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# COMMODITY EXPORT BOOM AND THE REAL EXCHANGE RATE: THE MONEY-INFLATION LINK

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ABSTRACT

This paper analyzes the relation between exogenous changes in commodity export prices and the real exchange rate in a monetary economy. The traditional Dutch-Disease case is extended, and the monetary consequences of an export boom are explored. It is shown that commodity export booms can generate, in the short run, either an excess demand or an excess supply for money. In a monetary setting the short-run behavior of the real exchange rate can differ significantly from the more traditional Dutch-Disease case without money. The model is tested using data for Colombia.

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# I. INTRODUCTION

A number of papers have recently analyzed the way in which commodity export booms affect production in other sectors of the economy. Most of these studies have focused on the behavior of the real exchange rate as the main transmission mechanism from the booming sector to the rest of the economy. This literature, which has come to be known as the Dutch Disease literature, has postulated that a commodity export boom will generally result in a real appreciation of the domestic currency, increased production of non-tradable goods and a decline in production and employment of the rest (i.e., non-boom) tradable sector. [1] However, commodity export booms can also have important short-run monetary effects, which will spill over to the real exchange rate. For example, a resource-based export boom will typically result in a balance of payments surplus and in the accumulation of international reserves. If this increase in reserves is not sterilized, the monetary base will increase and an excess supply of money may develop. If this is the case, the final effect will be inflation. This increase in the price level will, in general, be one of the mechanisms through which the real appreciation will actually take place. [2] It is possible, however, for the short-run increase in the rate of inflation to exceed what is required to bring about the equilibrium real appreciation generated by the export boom; in this case, the the real exchange rate will appreciate in the short run by more than what real factors only would indicate. These short-run monetary effects of commodity export booms have recently been important in a number of developing countries, including Indonesia, Kenya and Colombia.

In this paper a model of a developing country that relies heavily on the exports of a particular good (the "commodity export" for short) is fully worked out. The model emphasizes the effects of changes in commodity export prices on money creation and inflation. The model also allows for a fairly general exchange rate policy, ranging from a fixed nominal rate to a crawling peg based on a PPP rule. The model is empirically tested using data for Colombia. Experts have generally argued that fluctuatios in Colombia's real exchange rate have been mainly determined by world coffee price movements, with most observers emphasizing the consequences of coffee price change on money creation and inflation.

## II. THE MODEL

In this paper a model that can be used to analyze the way in which commodity export prices, money creation, inflation and the real exchange rate interact is presented. [3] The model is developed for the case of a small developing country, with capital controls and no domestic financial market.

The model consists of three interrelated main building blocks--a money market block, an inflation block and an exchange rate block.

### The Monetary Block

The first equation in the monetary block describes the process of money creation.

$$\hat{M}_t = \alpha \hat{R}_t + (1-\alpha)\, \hat{DCR}_t \qquad (1)$$

As usual $\hat{X}$ denotes the percentage change in variable X. $\hat{M}_t$ is, then, the rate of growth of nominal money, $\hat{DCR}_t$ is the rate of growth of domestic credit, and

$\alpha$ and $(1-\alpha)$ are base year shares. Domestic credit creation, in turn, is assumed to depend on the fiscal deficits as a proportion of high powered money (DEF). This assumption captures the fact that in most less developed countries (LDCs) the creation of money is an important source of financing for government expenditure. [4]

$$\hat{DCR}_t = \beta DEF_t. \qquad (2)$$

Regarding international reserves behavior through time, it is assumed that reserves respond to two factors. First an excess flow demand or supply for money will be reflected in accumulation or decumulation of reserves. Second, changes in the domestic price of the commodity export in period t will be translated, in the same period, into corresponding changes in reserves. [5] These assumptions regarding reserves behavior are captured by equation (3).

$$\hat{R}_t = \gamma_o[\hat{M}^d_t - \hat{M}_{t-1}] + \gamma_1 \hat{P}^c_t \qquad (3)$$

where R are international reserves expressed in domestic currency; $M^d$ is the nominal quantity of money demanded, $P^c_t$ is the price of the commodity export expressed in domestic currency. The world and domestic prices of the commodity export are linked by the following equation:

$$P^c_t = E_t P^{*c}_t \qquad (4)$$

where $P^{*c}_t$ is the world price of this commodity and where $E_t$ is the nominal

exchange rate in period t, expressed as units of domestic currency per unit of foreign currency.

