this case, the real exchange rate will appreciate in the short run by more than the amount

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real factors would indicate.[2] These short-run monetary effects of commodity export booms have recently been important in the economies of a number of developing countries, including Indonesia, Kenya, and Colombia.

In spite of the importance of understanding the mechanisms through which changes in commodity export prices are transmitted into real exchange rate changes, very few empirical studies have tackled this subject.[3] This paper develops and tests a model of the interactions among commodity export prices, money creation, inflation, and the real exchange rate. The empirical analysis focuses on the effects of changes in coffee prices on the real exchange rate in Colombia. A number of experts have argued that fluctuations in Colombia's real exchange rate have been mainly determined by world coffee price movements, with most observers emphasizing the consequences of coffee price changes for money creation and inflation. Since 1967 Colombia has had a crawling-peg exchange rate system, in which the rate of devaluation of the peso is determined according to the behavior of a set of indicators that presumably includes the world price of coffee. Moreover, for many years Colombian authorities have tried to implement policies designed to reduce the effects of (temporary) changes in coffee prices on the real exchange rate.[4]

The paper is organized in the following form. Section 7.2 briefly reviews the behavior of the real exchange rate and coffee prices in Colombia. Section 7.3 presents and estimates a model that explicitly takes into account the monetary and inflationary effects of coffee price movements on the real exchange rate. The model also includes an equation for the rate of adjustment of the nominal exchange rate, or rate of crawl. The results reported in that section indicate that changes in (world) coffee prices have been positively associated with money creation and inflation and negatively associated with the rate of devaluation of the nominal exchange rate in Colombia. Finally, the fourth section offers some concluding remarks and argues in particular that the approach taken in this paper is useful for analyzing other cases in which commodity export prices and the real exchange rate have been closely related.

7.2 Coffee and the Real Exchange Rate in Colombia: An Overview

The performance of the Colombian economy has traditionally been linked to the behavior of the world coffee market.[5] A number of authors have argued that changes in the world price of coffee have been transmitted to Colombia mainly through the effect they have on the real exchange rate (Weisner 1978; Urrutia 1981; World Bank 1984). Increases (decreases) in the world price of coffee have generated real

appreciations (depreciations) of the Colombian peso. These variations in the real exchange rate, in turn, have altered the competitiveness of the noncoffee tradables sectors, with a real appreciation generating losses of competitiveness or exchange rate "deprotection." For example, the recent coffee bonanza of 1975–79 resulted in a sharp real appreciation, which hampered the ability of the domestic sector to compete in international markets. Earlier episodes of sharp increases in the coffee price (in 1950, 1954, and 1956, for example) also led to steep appreciations of the peso (Weisner 1978; World Bank 1984.) Table 7.1 presents data on real exchange rates, coffee prices, and terms of trade in Colombia between 1952 and 1982, while table 7.2 contains data on money creation, international reserves growth, and devaluation and inflation rates for 1968–82. Figures 7.1 and 7.2 depict two alternative indexes of the real exchange rate and coffee prices.

In principle, changes in the price of coffee should affect the real exchange rate through at least two channels. First, a rise in the price of coffee will result in an increase in disposable income and an increase in the demand for tradable and nontradable goods. To the extent that the price of other (noncoffee) tradables is given by their world price and the exchange rate, this income effect will result in a higher relative price of nontradables and in a real appreciation of the peso. Second, and more important in the Colombian case, an increase in the price of coffee will tend to generate a balance-of-payments surplus and an accumulation of international reserves. If this increase in international reserves is not fully sterilized, the monetary base will also increase, and inflation will tend to result with the consequent further appreciation of the peso.[6] For example, as the data in table 7.2 show, the 1975–79 coffee bonanza generated a steep increase in international reserve holdings and in money creation. Regarding this particular episode, Urrutia (1981, 217) observed, "The increase in coffee prices started to produce increases in money supply which were . . . not neutralized rapidly enough. . . . But by 1976 all conceivable measures were taken to restrict money supply growth and to compensate for the growth in the monetary base caused by the growth in international reserves. . . . All these measures, however, were insufficient, and money supply increased by 34.7 percent."

Since World War II, the Colombian authorities have experimented with several schemes to reduce the impact of changes in coffee prices on the real exchange rate and on the rest of the economy. The main objective of the government during this period has been to reduce the undesirable short-run effects that temporary changes in coffee prices have on the degree of profitability, production, and employment in the rest of the economy.[7] For many years returns from coffee exports have been subject to a lower net rate of exchange than returns from other

Table 7.1 **Coffee Prices, Rates of Devaluation, and the Real Exchange Rate in Colombia, 1952–82 (1980 = 100)**

Year	Real Price of Coffee (1)	Terms of Trade (2)	Effective Real Exchange Rate (3)	Bilateral Real Exchange Rate with Respect to U.S. Dollar (4)
1952	75.94	—	47.11	62.20
1953	83.08	—	44.21	57.14
1954	110.82	—	40.88	52.70
1955	87.32	—	41.66	53.28
1956	98.53	87.65	39.95	51.65
1957	79.19	84.89	47.74	69.80
1958	71.40	72.18	81.40	104.08
1959	61.21	60.97	76.40	97.27
1960	61.55	63.04	77.23	97.23
1961	59.04	61.63	73.45	90.03
1962	56.91	57.80	75.82	91.50
1963	56.35	52.28	76.81	89.35
1964	70.35	63.21	65.96	76.11
1965	76.39	64.40	73.72	87.28
1966	73.14	51.15	84.97	96.97
1967	62.64	60.21	86.46	96.56
1968	64.34	62.01	94.17	104.99
1969	66.89	61.57	95.09	105.29
1970	83.40	75.02	100.84	108.79
1971	71.00	70.11	106.50	111.34
1972	75.72	73.71	111.81	112.48
1973	83.51	78.49	113.18	113.88
1974	69.60	81.92	111.10	120.10
1975	68.41	75.76	119.85	126.65
1976	126.49	106.29	116.11	123.63
1977	181.95	147.45	101.04	104.52
1978	125.29	110.06	102.85	101.67
1979	112.47	98.38	101.29	99.89
1980	100.00	100.00	100.00	100.00
1981	67.52	84.36	91.62	95.16
1982	72.34	81.87	87.56	98.99

Source: International Financial Statistics (*IFS*).

Notes: The real price of coffee is defined as the U.S.$ coffee price deflated by the U.S.$ import price index. The effective exchange rate was computed using trade weights and taking into account Colombia's ten major trade partners. The partners (and weights) are: U.S. (0.507); U.K. (0.047); France (0.037); Germany (0.163); Italy (0.033); Netherlands (0.044); Japan (0.058); Sweden (0.032); Spain (0.035); and Venezuela (0.045). According to the definitions of the real exchange rate used in this paper, an increase in the index reflects a real depreciation, whereas a decline in the index represents a real appreciation.

Table 7.2 **Coffee Prices and Rates of Devaluation, Money Growth, International Reserves Growth, and Inflation in Colombia, 1968–82**

Year	Rate of Devaluation (%) (1)	Rate of Growth of High-Powered Money (%) (2)	Rate of Growth of International Reserves (U.S. $) (%) (3)	Rate of Inflation (%) (4)	Real Price of Coffee (1980 = 100) (5)
1968	12.3	23.9	—	5.7	64.3
1969	6.3	25.7	37.3	9.6	66.9
1970	6.5	19.1	−3.1	6.5	83.4
1971	8.1	12.9	−0.5	7.8	71.0
1972	9.7	16.5	64.0	12.6	75.7
1973	8.1	24.3	67.0	18.9	83.5
1974	10.3	22.8	−16.5	21.6	69.6
1975	18.7	21.2	10.2	20.7	68.4
1976	12.2	29.6	131.8	18.4	126.5
1977	6.0	34.2	58.7	28.6	182.0
1978	6.3	39.7	35.4	16.3	123.5
1979	8.8	33.0	62.5	22.1	112.5
1980	11.1	25.5	25.7	23.5	100.0
1981	15.3	23.5	−0.6	24.3	67.5
1982	17.6	18.4	−19.6	24.5	72.3

Sources: Columns (1) through (4), International Financial Statistics (*IFS*); column (5), table 7.1.

exports. Further, in the past the degree of import protection was altered depending on the behavior of coffee prices: it was reduced when the world price of coffee increased and was raised when the price of coffee declined. In addition, several monetary measures, including steep increases in the banking system reserves requirements, have been implemented when the price of coffee has risen. During the 1975–79 coffee bonanza, for example, a novel mechanism was implemented to reduce the monetary impact of the higher coffee price. Specifically, in 1977 the maturity of certificates of exchange—which are government certificates received by exporters when they surrender their foreign exchange—was significantly lengthened. In that way, the monetary effect of the coffee boom was postponed, but not avoided (Weisner 1978).[8]

Many experts have indicated that Colombia's adoption of a crawling-peg system in 1967 was in response to the need to reduce the dependence of the country's real exchange rate on coffee price fluctuations (Weisner 1978; Urrutia 1981; Ocampo 1983). Nonetheless, since the inception of the crawling-peg system, the decision on the rate at which the peso should be devalued has been highly influenced by coffee prices.

