# Commodity Booms, Dutch Disease, and Real Business Cycles in a Small Open Economy: The Case of Coffee in Colombia

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# Commodity Booms, Dutch Disease, and Real Business Cycles in a Small Open Economy: The Case of Coffee in Colombia

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**Abstract**

This paper proposes a dynamic, stochastic, multisector growth model which integrates the real business cycle literature and booming sector and Dutch Disease economics to analyze fluctuations, resource allocation and relative price changes in small open (developing) economies subject to terms of trade shocks. The model is consistent with aggregate and sectoral cyclical behavior of this class of economies, and rationalizes as an efficient outcome the symptoms of Dutch Disease (temporary deindustrialization and appreciation of the real exchange rate) which are sometimes judged to be suboptimal responses and as the rationale for government intervention in developing countries. It is also found that commodity price stabilization policies do not significantly affect the cyclical pattern of fluctuations and that their welfare benefits are second order.

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## 1. Introduction

Developing countries are frequently exposed to macroeconomic adjustment in response to the behavior of primary commodity prices in world markets, process generally exacerbated by the low degree of export base diversification. A recent study, sponsored by the World Bank (Little et al., 1993), reviews the experience of 18 developing countries that faced terms of trade shocks over the 1974-1989 period and presents striking arguments suggesting that countries that experienced favorable terms of trade shocks did not performed better than countries that underwent negative shocks. It identifies two problems with positive shocks: the first is bad economic policy induced by unrepressed government euphoria, and the second, is the paradoxical effect, known as Dutch Disease, which gives rise to a loss of competitiveness and a deterioration of the non-booming industrial sector.

A branch of the macroeconomic literature uses the tradables-nontradables framework developed by Salter (1959) and Swan (1960, 1963) to study the effects of external shocks on the allocation of resources in small open economies. Extensions of this literature have given rise to the so-called booming sector and Dutch Disease economics[1]. This literature suggests that terms of trade shocks in countries where foreign exchange earnings heavily depend on primary exports, may have undesirable effects. This is why export booms are commonly stigmatized as a disease or as a mixed blessing, at best. According to the simplest version of the theory, a temporary export windfall increases domestic income and aggregate demand. Since the tradable good can be imported at given world prices, equilibrium requires increases in output and in the relative price of nontradables in order to get rid of the excess demand situation emerging from the wealth effect of the boom on higher spending on nontradables. This is the so-called *spending effect*, and explains the basic symptoms of the Dutch Disease: real appreciation and deindustrialization, i.e., contraction of the tradable sector. These effects are reinforced by the so-called *resource movement effect* of a boom which is brought about when factors are intersectorially mobile and the booming activity pulls them out from other activities. Income distribution turns out to be altered along this process while the net effect on the nontradable sector output is ambiguous.

Despite the extensive theoretical work, the analytic implications of the theory

[1]See for example, Corden and Neary (1982) and Corden (1984).

are very limited considering that the direction of the mentioned effects cannot be regarded as certain if further complications are introduced into the basic specific factors and Heckscher-Ohlin models. The burden of proof of the theory's relevance is on the empirical side. With regard to empirical results, there has been little effort made at providing an answer to the positive question of how resources get allocated in response to external shocks. The empirical research on this area has been limited and generally circumscribed to simple static general equilibrium and econometric analyses usually constructed under the presumption that responses on a Dutch Disease manner are harmful and with little success at disentangling long-run growth behavior, economic policy responses and other sources of business fluctuations from the effect of export booms. This empirical literature has also disregarded the use of recursive numerical methods developed by the real business cycle (RBC) literature, which represent an appropriate tool for examining the posed question in an intertemporal, stochastic framework.