The novelty of equation (3) is that, contrary to most monetary models of open economies, it explicitly allows for international reserve shocks to be a source of money creation in the short run. In the long run, however, $\hat{P}^{c*}_t = 0$, $\hat{M}^d_t = \hat{M}_t = \hat{M}_{t-1}$, and reserves will not change (i.e., $\hat{R}_t = 0$).

The monetary side of the model is closed by an equation for the rate of change of the nominal demand for money. Assuming that the demand for money function depends only on real income, we have:

$$\hat{M}^d_t = \hat{P}_t + \sigma\hat{y}_t \qquad (5)$$

Combining equations (1) through (5) we can obtain a first order semi-reduced form that describes the motion of money through times:

$$\hat{M}_t = -a_o\hat{M}_{t-1} + a_1\hat{P}_t + a_2\hat{y}_t + a_3\hat{P}^{c*}_t + a_4 DEF_t \qquad (6)$$

Since $0<a_o<1$ the convergence of (6) will be oscillatory. [6]

Inflation Block

The inflation side of the model is formed by four equations. The first one is the definition of the price level. Expressed in percentage changes we have:

$$\hat{P}_t = (1-\Psi)\hat{P}_{Nt} + \Psi\hat{P}_{Tt} \qquad (6)$$

Where $\hat{P}_{Nt}$ is the rate of change of nontradable prices and $\hat{P}_{Tt}$ is the rate of change of the price of tradables other than the commodity export, or "other tradables." [7] The rate of change of the price of these other tradables, in turn, is assumed to be equal to the rate of change of the nominal exchange rate plus the rate of change of the world price of the other tradables:

$$\hat{P}_{Tt} = \hat{E}_t + \hat{P}^*_{Tt} \qquad (7)$$

The rate of change of the price of nontradables will depend on the change in the price of other tradables, real income and the excess flow supply for money in period t: [8]

$$\hat{P}_{nt} = \Phi\hat{y}_t + \Pi\,(\hat{M}_t - \hat{M}^d_t) + \hat{P}_{Tt} \qquad (8)$$

Combining (6), (7) and (8) with equation (5) on the demand for money, we obtain the following semireduced form for the domestic rate of inflation: [9]

$$\hat{P}_t = b_o\hat{M}_t + b_1(\hat{E}_t + \hat{P}_{Tt}^*) - b_2\hat{y}_t \qquad (9)$$

where $b_o + b_1 = 1$ .

## III. THE RATE OF CRAWL AND THE DEFINITION OF THE REAL EXCHANGE RATE

The model is closed with three equations: the first one defines the rate of devaluation of the nominal exchange rate, or rate of crawl; the second equation relates real income to the price of the commodity export; and the third equation provides the definition of the real exchange rate.

The following expression summarizes the rule of the rate of crawl assumed to be followed by the monetary authorities at any moment in time: [10]

$$\hat{E}_t = \varepsilon_o \hat{P}_t - \varepsilon_1 \hat{P}_{Tt} - \varepsilon_2 \hat{P}^{*}_{t} \qquad (10)$$

This is a fairly general equation, that allows for a number of possible exchange rate policies. For example, if $\varepsilon_o = \varepsilon_1 = \varepsilon_2 = 0$, this country will have a fixed nominal exchange rate.

If $\varepsilon_o = \varepsilon_2 = 1$ and $\varepsilon_1 = 0$ , this country will have a strict PPP nominal exchange rate rule, where in each period the nominal exchange rate will be adjusted by the differential between domestic and world inflation. If, however, $\varepsilon_2 > 0$, it means that the authorities in this country recognize that changes in the commodity export price will have an impact on the real exchange rate, and will try to accommodate this effect through a slowing down of the rate of devaluation. In the present paper it will be assumed that $\varepsilon_0 \geq 0$ .

Regarding real income, it is assumed that changes in the real price of the commodity export (i.e., changes in the terms of trade) generate deviations of real income from its long-run trend:

$$\hat{y}_t = g + \rho(\hat{P}^{*c}_t - \hat{P}^{*}_{Tt}) \qquad (11)$$

Where g is the long-term trend rate of growth of output.