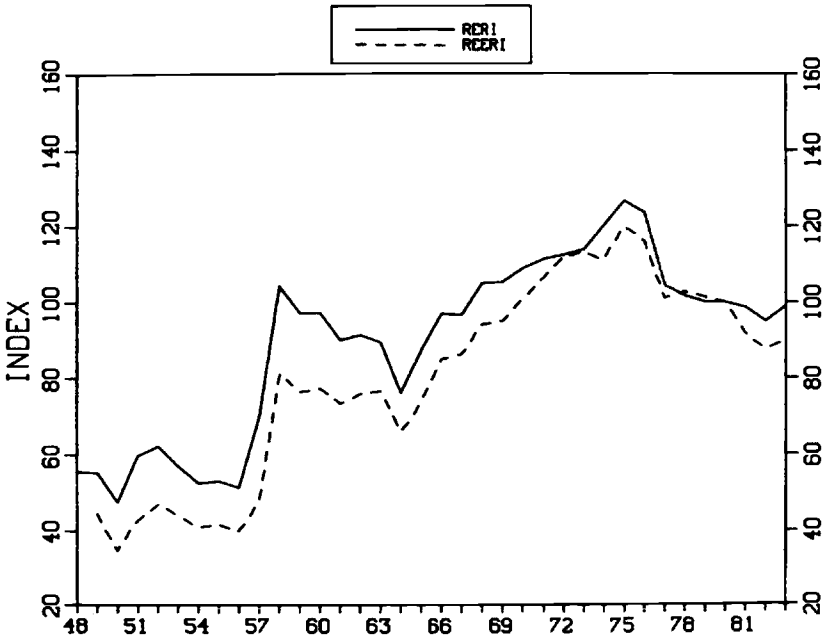

Fig. 7.1 Real (*RERI*) and real effective (*REERI*) exchange rate indexes in Colombia, 1948–83.

For example, according to Weisner (1978, 203), once the crawling peg was adopted, one of the main problems was to decide "at what pace to devalue when coffee prices rise." This problem has been compounded by a trade-off between the rate of nominal devaluation and inflation. In practice there has been an inverse relationship between the rate of devaluation of the peg and coffee prices. This relationship can be seen in table 7.2. The high coffee prices of 1976–79, for example, were accompanied by a significant slowdown in the rate of devaluation; when the price of coffee began to fall in 1980–82, the rate of the crawl was rapidly accelerated. This inverse relationship between world coffee prices and the nominal rate of devaluation in Colombia constitutes another mechanism—in addition to the effect of money creation on inflation—through which higher (lower) coffee prices have been translated into a lower (higher) real exchange rate.

Even though these measures, such as changes in the level of protection and variations in the maturity of exchange certificates, have helped reduce the degree of volatility of the real exchange rate, they have not eliminated its close dependence on the price of coffee. Nevertheless, since coffee prices are not the only determinants of the real exchange rate, during some periods its movement has mainly been in

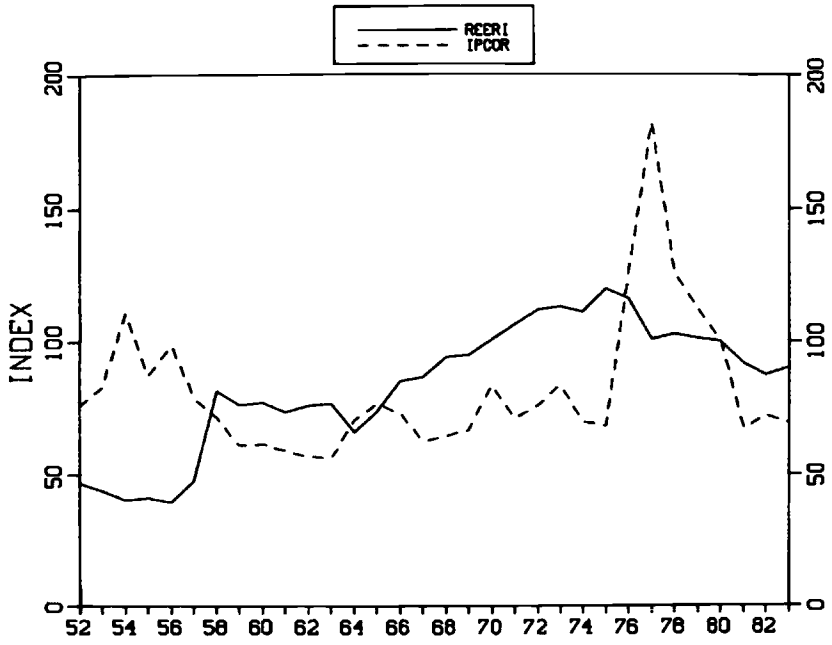

Fig. 7.2 Real exchange rates (*REERI*) and real prices (*IPCOR*) of coffee in Colombia, 1952–83.

response to other variables. Between 1968 and 1973, for example, changes in the real exchange rate were to a large extent the result of the lower degree of import protection and of the imposition of an export promotion scheme (Díaz-Alejandro 1976). The opening up of the Colombian economy carried out during this period resulted in a smooth real depreciation of the peso.

7.3 Coffee, Money, Inflation, and the Real Exchange Rate in Colombia

This section develops and estimates a model of the way in which coffee prices, money creation, inflation, and the real exchange rate interact. A central purpose of the model is to test formally whether, as a number of authors have casually observed, changes in coffee prices have indeed been related to money creation and inflation in Colombia. Also investigated is the extent to which manipulations of the rate of devaluation of the exchange rate have responded to coffee price changes. The model is quite simple, and its structure allows us to concentrate on the problem at hand without being sidetracked by other issues. An

obvious drawback of this strategy is that the simple structure requires the imposition of some simplifying assumptions.

7.3.1 The Model

The model focuses on the effects of changes in (world) coffee prices on money creation, inflation, and exchange rate adjustment. As presented in equations (1) through (11) below, the model assumes that there are three goods in the economy: coffee (c), nontradables (N), and other (noncoffee) tradables (T). It also assumes that, as has been the case in Colombia since 1967, the economy has a crawling-peg exchange rate system, one in which the nominal exchange rate is adjusted periodically according to the behavior of a set of indicators. It is further assumed that because of the existence of capital controls, the capital account is exogenously given.

$$\hat{M}_t = \omega\hat{R}_t + (1 - \omega)\,\hat{C}_t; \tag{1}$$

$$\hat{C}_t = c_0 + \phi\, DEH_t + z_t; \tag{2}$$

$$\hat{R}_t = \theta\,(\hat{M}_t^d - \hat{M}_{t-1}) + \psi\,\hat{P}_t^c; \tag{3}$$

$$\hat{M}_t^d = \hat{P}_t + \eta\,\hat{y}_t; \tag{4}$$

$$\hat{P}_t = (1 - \delta)\,\hat{P}_{Nt} + \delta\,\hat{P}_{Tt}; \tag{5}$$

$$\hat{P}_{Tt} = \hat{E}_t + \hat{P}_{Tt}^*; \tag{6}$$

$$\hat{P}_t^c = \hat{E}_t + \hat{P}_t^{c^*}; \tag{7}$$

$$\hat{P}_{Nt} = \hat{P}_{Tt} + \lambda(\hat{M}_t - \hat{M}_t^d) + \rho\,\hat{y}_t; \tag{8}$$

$$\hat{E}_t = \gamma_0\hat{P}_t - \gamma_1\hat{P}_t^{c^*} - \gamma_2\hat{y}_t - \gamma_3\hat{P}_{Tt}^* + \gamma_4 x_t; \tag{9}$$

$$\hat{y}_t = g_t + \tau(\hat{P}_t^{c^*} - \hat{P}_{Tt}^*); \tag{10}$$

$$e_t = (E_t\, P_{Tt}^*)/P_t. \tag{11}$$

As is customary the "hat" operator (ˆ) denotes a percentage change. The following notation is used:

- $\hat{M}_t$ = the rate of growth of nominal money in period t;
- $\hat{R}$ = the rate of change of international reserves (in pesos);
- $\hat{C}$ = the rate of change of domestic credit;
- DEH_t = the fiscal deficit in period t as a proportion of the stock of high-powered money in period $t - 1$;
- P^c = the domestic price of coffee;
- E = the nominal exchange rate, defined as units of domestic currency per unit of foreign currency;
- y_t = real income in period t;

P = the domestic price level;
P_T = the domestic price of tradables;
P_N = the domestic price of nontradables;
P_T^* = the world price of tradables;
P_t^{c*} = the world price of coffee;
$\hat{P}_T^*$ = the world rate of inflation;
z_t = other variables influencing domestic credit policy;
x_t = other variables influencing the rate of devaluation of the crawling peg; and
e = the real exchange rate.