On the other hand, in a different branch of the literature, the RBC theory has proved to be very successful when used to predict the cyclical behavior of industrialized countries exhibiting distinct degrees of participation in international financial markets. Less attention has been paid to the assessment of the theory's suitability to explain recurrent fluctuations in developing countries. The standard RBC model assumes complete markets by allowing households to have unrestricted access to state-contingent Arrow-Debreu securities that permit them to bear no idiosyncratic risk in equilibrium. This framework has been specialized to the case of small open economies through models in which the complete insurance assumption is replaced by a financial structure which offers imperfect insurance as a result of trading opportunities restricted to noncontingent real claims. The most notable contributions in this line of research have been devoted to examining the model's relevance to explain fluctuations in relatively developed and financially open economies[2]. One important exception is Mendoza's (1995) work. Though the paper focuses on the explanation of some international features of the business cycle -like the countercyclical behavior of net exports, the Harberger-Laursen-Metzler effect and the relationship between terms of trade shocks and the real exchange rate- for a number of developing countries, it completely ignores the model's sectoral implications. In addition, its characterization of the accessibility to international financial markets does not seem to accord with

[2]Some widely known examples are: USA and Germany (Cardia, 1991); Canada (Mendoza, 1991); Sweden (Lundvik,1991); Canada, Germany, Japan and the United Kingdom (Mendoza, 1992); and Portugal (Correia, Neves, and Rebelo, 1995).

the actual functioning of these markets. Most developing economies do not have access to world financial markets for consumption smoothing purposes due to the proliferation of barriers to cross-border portfolio investments, exchange rate controls, exchange restrictions, etc.[3], which bias the portfolio selection of households worldwide primarily in favor of domestic securities.

This paper integrates both strands of the literature. The cyclical behavior of a dynamic, stochastic, equilibrium growth model with three sectors and two factors is studied. The sectors are the booming, the tradable and the nontradable sectors, as in standard Dutch Disease models, while the factors are capital and labor services, which are assumed to be imperfectly mobile across sectors. The international financial linkages of the economy are restricted by assuming an upward-sloping supply curve of foreign credit. This assumption rules out the nonstationary behavior of consumption and the current account present in unrestricted small open economy models and also strengthens the real effects of terms of trade shocks. This is precisely the type of effects highlighted by the booming sector literature which hinges on the inability of developing countries to insure away country-specific risks.

The issue at hand is whether a neoclassical growth model, featuring rational expectations, optimizing behavior, continuous market clearing and limited participation in international asset markets, may explain aggregate and sectoral fluctuations in developing economies. Effort is devoted to test whether this type of model rationalizes as an efficient outcome the symptoms of the Dutch Disease -temporary deindustrialization and appreciation of the real exchange rate - which are sometimes judged as suboptimal responses to transient terms of trade shocks and as the rationale for the implementation of "structural adjustment" programs and government intervention in developing countries[4].

Disaggregation increases the dimensions along which RBC models may be evaluated and also increases the requirements of information. Due to difficulties in obtaining detailed information, the model is confronted, as a first test, only with data of Colombia and coffee; this case is a good example since it seemly fits the modeling assumptions, as substantiated below.

The paper is structured as follows. Section 2 describes a three sector RBC model and defines a competitive equilibrium for the economy. Section 3 summarizes the empirical regularities of the Colombian economy at business cycle

[3]See for example, IMF (1995).

[4]See Edwards and van Wijnbergen (1989) for a discussion of policy measures aimed at reducing the reallocation of investment in response to external shocks.

frequencies and their relation to shocks to the price of coffee; presents the calibration procedure and discusses the simulation results. Section 4 deals with the time pattern of the intersectoral resource allocation associated with transient coffee booms and section 5 evaluates the role of stabilization policies. Section 6 offers conclusions.

## 2. A Three Sector Model

This section begins by describing preferences, technologies, material balances and the financial structure of the economy. The consumer's problem is then formulated and the competitive equilibrium defined.