Finally, the real exchange rate (e) is defined as the domestic relative price of other (i.e., non-commodity export) tradeables to non-tradable goods. [11] In terms of rates of change:

$$\hat{e} = \hat{E}_t + \hat{P}^{*}_{Tt} - \hat{P}_{Nt} \qquad (12)$$

## IV. THE SOLUTION TO THE MODEL

### Permanent Monetary Equilibrium

The model can be further divided into a real and a monetary block. The real side, which is comprised of equations (8) and (11), can be solved under the assumption of full and permanent monetary equilibrium. In this case the mode becomes similar to most models on Dutch Disease which have traditionally concentrated on real aspects only. Assuming permanent monetary equilibrium, $\hat{E} = 0$ , replacing (11) with (8) and using the definition given by equation 12, the change in the real exchange rate resulting from changes in the commodity export world price is:

$$\hat{e}_t = - \phi \rho \hat{P}_t^{c*} < 0 \qquad (13)$$

This means that a (permanent) increase in the world price of the commodity export will generate a real appreciation of the domestic currency. In fact, equation (13) is the spending effect of a commodity export boom emphasized in the Dutch Disease literature (Corden, 1984). This real appreciation takes place because, as a result of the boom, there is an increase in expenditure on non-tradables. In order to maintain equilibrium in the non-tradable goods market, its relative price has to increase. Note from equation (13) that the extent of the real appreciation depends on the value of $\phi$ , the income elasticity of demand for non-tradables. If $\phi = 0$ --that is, if none of the increased real income is spent on non-tradables--the commodity export boom will have no effect on the real exchange rate. This, of course, is a standard result in the Dutch Disease literature. However, the model derived in this

paper goes beyond the real effects of a commodity export boom, emphasizing the monetary and inflationary repercussion of changes in commodity export prices.

Short-Run Monetary Disequilibrium

Allowing for short-run monetary disequilibrium, the complete model works in the following way. As in the real side model, an increase in the real world price of the commodity export results in higher real income (through equation (11)), and in an increased demand for non-tradables. This higher demand, in turn, affects, through equation (8), the relative price of non-tradables, generating the already discussed spending effect.

On the money side, the higher price of the commodity exports with its resulting higher real income and price of non-tradables affects both the demand and the supply for money. From equation (4), a higher demand for nominal (and real) money will result. The few Dutch Disease models that have incorporated monetary factors have emphasized this increase of the demand for money as a result of the export boom. [12] A particularly important effect of this higher demand for real money is that, if an excess demand for money results, some deflationary effect the boom can take place. This is because if after the boom the supply for money does not change, monetary equilibrium can only be reestablished if $\hat{P}_t$ decreases or if $\hat{y}_t$ goes down (equation (5)).

However, an excess demand for money is only one of the possible monetary consequences of the export boom. In fact, according to equations (3) and (1), after the boom international reserves will accumulate, and the rate of growth of money will also be higher. Whether the final result is an excess demand or an excess supply for money will depend on the relative values of some of the parameters in the model. In particular, if $\alpha Y_1 > (1-Y_0)\sigma$, the commodity export boom will result in a short-run excess supply for money. In

the rest of this section it will be assumed, unless otherwise indicated, that the export boom will generate an excess supply for money.

Under this assumption, the resulting excess supply of money will impact the nominal price of non-tradables, further appreciating the real exchange rate. What is the role of the nominal exchange rate policy in our story? Two things will happen according to equation (10). First, as a result of the higher commodity export price, the rate of the crawl will be slowed down in period t, helping to accommodate the real appreciation generated by the spending effect. Second, there will be a tendency to partially compensate the nominal exchange rate for the higher rate of inflation, throught $\varepsilon_0 \hat{P}_t$. 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 can be larger in the short run than in the long run [see Edwards (1984c)].

The model can be formally solved for the rate of change of the real exchange rate as a function of exogenous variables only. Equations (6), (9) and (10) are first solved for $\hat{E}_t$, $\hat{M}_t$ and $\hat{P}_t$. Then, the definition of the real exchange rate is used to find $\hat{e}$:

$$\hat{e} = k - b_o\delta_1(\varepsilon_o/(1+\Psi)-1)D^{-1}\hat{M}_{t-1} + b_o\delta_4(\varepsilon_o/1+\Psi)-1)D^{-1}DEF_t - [A+B]\hat{P}_t^{c*} \quad (14)$$

where k is a constant which includes the trend rate of real income growth (g) and,

$$D = 1-(b_o\delta_1 + \varepsilon_o(b_o\delta_3+b_1))$$

$$A = [b_2(\varepsilon_o/(1+\Psi)-1)+b_o\varepsilon_o(1-\varepsilon_o/(1+\Psi))]\rho D^{-1}$$

$$B = [\varepsilon_2(1-b_o\delta_1)/(1+\Psi)+b_o\delta_3(\varepsilon_o/1+\Psi)-1)-\varepsilon_2(\delta_3 b_o + b_1)]D^{-1}$$

$$\delta_1 = \gamma_o\alpha$$

$$\delta_2 = \gamma_o\alpha\sigma$$

$$\delta_3 = \alpha\gamma_1$$

$$\delta_4 = (1-\alpha)\beta.$$

From this expression we can find how an increase in the world price of the commodity export affects the real exchange rate in the short run. Furthermore, from the comparison of equations (14) and (13), it is possible to find out the extent to which, after the boom, the short-run real exchange rate diverges from the new long-run equilibrium real exchange rate.