The letters ω, ϕ, θ, ψ, η, δ, λ, ρ, τ, and γ represent parameters.

Equations (1) through (4) represent the monetary side of this simple model. Equation (1) states that the percentage change in the nominal quantity of money is a weighted average of the growth rate of domestic credit and of international reserves. Equation (2) gives the growth rate of domestic credit. It is assumed that, as has been the case in Colombia since World War II, domestic credit creation is closely linked to the fiscal deficit (Weisner 1978, Edwards 1983; World Bank 1983 and 1984). In this version of the model it is assumed that the deficit is exogenously determined. This, however, is not the most appropriate assumption for the case of Colombia, where there is some evidence that the deficit and the price of coffee have been negatively related. Lower coffee prices have usually resulted in larger deficits, stemming (partially) from an increase in the government's financial assistance to coffee growers.[9] It is also assumed that domestic monetary policy can be influenced by other factors besides the fiscal deficit. These factors are summarized by the term z_t. Equation (3) depicts the behavior of international reserves over time. According to this expression, reserves respond to two elements. First, an excess (flow) demand for or supply of money will be (partially) reflected in the accumulation or decumulation of reserves. Second, changes in the (domestic) price of coffee in period t will be translated, in the same period, into corresponding changes in reserves.[10] The novelty of this formulation is that, contrary to most monetary models of open economies, it explicitly allows for international reserves shocks to be a source of money creation in the *short run*. In the long run, however, $\hat{P}_t^c = 0$ and $\hat{M}_t^d = \hat{M}_t = \hat{M}_{t-1}$, and reserves will not change (that is, $\hat{R}_t = 0$). Equation (4) presents the rate of change of the nominal quantity of money demanded, where for simplicity it is assumed that the real demand for money is a function only of real income. This assumption, however, is relaxed below, where the expected rate of inflation is also included as an argument in the demand-for-money equation.[11] The parameter η is the elasticity of the (real) demand for money with respect to real income. Combining equa-

tions (1) through (4), the following equation for the rate of growth of money in period t is obtained:

$$(12) \quad \hat{M}_t = -\omega\theta\,\hat{M}_{t-1} + \omega\theta\,\hat{P}_t + \omega\theta\eta\,\hat{y}_t + \omega\psi\,\hat{P}_t^c + (1-\omega)\,\hat{C}_t.$$

Since ω and θ are smaller than one but positive, the convergence of (12) will be oscillatory. According to equation (12), then, a positive coffee price shock (that is, $\hat{P}_t^c > 0$) will result in a short-run increase in the rate of growth of money. But it is easy to verify from this equation that in the steady state (when $\hat{M}_t = \hat{M}_{t-1}$ and $\hat{P}_t^c = 0$) this economy will reach monetary equilibrium: $\hat{M}_t = (1-\omega)\,\hat{C}_t = \hat{M}_t^d$.

Equations (5), (6), and (8) form the inflation side of the model. According to (5), the domestic rate of inflation is a weighted average of the rate of change in the domestic prices of tradables and nontradables; this equation assumes that the price of coffee is not included in the price level. According to equation (6), the rate of change in the domestic price of noncoffee tradables is equal to the rate of devaluation plus the world rate of inflation in the price of tradables. Equation (8), on the other hand, states that the rate of change in the price of nontradables will depend on the rate of change in the price of tradables, on changes in real income, and in the short run on the excess flow supply of nominal money in period t.[12] Combining equations (4), (5), (6), and (8) yields the following expression for the rate of inflation:

$$(13) \quad \hat{P}_t = \frac{(1-\delta)\lambda}{1+\lambda(1-\delta)}\,\hat{M}_t + \frac{1}{1+\lambda(1-\delta)}\,(\hat{E}_t + \hat{P}_{Tt}^*) - \frac{(1-\delta)(\lambda\eta-\rho)}{1+\lambda(1-\delta)}\,\hat{y}_t.$$

Notice that in this equation the coefficients of nominal money creation and peso-denominated world inflation ($\hat{E} + \hat{P}_{Tt}^*$) add up to one. On the other hand, the coefficient of real income growth can be either negative or positive, depending on whether $\lambda\eta \gtrless \delta$.

Equation (9) is the rule of adjustment of the nominal exchange rate, or rule of crawl. It is assumed that the rate of devaluation in period t will depend on the rates of domestic and foreign inflation, on the rate of growth of real income, on the world price of coffee, and on other variables, such as commercial policies, captured by x_t. The values of the γ parameters will determine the type of crawl rule chosen by the authorities. If $\gamma_0 = 1$, $\gamma_3 = -1$, and $\gamma_2 = \gamma_1 = \gamma_4 = 0$, equation (9) becomes a strict Purchasing Power Parity (PPP) rule of crawl. It will be assumed in this paper that $0 \leqslant \gamma_0 \leqslant 1$. If $\gamma_1 = 0$, the authorities do not take into account the behavior of world coffee prices to determine the rate of the crawl. On the contrary, a positive γ_1 means that the authorities recognize the effect of changes in coffee prices on the real

exchange rate and therefore try to accommodate them (partially) through adjustments in the nominal exchange rate. Since growth in real income will generate (through equation [8]) a positive pressure on the price of nontradables, $\hat{y}_t$ has been incorporated in equation (9) as a possible determinant of the rate of the crawl. In this way the government is allowed to accommodate the real appreciation resulting from higher growth by manipulating the rate of devaluation. Equation (10) is the rate of growth of real income, and it is formed of two components: a term that is independent from world coffee price behavior (g_t), and a term that depends on coffee prices— $\tau(\hat{P}_t^{c*} - \hat{P}_{Tt}^*)$. An increase in the world real price of coffee generates a higher real income. Finally, equation (11) is the definition of the real exchange rate. This particular definition of e has been chosen because it has a close empirical counterpart. Alternatively, the real exchange rate could be defined as $E_t P_{Tt}^*/P_{Nt}$. All the qualitative effects discussed in this section will also hold for this definition of the real exchange rate.

The model works in the following way. An increase in the (real) world price of coffee results in higher real income (through equation [10]) and in an increased demand for nontradables. This higher demand, in its turn, affects, through equation (8), the relative price of nontradables. This is the *spending* effect of a commodity export boom (Corden 1982; Edwards and Aoki 1983). Independently of monetary or nominal exchange rate behavior, the higher price of coffee generates a real appreciation.

Let us turn now to the money side. The higher price of coffee, with its resulting higher real income and price of nontradables, affects both the demand for and the supply of money. From equation (4), a higher demand for nominal (and real) money will result. According to equations (3) and (1), however, after the export boom the rate of growth of money creation will also be higher. Depending on the value of the parameters involved, a higher price of coffee can result in either an excess flow supply of money or an excess flow demand for money. The more plausible case of a resulting excess supply of money will be considered here. Through equation (8) this excess supply of money will influence the nominal price of nontradables, further appreciating the real exchange rate.[13] What is the role of the rule of crawl in this story? Two things will happen according to equation (9). First, as a result of the higher coffee price, the rate of the crawl will be slowed down in period t, helping to accommodate the real appreciation generated by the spending effect. This will happen through two channels: $-\gamma_1 \hat{P}_t^{c*}$ and $-\gamma_2 \tau \hat{P}_t^{c*}$. Second, there will be a tendency (partially) to compensate the nominal exchange rate for the higher rate of inflation, through $\gamma_0 \hat{P}_t$. The final effect will be a real appreciation, resulting partially from the slowing down of the rate of the crawl and partially from

higher inflation. If the liquidity or money creation effect generated by the higher price of coffee is large enough, the real appreciation may be larger in the short run than in the long run.