### 2.1. Economic Environment

#### 2.1.1. Preferences

Our artificial economy is inhabited by a continuum of identical, infinitely lived households. The representative household is of measure $L_t$ and the number of members per household grows at the rate $\eta_L - 1$. Labor is internationally immobile, inelastically supplied and imperfectly mobile across sectors. Preferences are defined over stochastic streams of two types of consumption goods: tradables, $\{C_t^{T*}\}_{t=0}^{\infty}$, and nontradables, $\{C_t^N\}_{t=0}^{\infty}$. The representative household maximizes the expected lifetime utility given by:

$$W = E_0 \left\{ \sum_{t=0}^{\infty} \beta^t U\left(C_t^{T*}, C_t^N\right) \right\} \tag{1}$$

where $\beta \in (0,1)$ reflects time preference; $E_0$ is the mathematical expectations operator conditional on information available at date 0; expectations are based on the known probability distribution of the vector process governing the economy's stochastic structure. Total household consumption of tradables $(C_t^{T*})$ is the sum of imported $(C_t^*)$ and domestically produced $(C_t^T)$consumption goods, which are perfect substitutes. The function $U(.,.)$ has the following constant elasticity of substitution (CES) format:

$$U\left(C_t^{T*}, C_t^N\right) = \frac{1}{1-\sigma}\left[\left\{\left(C_t^{T*}\right)^{-\mu} + \omega\left(C_t^N\right)^{-\mu}\right\}^{-\frac{1}{\mu}}\right]^{1-\sigma} \tag{2}$$

where $\mu > -1$, $\omega \geq 0$ is the relative weight of nontradables to tradables in the utility index, and $\sigma > 0$. The degree of substitutability between tradables and nontradables in consumption is given by the constant elasticity $\frac{1}{1+\mu}$, and the intertemporal elasticity of substitution is given by $\frac{1}{\sigma}$.

### 2.1.2. Technologies and Adjustment Costs

For the sake of simplicity, it is assumed that the production side of the economy is directly run by households which make all hiring and investment decisions. There are three production sectors $j$, $j \in S$, in the economy: the tradable-good sector, denoted by the superscript $T$, the nontradable-good sector $N$, and the booming sector $B$. Let $p_t^j$ denote the relative price of commodity $j$ in terms of tradables[5]. The relative price of the booming sector good, $p_t^B$, is assumed to follow a first order linear Markov process while the relative price of nontradables, $p_t^N$, an important determinant of the real exchange rate, is determined endogenously in the rational expectations equilibrium, although it is taken as given by the representative household.

Each sector $j$ combines a fraction $\phi_t^j$ of the total stock of physical capital $K_t$, a fraction $\psi_t^j$ of the available amount of efficiency units of labor $H_t L_t$, and a Cobb-Douglas technology to produce type-$j$ output:

$$Y_t^j = \lambda_t^j \, \bar{A}^j \left(\phi_t^j K_t\right)^{\alpha^j} \left(\psi_t^j H_t L_t\right)^{1-\alpha^j} - AC_t^j, \qquad j \in S, \qquad S = (B, T, N) \quad (3)$$

where $\alpha^j$, $0 < \alpha^j < 1$, is the capital share in sector-$j$ output; $\bar{A}^j$ is a sectoral scale parameter; $\sum_{j \in S} \phi_t^j = \sum_{j \in S} \psi_t^j = 1$ and $AC_t^j$ stands for adjustment costs to be described shortly. Production technologies are subject to stationary productivity disturbances: $\lambda_t^j$ is a shock representing technical change in industry $j$; technology shocks are assumed to follow a vector Markov process. $H_t$ represents units of human capital. Human capital is embodied in each worker, depreciates at rate zero, and grows at a constant rate $\eta_H = H_{t+1}/H_t > 1$; per capita growth along the steady state balanced growth path is driven by $\eta_H$.

Physical capital depreciates at rate $\delta$, $0 \leq \delta \leq 1$, and aggregate investment is irreversible ($I_t \geq 0$). The law of motion for physical capital is:

$$K_{t+1} = (1 - \delta) K_t + I_t \quad (4)$$

[5]Note $p_t^T = 1$, $\forall$ $t$. Purchasing power parity holds for tradable commodities, excluding the booming good which, strictly speaking, is a tradable good as well.