Let us now focus on the way in which changes in the commodity export price affect the short-run real exchange rate. Term A captures the spending effect of a change in the price of the commodity export on the real exchange rate. Since stability requires that D>0, the spending effect will, as expected, generate a real appreciation. Let us now turn to the inflation and exchange rate effects. These are captured by term B. As can be seen from this expression, there are three different channels, in addition to the spending effect, through which changes in the commodity export price will affect e. Two of these channels indicate that a higher commodity price will generate a real appreciation. The third channel, however, suggests that- $\hat{e}$ and $\hat{p}^{c*}$ are positively related. Let us first look at the forces that suggest that there is a negative effect of $\hat{p}^{c*}$ on $\hat{e}$. First, a higher world price of the commodity results in an increase in international reserves and money growth in the same period. Assuming that, as a consequence, an excess flow supply for money results, this will generate inflation and, with other things given, a real appreciation. Second, according to equation (10), an

increase in the world price of this commodity slows down the rate of the crawl. This also works towards generating a real appreciation, with other things given. The forces that tend to generate a real depreciation as a consequence of the export boom are of a second order magnitude, and work through the following channel. The higher world commodity export price reduces the rate of the crawl and consequently, through equation (10), 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 given, a real depreciation. However, given the second order nature of this effect, the strong presumption is that under normal circumstances (i.e., under plausible values of the parameters involved), the appreciation effects will dominate. This is, however, an empirical issue, which can be resolved by estimating the model. [13]

## V. AN APPLICATION: COFFEE AND THE REAL EXCHANGE RATE IN COLOMBIA

In this section the model developed above is applied to the case of Colombia. The performance of the Colombian economy has been traditionally linked to the behavior of the world coffee market. [14] A number of authors have argued that changes in the world price of coffee have been transmitted into Colombia mainly through the effect that they have on the real exchange rate [Weisner (1978), Urrutia (1981), World Bank (1984), Edwards (1984c, 1986)]. 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 affected the degree of competitiveness of the non-coffee tradables sectors, with a real appreciation generating loss

of competitiveness or exchange rate "deprotection." For example, the coffee bonanza of 1975-79 resulted in a sharp real appreciation, which negatively affected the ability of the domestic sector to compete in international markets. Earlier episodes of sharp increases in the price of coffee (1950, 1954 and 1956, for example) have also been related to steep appreciations of the peso [Weisner (1978), World Bank (1984)]. In Table 1, data on real effective exchange rates, coffee prices, terms of trade, rate of growth of reserves and high-powered money, inflation, and the nominal rate of devaluation for 1968-82 are presented.

In the Colombian case, the monetary and inflationary effects of coffee price increases have been important. For example, as the data in Table 1 show, the 1975-79 coffee bonanza generated a steep increase in international reserve holdings and in money creation. The crucial role of the increase in the rate of money creation after the different coffee booms has

Table 1: PRICE OF COFFEE AND REAL EXCHANGE RATE IN COLOMBIA

| Year | Real price of coffee (1980=100) | Terms of trade (1980=100) | Rate of nominal devaluation (%) | Rate of growth of high-powered money (%) | Rate of growth of interests, real reserves (%) | Real effective exchange rate (1980=100) |
|---|---|---|---|---|---|---|
| 1968 | 64.3 | 62.0 | 12.3 | 23.9 | - | 104.9 |
| 1969 | 66.9 | 61.6 | 6.3 | 25.7 | 37.3 | 105.3 |
| 1970 | 83.4 | 75.0 | 6.5 | 19.1 | -3.1 | 108.8 |
| 1971 | 71.0 | 70.1 | 8.1 | 12.9 | -0.5 | 111.3 |
| 1972 | 75.7 | 73.7 | 9.7 | 16.5 | 64.0 | 112.5 |
| 1973 | 83.5 | 78.5 | 8.1 | 24.3 | 67.0 | 113.9 |
| 1974 | 69.6 | 81.9 | 10.3 | 22.8 | -16.5 | 120.1 |
| 1975 | 68.4 | 75.8 | 18.7 | 21.2 | 10.2 | 126.7 |
| 1976 | 126.5 | 106.3 | 12.2 | 29.2 | 131.8 | 123.6 |
| 1977 | 182.0 | 147.5 | 6.0 | 34.2 | 58.7 | 104.5 |
| 1978 | 125.3 | 110.1 | 6.3 | 39.7 | 35.4 | 101.7 |
| 1979 | 112.5 | 98.4 | 8.8 | 33.0 | 62.5 | 99.8 |
| 1980 | 100.0 | 100.0 | 11.1 | 25.5 | 25.7 | 100.0 |
| 1981 | 67.5 | 83.4 | 15.3 | 23.5 | -0.6 | 95.2 |
| 1982 | 72.3 | 81.9 | 17.6 | 18.4 | -19.6 | 99.0 |