Equations (9), (12), and (13) can be solved for $\hat{M}_t$, $\hat{P}_t$, and $\hat{E}_t$ in terms of exogenous variables only. These solutions can then be combined with $\hat{P}^*_{Tt}$ to find the formal reduced form for the actual rate of change in the real exchange rate. An interesting property of this model is that under an appropriate parameterization, it can generate time paths of the different variables that closely resemble what is observed. Under the simplifying assumptions that $\hat{P}^*_{Tt} = 0$, $z_t = 0$, and $\gamma_4 = 0$, the following expression for the actual change in the real exchange rate in period t is obtained:[14] (the reduced forms for $\hat{M}_t$, $\hat{P}_t$, and $\hat{E}_t$ are provided in appendix A):

$$(14) \quad \hat{e}_t = -\beta_0\pi_1(\gamma_0 - 1)\Delta^{-1}\hat{M}_{t-1} + \beta_0\pi_6(\gamma_0 - 1)\Delta^{-1}DEH_t - A_1 g_t - (A_1 + A_2)\hat{P}^c_t$$

where

$$A_1 = [\gamma_2(1 - \beta_0(\pi_2 + \pi_4) - \beta_1) + \beta_2(\gamma_0 - 1) + \beta_0\pi_3(1 - \gamma_0)]\Delta^{-1}$$

$$A_2 = [\gamma_1(1 - \beta_0\pi_2) + \beta_0\pi_4(1 - \gamma_0) - \gamma_1(\beta_1 + \beta_0\pi_5)]\Delta^{-1}$$

and

$$\beta_0 = \frac{(1 - \delta)\lambda}{1 + \lambda(1 - \delta)}; \quad \beta_1 = \frac{1}{1 + \lambda(1 - \delta)};$$

$$\beta_2 = \frac{(1 - \delta)(\lambda\eta - \rho)}{1 + \lambda(1 - \delta)}; \quad \pi_1 = \omega\theta;$$

$$\pi_2 = \omega\theta; \qquad \pi_3 = \omega\theta\eta;$$

$$\pi_4 = \omega\psi; \qquad \pi_5 = \omega\psi;$$

$$\pi_6 = (1 - \omega)\phi; \qquad \Delta = 1 - [\beta_0\pi_2 + \gamma_0(\beta_0\pi_5 + \beta_1)].$$

From equation (14) it is possible to find out, among other things, how an increase in the world price of coffee will affect the actual real exchange rate in period t. Let us first look at the term A_1. This term captures the spending effect of a change in the price of coffee on the real exchange rate. Since stability requires that $\Delta > 0$, the spending effect will, as expected, generate a real appreciation.[15] Next, the term A_2 captures the inflation and exchange rate effects of the higher price of coffee on the real exchange rate in t. As can be seen from this expression, there are three different channels, in addition to the spending effect, through which changes in coffee prices will affect e. Two of these channels indicate that a higher price of coffee will generate a

real appreciation.[16] The third channel, however, suggests that $\hat{e}$ and $\hat{p}^{c*}$ are positively related.

There are two main forces exerting a negative effect of $\hat{p}^{c*}$ on $\hat{e}$. First, a higher world price of coffee causes an increase in international reserves and money growth in the same period (see appendix A). Assuming that an excess flow supply of money results, inflation and, other things equal, a real appreciation will be the consequence. Second, according to equation (13), an increase in the world price of coffee slows down the rate of the crawl. The price increase also tends to bring about a real appreciation, other things equal. The forces that tend to generate a real depreciation as a consequence of the increase in the world price of coffee are of a second order of magnitude and work through the following channel. The higher world price of coffee reduces the rate of the crawl and consequently, through equation (13), the domestic price of tradables and inflation. These lower rates of inflation and devaluation, in turn, will tend to result in a lower rate of domestic money creation, through equation (12), and even lower inflation. This lower inflation, of course, will generate, with other things equal, a real depreciation. Given the second-order nature of this effect, however, the strong presumption is that under normal circumstances (that is, if the values of the parameters involved are plausible) the appreciation effects will dominate. But this is an empirical issue, one that will be resolved with the estimation of the model.[17]

It should be noticed that the model presented here employs some simplifying assumptions, including the exogeneity of DEH_t. It also assumes that the exchange rates applied to coffee and to other external transactions change at the same rate. In Colombia, however, a dual exchange rate system has been in effect during some years, with the net exchange rate for coffee changing at a rate somewhat different from the exchange rate prevailing in the rest of the economy (Weisner 1978).

The model presented above does not allow a distinction between the effect of coffee price changes perceived to be permanent and the effect of those perceived to be temporary. The model can be altered in several possible ways to allow for this distinction. The simplest way is to incorporate expected inflation as a factor in the demand-for-money equation:[18]

$$\left(\frac{M}{P}\right)_t = y_t^{\mu}\, e^{-a\hat{P}_t^e}, \tag{15}$$

where $\hat{P}_t^e$ is the rate of expected inflation, defined as $E_t(\log P_{t+1} - \log P_t)$, and E_t is the expectations operator. It is assumed that expectations are rational and formed conditional on all the information available up to period t. When equation (15) is used to represent the demand-for-

money function, equation (14) for the change in the real exchange rate becomes:

$$(16) \quad \hat{e}_t = -b_0\pi_1(\delta_0 - 1)\, D^{-1}\, \hat{M}_{t-1} + \beta_0\pi_6\,(\gamma_0 - 1)\, D^{-1}DEH_t - B_1 g_t - (B_1 + B_2)\, \hat{P}_t^{c*} + (\gamma_0 - 1)\, b_3\, \hat{P}_{t+1}^{e},$$

where the expected inflation term, $\hat{P}_{t+1}^{e}$, is:

$$(17) \quad \hat{P}_{t+1}^{e} = d \sum_{k=0}^{\infty} b^k\, E_t(\hat{P}_{t+1+k}^{c*}) + \ldots,$$

and where the Bs are:

$$B_1 = \{\gamma_2[1 - b_0(\pi_2 + \pi_4) - b_1] + b_2(\gamma_0 - 1) + b_0\pi_3(1 - \gamma_0)\}D^{-1}$$

$$B_2 = [\gamma_1(1 - b_0\pi_2) + b_0\pi_4(1 - \gamma_0) - \gamma_1(b_1 + b_0\pi_5)]D^{-1}$$

and d, D, and the bs are:

$$d = [b_0(\pi_4 + \pi_3) - (\pi_5 b_0 + b_1)(\gamma_1 + \gamma_2) - b_2];$$

$$D = 1 - [b_0\pi_2 + \delta_0(b_0\pi_5 + b_1)];$$

$$b = \frac{(1 - \delta)\lambda a}{1 + (1 - \delta)\lambda\,(1 + a)}; \quad b_0 = \frac{(1 - \delta)\lambda}{1 + (1 - \delta)\lambda\,(1 + a)};$$

$$b_1 = \frac{1}{1 + (1 - \delta)\lambda\,(1 + a)}; \quad b_2 = \frac{(1 - \delta)(\lambda\eta - \rho)}{1 + (1 - \delta)\lambda\,(1 + a)}.$$

The main difference between the new equation (16) for the real exchange rate and equation (14) is that an expected inflation term, $\hat{P}_{t+1}^{e}$, appears in equation (16). This is a crucial difference, since as shown in equation (17) $\hat{P}_{t+1}^{e}$ is a function, among other things, of all future expected changes in the price of coffee. That is, once the role of expectations is incorporated into the model, the change in the real exchange rate will depend on all the expected future values of the price of coffee and on the other exogenous variables. Now, for example, if the change in the price of coffee is expected to be permanent, the change in the real exchange rate will correspond to that already discussed above (equation [14]). But if the higher price of coffee is expected to last for one period only, $E_t(\hat{P}_{t+1}^{c*}) = -\hat{P}_t^{c*}$, and as equations (16) and (17) show, the real appreciation in period t will be smaller than it would be in the case of a permanent increase in the price of coffee. Another important characteristic of equation (16) is that it is not necessary for the price of coffee to increase to generate a real appreciation. If world coffee prices are only expected to increase in the future, a real appreciation will now take place.

7.3.2 Estimation

This section presents the results obtained from an estimation of a slight variant of the model given by equations (9), (12), and (13). Since from an empirical perspective it is difficult to make a distinction between temporary and permanent changes in the price of coffee, the results reported here do not take this distinction into account.[19] The estimation was performed using annual data for the years 1952–80, with an explicit distinction made between the pre-1967 and the post-1967 periods. The following variant of the money creation equation (12) was estimated (where the υ_t terms are error terms):

$$(18)\quad \hat{M}_t = \alpha_0 + \alpha_1\hat{M}_{t-1} + \alpha_2\hat{M}_{t-2} + \alpha_3\hat{M}_{t-3} + \alpha_4 DEH_t + \alpha_5(\hat{E}_t + \hat{P}_t^{c*}) + \upsilon_{1t}.$$

The following version of the inflation equation (12) was estimated, where *DUM* is a dummy variable that takes a value of zero up to 1967 and a value of one thereafter.

$$(19)\quad \hat{P}_t = \delta_0 + \delta_1\hat{M}_t + \delta_2\hat{y}_t + \delta_3(\hat{E}_t + \hat{P}_{Tt}^*) + \delta_4 DUM_t + \upsilon_{2t}.$$

Finally, the exchange rate devaluation equation was the following:

$$(20)\quad \hat{E}_t = \mu_0 + \mu_1\hat{P}_t + \mu_2(\hat{P}_t DUM_t) + \mu_3\hat{P}_{Tt}^* + \mu_4\hat{P}_t^{c*} + \mu_5 DUM_t + \upsilon_{3t}.$$

The system given by equations (18), (19), and (20) was estimated using two- and three-stage least-squares for the years 1952–80. The results obtained are presented in tables 7.3 and 7.4. The data sources are given in Appendix B. As may be seen, these results are very satisfactory. Most of the coefficients have the expected signs and are significant at the conventional levels.