Capital and investment are expressed in terms of the numéraire.

Adjustment costs are incorporated to reduce the economy's excessive responsiveness at business cycle frequencies to sectoral differences in productivity. Total adjustment costs in sector $j$ $\left(AC_t^j\right)$take the following form:

$$AC_t^j = \frac{\xi_L^j}{2}\left(\psi_t^j - \bar{\psi}^j\right)^2 H_t L_t, \qquad j \in S, \qquad S = (B, T, N) \tag{5}$$

where $\xi_L^j \geq 0$ and $\bar{\psi}^j$ is the steady state share of sector $j$ in total employment. Adjustment costs are assumed to be associated with the intersectoral reallocation of labor[6]. Specifically, costs in connection with the intratemporal reallocation of labor services are modeled as directly related to temporary deviations from the steady state shares in the sectoral use of the factor. The formulation in (5) ensures that the economy's steady state is the same under both arrangements: with and without adjustment costs.

### 2.1.3. Financial Structure

Now the economy's international financial linkages are described. The country's financial structure is characterized by imperfect access to internationally traded real claims. The law of motion of the stock of net foreign debt $(D_t)$ is:

$$D_{t+1} = (1 + r_t)\, D_t - TB_t \tag{6}$$

where all variables are expressed in terms of tradables. $TB_t$ stands for the trade balance defined as the difference between the production of the booming and tradable sectors and the domestic absorption of tradable goods. $r_t$ is the real interest rate charged by foreign creditors.

In order to allow for transitional dynamics out of the steady state equilibrium along with foreign debt accumulation and consumption tracing stationary processes, it is assumed, following Senhadji (1993), that the economy faces an upward sloping supply curve of foreign funds:

$$r_t = r^* + s\left(\frac{D_t}{H_t L_t}\right) \tag{7}$$

[6] The adjustment cost function may be specified more generally by including the costs of reallocating capital intersectorially and installing new capital. However, the simpler specification turned out to be enough to get rid of the model's unreasonable volatility.

where $r^*$ is the world's real interest rate and $s(\cdot)$, $s(\cdot) > 0$, is a risk premium function which depends positively on the stock of foreign debt relative to the size of the economy. The model is consistent with the domestic interest rate being systematically greater than the world's real interest rate and with positive and finite steady state levels of foreign debt, features observed in most developing economies.

### 2.1.4. Material Balances

Production originating in the booming sector does not have a domestic use as a final consumption good or as an intermediate good. It is entirely devoted to trade in competitive international markets. Under this lens, this sector's output may be understood as a final consumption good, a primary commodity or even a raw material not essential for domestic consumption or production[7]. On the other hand, the domestic tradable-producing industry does not produce an investment good; its production is consumed and exported. In equilibrium, the following market-clearing condition is required on the total production of tradables:

$$Y_t^T + p_t^B Y_t^B = C_t^T + X_t^T + p_t^B X_t^B \tag{8}$$

The nontradable-producing industry faces the following resource constraint:

$$Y_t^N = C_t^N + I_t^N \tag{9}$$

Nontradables are (domestically) consumed and invested. Total investment ($I_t$), consumption ($C_t$), imports ($M_t$), and exports ($X_t$) satisfy the following material balances:

$$I_t = I_t^* + p_t^N I_t^N \tag{10}$$

$$C_t = C_t^* + C_t^T + p_t^N C_t^N = C_t^{T*} + p_t^N C_t^N \tag{11}$$

$$M_t = C_t^* + I_t^* \tag{12}$$

$$X_t = X_t^T + p_t^B X_t^B \tag{13}$$

and the trade balance is defined as:

$$TB_t = X_t - M_t = Y_t^T + p_t^B Y_t^B - C_t^{T*} - I_t^* \tag{14}$$

[7] An interesting variant, usually highlighted in the so-called Dutch Disease literature, arises when the booming sector produces an intermediate input indispensable for domestic use (oil, for example). This case is not studied in the paper although it can be easily accommodated in our framework.