Note: The real price of coffee is defined as the US$ coffee price deflated by the US$ 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 real exchange rate used in this paper an increase in the index reflects a real depreciation, whereas a decline in the index reflects a real depreciation, whereas a decline in the index represents a real appreciation. The raw data were taken fromn the IFS.

been forcefully pointed out by a number of experts on the colombian economy, including Urrutia (1981), Weisner (1978) and Karnes (1985).

Since World War II, the Colombian authorities have tried to use 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 profita-

bility, production and employment in the rest of the economy. [15] For many years returns from coffee exports were subject to a lower net rate of exchange. Also, in the past, the degree of import protection was altered depending on the behavior of coffee prices; it was reduced as a consequence of increases in the price of coffee, and raised when the world price of coffee declined. In addition, several monetary measures--including steep increases in the banking system's reserves requirements--have been implemented when the price of coffee has risen. [16]

A number of experts have indicated that the adoption of a crawling peg system in 1967 responded to the need to reduce the dependence of the real exchange rate on coffee price fluctuations [Weisner (1978), Urrutia (1981), Ocampo (1982)]. However, 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. For example, according to Weisner (1978), once the crawling peg was adopted, one of the main problems was to decide "at what pace to devalue when coffee prices rise" (p. 203). This problem has been compounded by the existence of 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. The high coffee prices of 1976-79, for example, were accompanied by a significant slowdown of 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 constitutes another mechanism--in addition to the money creation inflationary effect--

through which higher (lower) coffee prices have been translated into a lower (higher) real exchange rate.

In this section annual data for Colombia for 1960-82 are used to econometrically analyze the extent to which changes in coffee prices have, in fact, influenced the real exchange rate in that country. This empirical analysis is carried out in two ways. First, a reduced form equation for the rate of change of the real exchange rate is estimated. This equation, which is in some ways similar to equation (14) above, relates changes in the real exchange rate in Colombia to changes in the price of coffee and other real exogenous variables suggested by the theory. [17] Second, the model developed in Section II, which incorporates the role of monetary sectors in the short run, is explicitly developed by estimating simultaneously the money, inflation and rate of crawl equations from the model of Section II.

## VI. REAL EXCHANGE RATE BEHAVIOR IN COLOMBIA: REDUCED FORM ANALYSIS

In this sub-section some preliminary econometric evidence on the behavior of the real exchange rate in Colombia is presented. The analysis is based on the estimation of reduced form equations and, as in Barro (1983), focuses on the role of real determinants of the real exchange rate.

In the empirical analysis of this section two definitions of the real exchange rate are used: RER is a bilateral measure of the real exchange rate computed as the nominal rate with respect to the U.S. dollar (pesos per dollar), times the U.S. WPI and divided by Colombia's CPI. REER, on the other hand, is an index of the effective real exchange rate, computed relative to a basket of ten currencies where a weighted average of the trade partner's WPI's is used in the numerator and Colombia's CPI is used as a deflator in the

denominator. According to these definitions of the real exchange rate an increase in these indexes denotes a real depreciation, whereas a decline indicates that the domestic currency is appreciating in real terms.