The most interesting result from the estimation of the money creation equations is that they confirm the hypothesis that higher (domestic) prices of coffee resulted in *short-run* increases in the rate of money creation. As discussed above, the mechanism through which this takes place is the accumulation of international reserves that are monetized by the central bank. Moreover, the estimates of the coefficients of the lagged $\hat{M}$ terms suggest that the effect of changes in coffee prices on money growth has some persistence over time. The estimation of the money growth equation (18), then, provides statistical support to the claim made by numerous authors (for example, Weisner 1978; Urrutia 1981) that Colombia's ability to carry out a successful monetary policy has been hampered by the dependence of money creation on the behavior of coffee prices. These results also support the hypothesis that the process of money creation in Colombia has been critically influenced by the behavior of the fiscal side of the economy (equations

Table 7.3 **Two-Stage Least-Squares Estimation of the Model, for the Years 1952–80**

Equation No.	Estimation	S.E.E.	D.W.
(18.1)	$\hat{M}_t = \underset{(-0.177)}{-0.006} + \underset{(3.596)}{0.634}\,\hat{M}_{t-1} + \underset{(0.691)}{0.123}\,\hat{M}_{t-2} + \underset{(2.293)}{0.140}\,\hat{M}_{t-3} + \underset{(3.354)}{0.222}\,DEH_t + \underset{(2.023)}{0.079}\,(\hat{P}_t^{c*} + \hat{E}_t)$	0.037	2.238
(19.1)	$\hat{P}_t = \underset{(-0.729)}{-0.006} + \underset{(2.669)}{0.705}\,\hat{M}_t - \underset{(-0.363)}{0.040}\,\hat{y}_t + \underset{(2.182)}{0.311}\,(\hat{E}_t + \hat{P}^*_{Tt}) + \underset{(0.314)}{0.010}\,DUM_t$	0.060	2.231
(20.1)	$\hat{E}_t = \underset{(-0.119)}{-0.006} + \underset{(2.569)}{1.333}\,\hat{P}_t - \underset{(-1.678)}{0.850}\,(\hat{P}_t\,DUM_t) - \underset{(-0.063)}{0.060}\,\hat{P}^*_{Tt} - \underset{(-1.604)}{0.198}\,\hat{P}_t^{c*} + \underset{(0.469)}{0.043}\,DUM_t$	0.108	1.728

Notes: The numbers in parentheses are t-statistics. S.E.E. is the standard error of the regression. D.W. is the Durbin-Watson statistic. The following instruments were used: lagged, twice lagged and three periods lagged, $\hat{M}$, contemporaneous, and lagged DEH, the world price of coffee, world inflation, lagged inflation, the change in the world price of coffee, the dummy variable, and a constant.

Table 7.4 **Three-Stage Least-Squares Estimation of the Model, for the Years 1952–80**

Equation No.	Estimation	S.E.E.	D.W.
(18.2)	$\hat{M}_t = \underset{(0.130)}{0.004} + \underset{(4.115)}{0.602}\,\hat{M}_{t-1} + \underset{(1.014)}{0.145}\,\hat{M}_{t-2} + \underset{(2.165)}{0.109}\,\hat{M}_{t-3} + \underset{(3.218)}{0.180}\,DEH_t + \underset{(2.882)}{0.096}\,(\hat{P}_t^{c*} + \hat{E}_t)$	0.034	2.280
(19.2)	$\hat{P}_t = \underset{(-1.303)}{-0.077} + \underset{(3.331)}{0.723}\,\hat{M}_t + \underset{(0.609)}{0.005}\,\hat{y}_t + \underset{(3.596)}{0.411}\,(\hat{E}_t + \hat{P}^*_{Tt}) + \underset{(0.487)}{0.013}\,DUM_t$	0.057	2.175
(20.2)	$\hat{E}_t = \underset{(-0.637)}{-0.027} + \underset{(4.057)}{1.574}\,\hat{P}_t - \underset{(-1.208)}{0.732}\,(\hat{P}_t\,DUM_t) - \underset{(-0.645)}{0.463}\,\hat{P}^*_t - \underset{(-1.349)}{0.124}\,\hat{P}_t^{c*} + \underset{(0.419)}{0.031}\,DUM_t$	0.102	1.709

Note: The specifications and abbreviations are as described in the note to table 7.3.

[18.1] and [18.2] in the tables). An increase in the fiscal deficit, measured as a proportion of lagged base money, of 10 percentage points resulted, on average, in an increase in the rate of growth of money of approximately 1.8 to 2.2 percentage points. This finding illustrates that the separation of the fiscal and monetary sides of the economy in traditional macroeconomic analysis may not be fully appropriate in studying less developed countries. In developing countries—and especially in Latin America—fiscal deficits are usually financed by printing money; the LM and IS curves are not fully independent.

The estimation of the inflation equation (19) also yields interesting results. With the exception of income growth and the dummy variable, the coefficients are significant and have the expected signs. The coefficient of $\hat{M}_t$ indicates that, with other things equal, an increase in the rate of money creation of 10 percentage points resulted in an increase in inflation of approximately 7 percentage points. On the other hand, according to the coefficient of $(\hat{E}_t + \hat{P}^*_{Tt})$ a higher rate of devaluation or higher world inflation, or both, was passed on in almost one third to price increases.[20] As the model indicates, the sum of the coefficients of the prices of $\hat{M}_t$ and $(\hat{E}_t + \hat{P}^*_{Tt})$ were not significantly different from one. The coefficient of real income growth was, however, insignificant in all the regressions.

The exchange rate adjustment equation (20) yielded, in some sense, less satisfactory results. The estimation indicates that for the post-1967 period—after the crawling peg was adopted—and with other things equal, the exchange rate tended to be adjusted by less than the ongoing domestic rate of inflation. Nonetheless, these results confirm the hypothesis that the Colombian authorities took into account the behavior of world coffee prices when deciding by how much to devalue the nominal exchange rate. Lower (higher) world coffee prices resulted in higher (lower) rates of the devaluation of the crawl. Given the relatively poor results obtained from the estimation of equation (20), several alternative specifications of the exchange rate adjustment equation were also tried. Some of the results obtained are presented in table 7.5, where $\hat{R}^r_t$ is the percentage change in the real value of international reserves, measured in dollar terms. The nonsignificance of the coefficient of this reserves change variable confirms Urrutia's (1981) contention that the Colombian authorities did not directly take into account the level of international liquidity when deciding by how much to devalue the nominal exchange rate. The negative and insignificant coefficient of $\hat{M}_t$ is somewhat surprising, however, because it has been argued that changes in the nominal stock of money have been an important indicator when deciding the rate of devaluation of the peso (Urrutia 1981). Even though these regressions do not represent a significant improvement over those reported in tables 7.3 and 7.4, they

do confirm the fact that the rate of devaluation has been positively related to the domestic rate of inflation—with an average coefficient of around one—and negatively related to the behavior of the world price of coffee.

The point estimates obtained from the regression analysis of equations (18) through (20) can be combined to get an approximate idea of the way in which coffee price changes will affect the real exchange rate. For example, from the estimates reported in table 7.3, the effects of changes in world coffee prices on inflation, nominal devaluation, and the real exchange rate, assuming all other exogenous variables as given, are:

$$\hat{P}_t = \frac{\alpha_5\delta_1 + \delta_3 + \delta_1\alpha_6}{(\mu_1 + \mu_2 DUM)(\delta_3 + \alpha_5\delta_1)} \hat{P}_t^{c*} = 0.513\, \hat{P}_t^{c*};$$

$$\hat{E}_t = \frac{(\mu_1 + \mu_2 DUM)\,\delta_1\alpha_6 + \mu_4}{(\mu_1 + \mu_2 DUM)(\delta_3 + \alpha_5\delta_1)} \hat{P}_t^{c*} = -0.208\, \hat{P}_t^{c*};$$

$$\hat{e}_t = \frac{(\mu_1 + \mu_2 DUM)\delta_1\alpha_6 + \mu_4 - (\alpha_5\delta_1 + \delta_3 + \delta_1\alpha_6)}{(\mu_1 + \mu_2 DUM)(\delta_3 + \alpha_5\delta_1)} \hat{P}_t^{c*}$$

$$= -0.721\, \hat{P}_t^{c*}.$$

These numbers are obviously quite large, suggesting that, other things equal, a change in coffee prices will result in substantial changes in inflation, the rate of devaluation, and the real exchange rate. In fact, these results suggest that immediately following an increase in world coffee prices most of the resulting real appreciation will materialize through the money creation and inflation channels. A possible problem with this exercise, however, is the assumption that other things are equal. As discussed above, coffee price movements are likely to be related to some of the variables I have considered exogenous here. In particular, coffee price movements will result in changes in real income, the fiscal deficit, and world inflation. In addition, since no distinction between temporary and permanent changes has been made in the estimation, the results from this exercise should be interpreted with caution.