Investment goods may be produced domestically by the nontradable industry $(I_t^N)$ and imported from abroad $(I_t^*)$. To keep the model simple, it is assumed that the elasticity of substitution between domestic and imported investments is equal to that governing the substitution between nontradable and tradable consumption goods. Aggregate investment comprises both types of goods; consequently, and according to (4), the capital stock may be understood as a composite good.

### 2.2. Competitive Equilibrium

The problem solved by the representative household is to maximize (1) subject to (3)-(14) given (2) and the forcing processes for the sources of uncertainty in the economy. Preferences and technologies are consistent with steady state growth according to the conditions specified in King, Plosser and Rebelo (1988). The model economy is transformed into a stationary representation by expressing all nonstationary variables relative to $H_t L_t$. Lowercase letters stand for transformed variables; for example: $c_t^{T*} = \frac{C^{T*}}{H_t L_t}$; $c_t^N = \frac{C_t^N}{H_t L_t}$; $k_t = \frac{K_t}{H_t L_t}$; $i_t = \frac{I_t}{H_t L_t}$, $ac_t^j = \frac{AC_t^j}{H_t L_t}$, $d_t = \frac{D_t}{H_t L_t}$, $tb_t = \frac{TB_t}{H_t L_t}$, etc. The discount factor is transformed as follows $\tilde{\beta} = \beta(\eta_L \eta_H)^{1-\sigma}$, with $\tilde{\beta} < 1$ required to ensure $W < \infty$. As a result, the nonstochastic version of the transformed economy converges to a feasible steady state.

The model does not have an exact analytical solution; however, there is available a number of numerical methods devoted to computing the equilibrium process of this class of models. The algorithm implemented is a variant of the method used by Kydland and Prescott (1982) and Cooley and Hansen (1989) which makes use of the notion of recursive equilibrium advanced in Prescott and Mehra (1980).

The information relevant for household decision making is characterized by a quintuplet of state variables consisting of three exogenous states[8] $\mathbf{z} = (p^B, \lambda^T, \lambda^N)$, and two endogenous states, $k$ and $d$. In what follows, time subscripts will be dropped and a prime (′) will denote the corresponding next period values, according to the standard convention. The representative household chooses the decision vector $\mathbf{\Lambda}$, $\mathbf{\Lambda} = (c^{T*}, c^N, i^*, i^N, \phi^B, \phi^T, \phi^N, \psi^B, \psi^T, \psi^N, k', d')$, taking as given the equilibrium pricing function $p^N = p^N(\mathbf{z}, k, d)$ and the laws of motion for the exogenous shocks $\ln \mathbf{z}' = \mathbf{\Omega} \ln \mathbf{z} + \varepsilon'$, and for the accumulation of capital and foreign

[8] Note the simplifying assumption of no technical change in the booming sector, i.e., $\lambda_t^B = 1$, $\forall t$.

debt. The problem belongs to the time invariant class of dynamic structures that satisfy the following Bellman's equation:

$$v\left(\mathbf{z},k,d,p^N\left(\mathbf{z},k,d\right)\right)=\max_{\mathbf{A}}\left\{U\left(c^{T*},c^N\right)+\tilde{\beta}E\left[v\left(\mathbf{z}',k',d',p^N\left(\mathbf{z}',k',d'\right)\mid\mathbf{z}\right)\right]\right\}$$

subject to:

$$c^{T*}=-tb-i^*+\sum_{j=T,B}p^j\left\{\lambda^j\bar{A}^j\left(\phi^jk\right)^{\alpha^j}\left(\psi^j\right)^{1-\alpha^j}-\left(\tfrac{\xi_L^j}{2}\right)\left(\psi^j-\bar{\psi}^j\right)^2\right\}$$

$$c^N=-i^N+\lambda^N\bar{A}^N\left(\phi^Nk\right)^{\alpha^N}\left(\psi^N\right)^{1-\alpha^N}-\left(\tfrac{\xi_L^N}{2}\right)\left(\psi^N-\bar{\psi}^N\right)^2$$