In addition to investigating the nature of the relation between coffee price (and terms of trade) changes and the real exchange rates, two other hypotheses are tested. The first is that the rate of growth in income per capita and the rate of change of the real exchange rate are negatively related. This hypothesis is derived from the Ricardo-Balassa effect, which states that countries with a higher rate of productivity gains will experience a real appreciation in their currency. In the model derived in Section II this effect of the rate of growth of real income on the real exchange rate was captured by term K in equation (14). In this study the rate of growth of per capita income is used as a proxy to measure these productivity gains. The other hypothesis being tested refers to the relationship between the levels of import protection and the real exchange rate. [18] Even though in a general equilibrium setting with exportables, importables and non-tradeable goods the effect of changes in import tariffs on the real exchange rate cannot be determined a priori, the presumption is that for most countries higher tariffs result in a real appreciation (Edwards 1984a). In the regression analysis the following reduced forms for the real exchange rate were estimated:

$$\hat{e}_t = a_o + a_1 \hat{y}_t + a_2 \hat{\tau}_t + a_3 \Delta D_t + v_t \qquad (15)$$

and

$$\hat{e}_t = b_o + b_1 \hat{y}_t + b_2 \hat{p}^c_t + a_3 \Delta D_t + u_t \qquad (16)$$

where:

$\hat{e}$ = percentage change of either RER or REER

$\hat{y}$ = percentage change in real GDP per capita

$\hat{\tau}$ = percentage change in the terms of trade, measured as export prices over import prices

$\Delta D$ = change in a dummy variable that measures the level of protection in every period

$\hat{p}_t^c$ = percentage change in the real price of coffee, defined as an index of the dollar price of coffee deflated by and index of import prices for Colombia

$u,v$ = error terms.

It is expected, then, that $a_1, b_1 < 0$, and that $a_2, b_2, a_3, b_3 < 0$. In equation (16), changes in the real price of coffee ($\hat{p}_t^c$) are used instead of the change in the terms of trade ($\hat{\tau}$), since changes in coffee prices are the main determinants of $\hat{\tau}$ and because our main interest is to investigate how changes in the price of the main commodity export affect the real exchange rate.

The results obtained from the estimation of equations (15) and (16), as well as some variants, using OLS, are presented in Table 2. As can be seen, while all the coefficients have the expected signs, only a few are significant at conventional levels. On the other hand, the goodness of fit, as measured by the $R^2$, is rather poor. Nevertheless, these results provide

Table 2: THE REAL EXCHANGE RATE IN COLOMBIA: REDUCED FORM ESTIMATES

(OLS)

| EQ. | Dep. Var. | Period | Constant | $\hat{p}^c$ | $\hat{\tau}$ | $\hat{y}$ | $\Delta D$ | $R^2$ | D.W. |
|---|---|---|---|---|---|---|---|---|---|
| (15.1) | RER | 57-83 | 0.022 | -0.159 | - | - | 0.082 | 1.394 | |
| | | (1.009) | (-1.942) | | | | | | |
| (15.2) | RER | 57-83 | 0.024 | - | -0.257 | - | 0.113 | 1.293 | |
| | | (1.106) | | (-1.787) | | | | | |
| (15.3) | RER | 57-83 | 0.108 | -0.146 | - | -0.018 | -0.006 | 0.162 | 1.303 |
| | | (1.590) | (-1.322) | | (-1.240) | (-0.102) | | | |
| (16.1) | REER | 57-83 | 0.028 | -0.122 | - | - - | 0.041 | 1.803 | |
| | | (1.178) | (-1.027) | | | | | | |
| (16.2) | REER | 57-83 | 0.030 | - | -0.293 | - - | 0.125 | 1.737 | |
| | | (1.284) | | (-1.891) | | | | | |
| (16.3) | REER | 57-83 | 0.103 | -0.120 | - | -0.017 | -0.030 | 0.085 | 1.615 |
| | | (1.233) | (-0.957) | | (-1.019) | (0.471) | | | |

Notes: The numbers in parentheses are t-statistics. $R^2$ is the coefficient of determination and D.W. is the Durbin-Watson statistic.

some preliminary evidence that the hypothesized negative effect of terms of trade changes--and especially coffee's terms of trade changes--on the real exchange rate in Colombia is indeed present.

A problem with these estimates is that by concentrating on reduced forms, they do not capture most of the action, missing in particular the mechanisms through which coffee price changes are transmitted into the real exchange rate. For this reason in the next section the model developed in Section II is explicitly tested.