To summarize, I have developed and estimated in this section a model of the interaction between commodity export prices and the real exchange rate in Colombia. The model focused on three basic elements: the money creation process ($\hat{M}_t$); domestic inflation ($\hat{P}_t$); and the rate of adjustment of the nominal exchange rate ($\hat{E}_t$). These last two elements, plus the rate of foreign inflation, $\hat{P}^*_{Tt}$, constitute, by definition, the elements that determine the behavior of the real exchange rate over time (that is, $\hat{e}_t = \hat{E}_t - \hat{P}_t + \hat{P}^*_{Tt}$). The model

Table 7.5 **Two-Stage Least-Squares Estimation of the Exchange Rate Adjustment Equation, for the Years 1952–80**

Equation No.	Estimation	S.E.E.	D.W.
(20.3)	$\hat{E}_t = \underset{(0.539)}{0.029} + \underset{(2.452)}{1.273}\,\hat{P}_t - \underset{(-1.050)}{0.961}\,\hat{P}^*_{Tt} - \underset{(-1.168)}{0.424}\,\hat{P}_{t-1} + \underset{(1.251)}{0.967}\,\hat{P}^*_{Tt-1} - \underset{(-2.243)}{0.295}\,\hat{P}^{c^*}_t + \underset{(0.854)}{0.052}\,\hat{R}^f_t - \underset{(-0.833)}{0.054}\,DUM_t$	0.115	1.856
(20.4)	$\hat{E} = \underset{(1.812)}{0.223} + \underset{(2.458)}{1.258}\,\hat{P}_t + \underset{(0.081)}{0.089}\,\hat{P}^*_{Tt} - \underset{(-0.603)}{0.225}\,\hat{P}_{t-1} - \underset{(-0.914)}{0.071}\,\hat{P}^*_{Tt-1} - \underset{(-1.769)}{1.364}\,\hat{M}_t - \underset{(-1.617)}{0.172}\,\hat{P}^{c^*}_t + \underset{(0.669)}{0.039}\,\hat{R}^r - \underset{(-0.632)}{0.041}\,DUM_t$	0.113	2.220

Note: See table 7.3 for all specifications and abbreviations.

incorporated the traditional spending effect of a commodity export boom and explicitly took into account the monetary effects of changes in commodity prices. In particular, and contrary to most Dutch disease models, the model developed here explicitly allowed for changes in the price of coffee to affect, in the short run, the rate of money growth. The results obtained from the regression analysis were, in some sense, surprisingly robust, and they confirmed the basic hypothesis that higher (lower) coffee prices lead to higher (lower) rates of money growth and consequently in higher (lower) inflation rates. The regressions also showed that the rate at which the Colombian authorities have adjusted the exchange rate has been negatively related to coffee prices: higher (lower) coffee prices have resulted in slower (faster) rates of devaluation.

7.4 Concluding Remarks

With increasing regularity, the exchange rate is being singled out as one of the most important economic variables in developing countries. In fact, it is almost impossible these days to discuss macroeconomic policy problems in the less developed countries without addressing exchange rate issues. From a policy perspective one of the most important problems is determining whether the real exchange rate in a particular country is out of line with respect to its equilibrium value.[21] To the extent that the real exchange rate is misaligned, policy actions designed to reestablish equilibrium will be called for.[22] From a policy viewpoint, then, a crucial aspect of any analysis of real exchange rates is to distinguish between equilibrium and disequilibrium movements of these rates. Only in this way will it be possible to develop appropriate policy measures.

In spite of the obvious policy importance of analyzing the mechanism through which real exchange rate movements take place, very few empirical studies have tackled this problem. In this paper the more specific problem of the effect of commodity export price changes on the real exchange rate has been investigated empirically. The third section of the paper developed and estimated a model of the effects of coffee price changes on money creation, inflation, and the rate of devaluation in Colombia. A virtue of this model is that it highlights two of the channels that have been traditionally mentioned in casual discussions of the effect of commodity price changes on the real exchange rate: money creation and inflation, and the rate of adjustment of the nominal exchange rate (the rate of devaluation of the crawling peg).

The model showed that commodity export booms will generally lead to short-run increases in money creation and inflation and to a real

appreciation. In fact, it is possible that the real appreciation generated through this channel exceeds the "equilibrium" real appreciation resulting from the boom. If this boom is perceived as temporary, the real appreciation will be smaller but still potentially significant. An important question that arises in this context is whether there are mechanisms that would allow the authorities to reduce the impact of the changes in commodity export prices on the real exchange rate. Although the model presented here suggests that some mechanisms could actually be made available, none of them is easy to implement or free of problems. First, open market operations could be used to sterilize the monetary impact of changes in coffee prices. A problem with this type of solution in developing countries, however, is that local capital markets have not reached the stage of development required to perform massive open market operations. A second alternative would be to manipulate commercial policy to reduce the fluctuation in the real exchange rate. If commodity export prices are highly volatile, however, this option will be to a large extent impractical. Finally, another alternative is to open the capital account, allowing the short-run excess liquidity generated by the export boom to be curbed by outflows of capital. One problem with this measure, however, is that by fully opening the capital account, other sources of instability could arise.[23]

The model presented in this paper was empirically tested for the case of coffee in Colombia. The results obtained indicate that coffee price changes have indeed been closely related to money creation and inflation. Furthermore, coffee price changes have been negatively related to the rate of devaluation. These results suggest that in Colombia the real appreciation resulting from coffee price increases has been accommodated partially by money creation and inflation and partially by an adjustment in the nominal exchange rate.

The model employed here was deliberately designed to be simple and limited in its scope. As such, it has been useful in clearly pinpointing the role of coffee in the inflation and devaluation process. A drawback of that approach, however, was that it required making some simplifying assumptions.[24]

Appendix A: Solution of the Model in 7.3

Equations (10), (11), and (12) can be combined to find the reduced-form solutions for $\hat{M}_t$, $\hat{P}_t$, and $\hat{E}_t$. Under the simplifying assumption that $\hat{P}^*_{Tt} = 0$ these solutions are:

$$(A1)\quad \hat{M}_t = -\pi_1(1 - \gamma_0\beta_1)\,\Delta^{-1}\,\hat{M}_{t-1} + \pi_6(1 - \gamma_0\beta_1)\,\Delta^{-1}\,DEH_t + [\pi_4(1 - \gamma_0\beta_1) - \gamma_1(\pi_2\beta_1 + \pi_5)]\,\Delta^{-1}\,\hat{P}_t^{c*} - [\beta_2(\pi_2 + \gamma_0\pi_5) + \gamma_2\,(\pi_2\beta_1 + \pi_5) - \pi_3(1 - \gamma_0\beta_1)]\,\Delta^{-1}\,\hat{y}_t;$$

$$(A2)\quad \hat{P}_t = -\beta_0\pi_1\Delta^{-1}\,\hat{M}_{t-1} + \beta_0\pi_6\Delta^{-1}\,DEH_t - [\beta_2 + (\pi_5\beta_0 + \beta_1)\gamma_2 - \beta_0\pi_3]\Delta^{-1}\,\hat{y}_t + [\beta_0\pi_4 - \gamma_1(\pi_5\beta_0 + \beta_1)]\Delta^{-1}\,\hat{P}_t^{c*};$$

$$(A3)\quad \hat{E}_t = -\beta_0\gamma_0\pi_1\Delta^{-1}\,\hat{M}_{t-1} - [\gamma_1(1 - \beta_0\pi_2) - \beta_0\gamma_0\pi_4]\Delta^{-1}\,\hat{P}_t^{c*} - [(1 - \beta_0\pi_0)\gamma_2 + \beta_2\gamma_0 - \beta_0\gamma_0\pi_3]\Delta^{-1}\,\hat{y}_t + \beta_0\gamma_0\pi_6\,\Delta^{-1}\,DEH_t,$$

where:

$$\beta_0 = \frac{(1 - \delta)\lambda}{1 + \lambda(1 - \delta)};\ \beta_1 = \frac{1}{1 + \lambda(1 - \delta)};$$

$$\beta_2 = \frac{(1 - \delta)(\lambda\eta - \rho)}{1 + \lambda(1 - \delta)};\ \pi_1 = \omega\theta;$$

$$\pi_2 = \omega\theta;\ \pi_3 = \omega\theta\eta;$$

$$\pi_4 = \omega\psi;\ \pi_5 = \omega\psi;$$

$$\pi_6 = (1 - \omega)\phi;\ \Delta = 1 - [\beta_0\pi_2 + \gamma_0(\beta_0\pi_5 + \beta_1)].$$

Stability requires that $|\pi_1(1 - \gamma_0\beta_1)\Delta^{-1}| < 1$. Notice that in this Appendix, in order to simplify the presentation, the rate of growth of real output $\hat{y}_t$ has not been decomposed into its exogenous term g_t and its coffee price–induced term $\tau\hat{P}_t^{c*}$.