## VII. COFFEE, MONEY, INFLATION AND THE REAL EXCHANGE RATE IN COLOMBIA

In the preceding section, results obtained from the estimation of reduced form equations for changes in the real exchange rate in Colombia were presented. These regressions indicated that changes in the world (real) price of coffee have had a [marginally] significant negative effect on the real exchange rate in Colombia. However, a problem with these results is that, as in most analyses based on reduced form regressions, the mechanisms through which a particular exogenous variable (the price of coffee) affects the endogenous variable (the real exchange rate) is not explicitly presented. In the colombian case this is particularly troublesome, since by basing the analysis on reduced forms the possible monetary effect of higher prices of coffee is missed. In this section this problem is faced by directly estimating a version of the model presented in Section II. [19]

In this section the three main equations from the model (equations (6), (9) and (10)) are estimated simultaneously. The estimation was performed using annual data for 1952-1980, with an explicit distinction made between the pre-1976 period and the post-1967 period. The following variant of the money creation equation (6) was estimated (where the $\nu_i$s are error terms):

$$\hat{M}_t = \alpha_o + \alpha_1 \hat{M}_{t-1} + \alpha_2 \hat{y}_t + \alpha_3 \hat{P}_{t-1} + \alpha_4 \hat{P}^{c*}_t + \alpha_5 DEH_t + \nu_{1t} \qquad (17)$$

The following version of the inflation equation (9) was estimated, where DUM is a dummy variable that takes a value of zero up to 1967 and a value of one from there onward.

$$\hat{P}_t = \delta_o + \delta_1 \hat{M}_t + \delta_2 \hat{y}_t + \delta_3 (\hat{E}_t + \hat{P}^*_{Tt}) + \delta_4 DUM_t + \nu_{2t} \qquad (18)$$

Finally, the exchange rate devaluation equation (10) was the following:

$$\hat{E}_t = \mu_o + \mu_1 \hat{P}_t + \mu_2 (\hat{P}_t DUM_t) + \mu_3 \hat{P}^*_{Tt} + \mu_4 \hat{P}^{c*}_t + \mu_5 DUM_t + \nu_{3t} \qquad (19)$$

The estimation of (16) using two stages least squares yielded the following result:

$$\hat{M}_t = \underset{}{-0.030} + \underset{(0.883)}{0.607}\ \hat{M}_{t-1} + \underset{(4.067)}{0.318}\ \hat{y}_t + \underset{(0.768)}{0.137}\ \hat{P}_{t-1} + \underset{(1.373)}{0.095}\ \hat{P}^{c*}_t + \underset{(2.776)}{0.125}\ DEH_t \underset{(2.345)}{}$$

D.W. = 2.03 SEE = 0.035

The most interesting result from the estimation of this equation is that it confirms the hypothesis that higher (domestic) prices of coffee have 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. Also, estimates of the coefficients of the lagged $\hat{M}$ suggest that the effect of changes in coffee prices on money growth have some persistence through time. The estimation of the money growth equation, then, provides statistical support to the claim made by numerous authors [i.e., Weisner (1978), Urrutia (1981)] that in Colombia the ability to perform monetary policy has been hampered by the dependence of money creation on the behavior of coffee prices. Also, these results 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. An increase in the fiscal deficit--measured as a proportion of lagged base money--of 10 percentage points has resulted, on average, in an increase in the rate of growth of money of approximately 1.8 to 2.2 percentage points. This finding points out that the separation of the fiscal and monetary sides in traditional macroeconomic analysis might not be fully applicable to LDCs. [20]

The estimation of the inflation equation using two stages least squares yielded the following results:

$$\hat{P}_t = \underset{(-0.729)}{-0.006} + \underset{(2.669)}{0.705}\,\hat{M}_t - \underset{(-0.363)}{0.040}\,\hat{y}_t + \underset{(2.182)}{0.311}\,(\hat{E}_t + \hat{P}^*_{Tt}) + \underset{(0.314)}{0.010}\,DUM_t$$

$$SEE = 0.060$$

$$D.W. = 2.23$$

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 given, an increase in the rate of money creation by 10 percentage points has resulted in an increase of 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 and/or higher world inflation, will be passed on almost one-third to price increases. [21] As the model indicates, the sum of the coefficients of $\hat{M}_t$ and $(\hat{E}_t + \hat{P}^*_{Tt})$ is not significantly different from one. However, the coefficient of real income growth was, in all runs, insignificant.

Finally, the estimation of the crawling peg equation yielded:

$$\hat{E}_t = \underset{(-0.119)}{-0.006} + \underset{(2.569)}{1.333}\,\hat{P}_t - \underset{(-1.678)}{0.850}\,(\hat{P}_t\ DUM_t) - \underset{(-0.063)}{0.060}\,\hat{P}^*_{Tt} - \underset{(-1.604)}{0.198}\,\hat{P}^{c*}_t + \underset{(0.469)}{0.043}\ DUM_t$$

D.W. = 1.728 SEE = 0.108

These results confirm the hypothesis that the Colombian authorities have taken into account the behavior of world coffee prices when deciding by how much to devalue the nominal exchange rate. Lower (higher) world coffee prices result in higher (lower) rates of devaluation of the crawl. Also, according to this equation, in the past--1967 period--after the crawling peg was adopted--and with other things given, the exchange rate tended to be adjusted by less than the ongoing domestic rate of inflation. On the other hand, while the coefficient of the world rate of inflation is negative, as expected, the absolute value of its point estimate is very small and not significant. [22]

## VIII. CONCLUDING REMARKS

In this paper, the interaction between changes in commodity export prices and the real exchange rate has been investigated. In Section II, a model that relates coffee price changes to money creation, inflation and the rate of devaluation was developed. The model was then estimated for Colombia. A virtue of this model is that it highlights two of the channels that have been traditionally pointed out in casual discussions on 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 (i.e., the rate of devaluation of the crawling peg).

The model shows that commodity export booms will generally generate short-run increases in money creation, inflation and 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 could still be significant.

The model presented in this chapter was empirically tested for the case of coffee in Colombia. Two approaches were taken in the empirical section. First, a reduced form equation that relates changes in the real exchange rate to changes in the price of coffee, and other exogenous variables, was estimated. The results obtained provided preliminary evidence indicating that increases (reductions) in the world price of coffee have indeed resulted in a real appreciation (depreciation). Second, the model developed in Section II was explicitly tested using a simultaneous equation approach. The results obtained indicate that coffee price changes have indeed been closely related to money creation and inflation. Also, coffee price changes have been negatively related to the rate of devaluation. These results indicate 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 used in this paper has been deliberately kept small and simple. As a result, it has been possible to clearly pinpoint the role of coffee in the inflationary and devaluation process. A cost of this approach, however, has been that some simplifying assumptions had to be made.

## DATA SOURCES

All data refer to annual averages.

E = Pesos per US$ nominal exchange rate, taken from IFS.

M = $M_2$ definition of money taken from IFS.

P = Consumer Price Index taken from IFS.

y = Real GDP 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. From 1970 to 1980 data from DNP that corrects for the Cuenta Especial de Cambio is used. (These data were supplied by Colombia's Departamento Nacional de Planeacion.)

## Footnotes

1. On Dutch-Disease see Corden (1984) and the papers in this volume.
2. On some of the monetary aspects of Dutch-Disease see, for example, Neary and van Wijnbergen (1984).
3. This section draws partially on Edwards (1986).
4. See Edwards (1983).
5. Notice that, for simplicity, the model ignores issues related to the demand for international reserves. For an integration of the demand for reserves literature with a balance of payments equilibrium analysis, see Edwards (1984b).
6. For exact expressions for the a's in terms of the structural parameters, see Edwards (1986).
7. Notice that in defining the price level, we have assumed that the commodity export does not enter into this index. This is a realistic assumption, since developing countries usually consume very little of their main export.
8. This equation is derived from assuming equilibrium in the non-tradables sector.
9. For expressions of the b's in terms of the structural parameters, see Edwards (1986).
10. In Edwards (1986) a more general rule of crawl is assumed.
11. It is also possible to define the real exchange rate as the PPP real rate. See Edwards (1986) for the derivation of a similar model, where the real exchange rate is defined in that way.
12. See, for example, Neary and van Wijnbergen (1984).
13. Notice that the model presented here has ignored the distinction between permanent and transitory changes in the price of coffee. In Edwards

(1986) a similar model in developed where this distinction is explicitly taken into account.

14. On the Colombian economy see, for example, Diaz-Alejandro (1976), Ocampo (1983), Weisner (1978), Kamas (1983), World Bank (1983a, 1983b). Coffee represents approximately 55 percent of Colombia's foreign earnings from legal exports. It is important to notice that the presence of important illegal exports makes the empirical analysis of Colombia's 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).
15. See Weisner (1978).
16. In that regard, the results from this reduced form can be viewed as preliminary, since they ignore the possible short-run effects of monetary variables.
17. The effect of commercial policies changes on the real exchange rate have traditionally been explained in the literature. In order to simplify the discussion, the model of Section II ignored commercial policy. However, the result reported in this section indicate that for the case of Colombia the effect of changes in trade taxes have not been very important in determining the behavior of the real exchange rate.
18. Some of the results reported in this subsection draw on Edwards (1986).
19. The positive effect of changes in coffee prices on the rate of money creation is very robust to changes in the specification in the money growth equation. For alternative specifications, see Edwards (1986).
20. These results are consistent with those reported in Hanson (1982).
21. See Edwards (1986) for a detailed analysis on alternative specifications of a crawling rule equation for Colombia.

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