Appendix B: Data Sources

All data refer to annual averages.

- E = Pesos per U.S.$ nominal exchange rate, taken from International Financial Statistics (*IFS*).
- M = M_2 definition of money taken from *IFS*.
- P = Consumer price index taken from *IFS*.
- y = Real gross domestic product taken from *IFS*.

P_T = Price of tradables in pesos. Constructed as the product of the U.S. wholesale price index and the Colombian exchange rate.

P^{c^*} = Price of coffee in dollar terms. Constructed from data in the *IFS*.

DEH = Fiscal deficit, in nominal terms, scaled by the lagged quantity of high-powered money. For the years 1970–80, data that correct for the *cuenta especial de cambio* are used. These data were supplied by Colombia's Departamento Nacional de Planeación.

Notes

1. Much of this work has been done in the context of Dutch disease models. See, for example, the survey of these models by Corden (1982).

2. On the monetary effects of commodity export booms, see, for example, Harberger (1983), Edwards and Aoki (1983), Neary (1984), and Neary and van Wijnbergen (1984). Notice that an export boom will also generate an increase in the demand for money. Inflation will result only if the liquidity effect of the commodity boom exceeds the increase in the quantity of money demanded (see Edwards and Aoki 1983).

3. Moreover, very few papers have discussed the mechanism through which real exchange rate changes actually take place following changes in commodity export prices. Under floating exchange rates, fluctuations in the nominal exchange rate are the main mechanism. Under fixed exchange rates, however, the real exchange rate adjustment will require a change in the price level (more exactly, a change in the nominal price of nontradables) and in the stock of money. In a more general case, the adjustment could be distributed between inflation and nominal exchange rate changes. An important question, and one that has not yet been addressed, is to define the most efficient mechanism for bringing about the real exchange rate adjustment. Another important problem, which also has not been analyzed in detail, is the desirability of allowing the real exchange rate to appreciate when the commodity export boom stems from a *temporary* hike in export prices.

4. On the Colombian economy see, for example, Díaz-Alejandro (1976), Ocampo (1983), Weisner (1978), Kamas (1983), World Bank (1983, 1984). Some recent studies, however, have empirically analyzed the relationship between the terms of trade and the real exchange rate. See, for example, Díaz-Alejandro (1984) and Edwards (1984a).

5. Coffee represents approximately 55 percent of Colombia's foreign earnings from legal exports. It is important to notice that the importance of illegal exports in the Colombian economy makes the empirical analysis of the external sector quite difficult. For obvious reasons there are no reliable data on the magnitude of these illegal transactions. On the importance of illegal exports in Colombia, see Junguito and Caballero (1978).

6. The increase in the world price of coffee will result in a higher real income and consequently in a higher demand for money. Inflation will result only if the accumulation of reserves exceeds the increase in the demand for money (Edwards and Aoki 1983). A number of authors have argued that over the years 1975–79 the resulting inflation largely exceeded what was required to accommodate the equilibrium real appreciation (Weisner 1978; World Bank 1984).

7. To the extent that there are adjustment costs, rigidities, and inflexibilities, short-run real exchange rate movement generated by temporary swings in commodity export

prices can indeed result in adverse (that is, welfare-reducing) effects. See Edwards and Aoki (1983).

8. On the institutional arrangements used for coffee marketing and exporting in Colombia, see the detailed description in World Bank (1984).

9. On credits to coffee growers and fiscal deficits, see Weisner (1978, p. 186). Another simplification in equation (4) is that it does not explicitly allow for sterilization by linking reserves changes to credit creation. Nonetheless, to the extent that DEH_t is negatively related to coffee prices, an indirect channel to trigger (partial) sterilization is allowed. On sterilization in Colombia, see Kamas (1983).

10. Notice that another simplifying assumption of this model is that it ignores the demand for international reserves. For the important role played by reserves demand in Colombia, see Weisner (1978, chap. 1). See also Diaz-Alejandro (1976). For a discussion on the integration of the demand-for-reserves theory and monetary equilibrium, see Edwards (1984b).

11. A reason to ignore interest rates in the demand-for-money function is that there are no reliable data on interest rates in Colombia for the entire period considered in this study. See, however, the discussion below. On interest-rate behavior in Colombia since 1968, see Edwards (1985).

12. This equation can be derived from the equilibrium condition in the nontradable goods sector. See Edwards (1984c).

13. Notice that the assumption of an exogenously given capital account plays an important role here. If, on the contrary, there is perfect capital mobility, the incipient excess supply of money resulting from the higher coffee price would be rapidly eliminated through the capital account, without affecting the price of nontradables.

14. Equation (14) gives the actual short-run, and not necessarily the equilibrium long-run, change in the real exchange rate resulting from a change in coffee prices. To determine the long-run effect, we would have to solve equations (10), (8), (7), and (11) under the conditions of monetary equilibrium.

15. See appendix A. Notice that the real appreciation will take place if the following (plausible) conditions hold: $\omega(\theta + \psi) < 1$; $\gamma_0 \leq 1$; and $\rho > \lambda\eta$. These are sufficient conditions.

16. Díaz-Alejandro (1984) reported results from regressions of the level of the (log of the) real exchange rate and a set of explanatory variables for Colombia and other Latin American countries. For Colombia the coefficient of the (log of the) terms of trade was significantly negative (-0.56), as expected. See also Edwards (1984a).

17. From equation (13) it is also possible to find how changes in the other exogenous variables, such as the fiscal deficit, affect the real exchange rate.

18. There are two other ways to introduce the difference between permanent and temporary changes in coffee prices: changes in permanent income, instead of actual real income, can be used in equation (8); and in the crawling-peg equation the term for coffee price changes can be split in two parts, one corresponding to changes perceived to be temporary, and the other to changes perceived to be permanent.

19. See, however, Cumby and van Wijnbergen (1984).

20. These results are consistent with those obtained by Hanson (1982). See also Edwards (1984c). The money growth equations were also estimated for shorter periods of time. The results obtained confirm those reported in this paper. See World Bank (1984).

21. Cline (1983), for example, has recently pointed out that in many LDCs real exchange rate misalignments contributed to the international debt crisis.

22. On real exchange rate disequilibria and policies to realign them see, for example, Williamson (1983), Artus and Knight (1984), and Edwards (1984a).

23. This is not necessarily the case. On the effect of opening the capital account on the balance of payments in developing countries, see Edwards (1984d) and Obstfeld (1984).

24. A possible interesting extension of this model would be to incorporate an explicit equation for the current account, deriving from it the equilibrium real exchange rate. Even though this is not a difficult thing to do theoretically, the empirical implementation would be much more difficult.

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Comment

Armeane Choksi

Sebastian Edwards has written a very interesting paper. He has not gone on a fishing expedition in search of statistically significant coefficients, and, at least on the face of it, his effort is not a case of measurement without theory. He has developed a simple model that attempts to explain the interaction among coffee prices, money crea-

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This comment centers on the version of Edwards's paper presented at the NBER–World Bank conference. Subsequently, Edwards made some minor changes.

tion, inflation, and the real exchange rate. I particularly like his clear exposition of how he sees his model working through an increase in the price of coffee, and he has used that structure to derive a set of equations used in the estimating procedure. Edwards makes a number of assumptions, however, that may have a bearing on the results. I would like to talk about five of these assumptions. Some have been explicitly recognized by Edwards in his paper or in the conference presentation, whereas others have not.

First, Edwards explicitly recognized in his original conference paper that the demand for money is a function only of income and not of the interest rate. The reason given is that there are no data on the interest rate, and consequently it is dropped from the model. The second assumption is related to the question that always arises in the context of Colombia: Where is the white stuff? The price of noncoffee tradables is explicit in the structural model, but a significant proportion of such tradables is cocaine, and this, for obvious reasons, is not easily measurable. There is a footnote in the paper that alludes to cocaine, but it does not address the implications of excluding it from the analysis and the estimation process. Excluding it in this manner would suggest that cocaine does not affect the exchange rate, and that is very hard to believe. Third, there is no mention in the paper of the institutional structure by which coffee is sold on the world market; if, for example, there is a form of a marketing board, this may well lead to the smuggling of coffee. Depending on the world price and the price paid to farmers, this omission may or may not be a significant one. If it is, the exchange rate would be influenced accordingly.

These three assumptions could well lead to biases in the estimation procedure. The first misspecifies the model by omitting a variable. The second and third would result in errors in measurement and also lead to a bias. Whether these biases are important or not is not obvious from the presentation, and there is no discussion in the paper to shed any light on this issue. I would suspect, however, that the estimates given are not asymptotically unbiased, as suggested by the theory behind Edwards's two- and three-stage least-squares estimation procedure. I also suspect that this potential bias is at least part of the explanation of the seemingly large size of the estimated coefficients, as pointed by Rajapatirana (see below).

A fourth assumption appears in equation (9), which specifies the rule of crawl as a function of the rates of domestic and foreign inflation, the rate and growth of real income, and the world price of coffee. But as stated earlier in the paper, between 1968 and 1973 changes in the real exchange rate were to a large extent the result of the reduction of the degree of import protection and export promotion schemes. These other variables are not specified here, and again this could lead to biases

in estimating the coefficients. Finally, a fifth assumption, which initially struck me as very odd, appears in equation (3), which specifies the behavior of international reserves. The excess demand for money is specified in intertemporal terms, and I cannot see an economic rationale for doing so. Edwards has demonstrated, however, that specifying this excess demand in *contemporaneous* terms makes no substantive difference, except for the fact that the estimated value of θ, the determinant of the speed of adjustment, would be different in the two specifications. Since there is no major difference, I would suggest the use of a specification for which there is an obvious economic rationale, namely, to specify this function in contemporaneous terms.

Turning to the links between the structure and the reduced-form equations, I would have liked to see the latter set of estimation equations more closely related to the structure of the model. As I mentioned before, Edwards does not take a shotgun approach to estimation. I nevertheless believe that the links between the structure and this reduced set should be more direct and obvious than they are in the paper. This is particularly true for the money creation equation (15) which adds on—in the reduced form—additional lags and omits the rate of growth of real income.

As far as the policy implications are concerned, after having read this paper, I came away mainly with the sentiment "interesting, but so what." Edwards has shown that changes in the price of coffee affect, in the short run, the rate of money growth, and he confirms the hypothesis (one I believe very few would question) that higher coffee prices result in higher rates of money growth and higher rates of inflation. Thus, Edwards has formalized and quantified the obvious. This is not necessarily useless; but clearly, by not drawing out the policy implications, Edwards has not done justice to his work. He shows through his estimation procedure (and one must keep in mind the estimation biases mentioned earlier) that there could be some useful and interesting policy conclusions, but he does not follow through by delineating them. For example, one conclusion from which some broad policy suggestions on sterilization may be drawn is that monetary policy in Colombia has been hampered by the dependence of money creation on the behavior of coffee prices. This conclusion may also be used to suggest some changes in the institutional mechanism by which coffee is exported: If state control of export marketing were relinquished to individual economic agents and repatriation of foreign exchange to Colombia were not mandatory, would the formulation of monetary policy be easier? That is, would the private economic agents sterilize foreign exchange earnings in a manner superior to that of the state, or would there be capital flight? Another set of conclusions could be drawn from the quantitative relationships between the fiscal deficit and the

rate of growth of money supply, and between money supply and inflation. Both of these relationships have policy implications, as does the relationship between the rate of crawl and the increase in the world price of coffee. Of course, some of these policy conclusions would assume optimizing behavior on the part of the government, and this assumption may not be the case. Furthermore, all of the quantitative conclusions would depend upon the specification of the model and the quality of the estimation procedures. But this is a fruitful area that Edwards must pursue if this paper is not to be dismissed as another article that formalizes and proves the obvious.

Comment

Sarath Rajapatirana

Sebastian Edwards poses a general question: What is the short-term impact of changes in export prices on the real exchange rate? To answer this question, he traces the relationship between these two variables for the case of Colombia over the years 1952–80. The question is, of course, a relevant and important one for countries that rely on only a few exports and have to respond to changes in export prices while pursuing their other national objectives.

My comments on this paper are organized under three headings: the specification of the model, the econometric findings, and the implications of the findings for policy formulation.

The Specification of the Model

In formulating his model to study the relationship between export prices and the real exchange rate, Edwards borrows a page each from the Dutch disease literature, the classical specie flow mechanism, and the Colombian experience, in which the rate of crawl of the peso is thought to be adjusted to changes in the export price of coffee. The effects of changes in coffee prices thus operate through three channels by which an increase in the coffee price causes an appreciation of the real exchange rate: (1) The "spending effect" described by Corden and Neary (see Edwards's references) in the Dutch disease literature; (2) the money creation effect, which takes place when the increase in foreign reserves resulting from increased export revenues are monetized; and (3) the reaction of the government whereby it reduces the rate of crawl or the rate of nominal devaluation in response to an increase in the price of coffee.

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Edwards's model concentrates on the monetary rather than the real side, however, taking international inflation and the size of the fiscal deficit as exogenous.[1] Basically, it is a very simple and clearly defined simultaneous-equations system that allows the author to test three hypotheses: first, that higher prices of coffee result in an increase in the rate of money creation; second, that there is a relationship between the rate of inflation and the exchange rate; and third, that the rate of devaluation of the peso is negatively correlated with the price of coffee.

Although the model specification allows the author to capture the relationships described, one can think of a number of extensions of the model to interject more realism into the model and thereby be able to interpret the econometric results more clearly. Two such extensions are suggested here.

First, as the author himself recognizes, one needs to treat the fiscal deficit as an endogenous variable in order to trace the behavior of public expenditures in response to changes in coffee prices. This requirement is all the more relevant in light of the fact that the Colombian government must rely heavily on coffee for public revenue and in light of its attempts to stabilize the income of coffee growers.

Second, the influence on the real exchange rate of the spending effect and the money creation effect will be very much influenced by the patterns of expenditures in the public and private sectors. If, for example, a larger proportion of the increase in the export price accrues to the government than to the private sector, it is conceivable that the government expenditure on balance will be spent more on nontraded than on traded goods. It may therefore be necessary, especially in the general case, to consider how export revenues are distributed between the public sector and the private sector. This will be an important issue in discussing the policy implications of these findings.

In the general case, with no sterilization of the additional foreign exchange, there is no avoiding an increase in export prices leading to an appreciation of the exchange rate. Under a fixed exchange rate system this happens through domestic inflation when the increase in foreign reserves is monetized. Under a floating rate system the appreciation will operate through the nominal exchange rate. And it is through this appreciation that the resource increase is absorbed. The interesting question here is whether the government should deliberately change the rate of crawl when export prices increase or instead use expenditure policies to handle the disturbance.

The Econometric Results

The econometric results derived through the reduced-form equations generally confirm the hypotheses advanced. Nonetheless, the esti-

mates are surprisingly large. Among the point estimates, a change in the price of coffee by 10 percentage points leads to a 5 percent increase in the rate of inflation, a 2 percent appreciation in the nominal exchange rate, and an appreciation in the real exchange rate of over 7 percent.

As Edwards recognizes the size of the estimates may be the result of taking real income and the fiscal deficit as exogenous and the result of some important export that has a positive covariance with coffee influencing the real exchange rate. The fiscal issue is very important and lies at the heart of the mechanism that transmits export price increases to the real exchange rate. Furthermore, because real income is assumed exogenous in the estimated model, the powerful real effects of a coffee price boom may be being picked up by the monetary variables.

Policy Implications

What then are the implications of these relationships for policy formulation? The question here is what is best policy to pursue when a commodity boom takes place. Should a country fine-tune its response to such external price changes in the short run by manipulating the exchange rate?

I think not. If the export boom is temporary, the government would use fiscal policy through budget surpluses during the boom and through deficits during the slump to stabilize the economy. This response is all the more important if export revenues accrue to the government and if monetary policy is ineffective. With aggregate expenditure policies, the government can aim directly at the source of the disturbance. On the other hand, if the export price rise is permanent, the exchange rate should rightly reflect the new relative price structure.

There is another reason to eschew the use of the rate of the crawl. Policy formulation is difficult if policy makers cannot clearly distinguish between price changes that are transitory and those that are permanent. Adjustment costs can be minimized only by managing the economy in such a way as to avoid unemployment and forgone output costs arising from responses to transitory phenomena (such as a crop failure abroad that will raise export prices and lead to an appreciation).

The Colombian authorities have tried an implicit dual exchange rate system, changing levels of protection inversely with changes in coffee prices, raising the reserves requirement for commercial banks, and paying exporters with certificates of longer maturity. These attempts to accommodate the effects of export prices are second-best to an overall policy, such as public expenditure reduction in the boom and expansion during the slump so as to avoid policy-induced distortions.

Note

1. Although the structural equations (1) through (11) of Edwards's paper include real income as an endogenous variable (the "spending effect"), the estimated model considers real income as exogenous (see the paragraph before Edwards's summary of section 7.3).