$$\eta_L\eta_Hk'=(1-\delta)\,k+p^Ni^N+i^*$$

$$\eta_L\eta_Hd'=(1+r\,(d))\,d-tb$$

$$\sum\nolimits_{j\in S}\phi^j=\sum\nolimits_{j\in S}\psi^j=1$$

$$\ln\mathbf{z}'=\mathbf{\Omega}\ln\mathbf{z}+\boldsymbol{\varepsilon}'$$

$$p^N=p^N\left(\mathbf{z},k,d\right)$$

where ln stands for the natural logarithm; $\mathbf{\Omega}$ is a 3x3 matrix characterizing the AR(1) component of the shocks; the vector $\boldsymbol{\varepsilon}$ has zero mean , $E\left[\boldsymbol{\varepsilon}\right]=\mathbf{0}$, and variance-covariance matrix $Var\left[\boldsymbol{\varepsilon}\right]$; and $v\left(\mathbf{z},k,d,p^N\left(\mathbf{z},k,d\right)\right)$is the household's optimum value function. The solution to the problem yields stationary decision rules specifying allocation decisions as functions of the state variables which summarize the effect of past equilibrium decisions and new information. This leads to the following definition.

**Definition 2.1.** *A Recursive Competitive Equilibrium for a small open economy consists of a set of decision rules:* $c^{T*}\left(\mathbf{z},k,d\right)$, $c^N\left(\mathbf{z},k,d\right)$, $i^*\left(\mathbf{z},k,d\right)$, $i^N\left(\mathbf{z},k,d\right)$, $\phi^B\left(\mathbf{z},k,d\right)$, $\phi^T\left(\mathbf{z},k,d\right)$, $\phi^N\left(\mathbf{z},k,d\right)$, $\psi^B\left(\mathbf{z},k,d\right)$, $\psi^T\left(\mathbf{z},k,d\right)$, $\psi^N\left(\mathbf{z},k,d\right)$, $k'\left(\mathbf{z},k,d\right)$ *and* $d'\left(\mathbf{z},k,d\right)$*; a price function* $p^N\left(\mathbf{z},k,d\right)$ *and a value function* $v\left(\mathbf{z},k,d\right)$ *such that:*

*a) The functions* $v$ *and* $p^N$ *satisfy the Bellman's equation and the allocations* $c^{T*}$, $c^N$, $i^*$, $i^N$, $\phi^B$, $\phi^T$, $\phi^N$, $\psi^B$, $\psi^T$, $\psi^N$, $k'$ *and* $d'$ *are the associated optimal decision rules.*

*b) Markets clear:* $y^T+p^By^B=c^{T*}+i^*+tb$; $y^N=c^N+i^N$; $y=y^T+p^By^B+p^Ny^N=c+i+tb$.

# 3. Business Cycles in a Small Open Economy: Coffee in Colombia

## 3.1. Empirical Regularities

The empirical relevance of the model designed to typify the business cycle behavior in small open economies is tested along several dimensions with Colombian yearly data covering the 1952-1992 period.

Colombia is a good example because it acceptably exhibits most of the features assumed to characterize this class of economies; the country's production and trade structure makes of it an interesting case for studying dynamic responses to terms of trade shocks. The country has historically faced large and repeated terms of trade shocks largely originating in the behavior of the world coffee price. Table 1 shows the macroeconomic importance of the coffee sector and highlights the heavy dependence of the country on exports of a single primary commodity. Coffee exports accounted for 77.7% of total exports during the 1950s; this share has continuously fallen since but still representing a substantial portion of the country's foreign exchange revenues during the remaining sample period. Table 2 shows that coffee is also a good example. According to Deaton and Laroque (1992), primary commodity prices are remarkably volatile and seemingly exhibit mean reversion or stationarity around a deterministic trend. Their data show that the price of coffee displays both features. It is worth noticing that since 1952 -the beginning of our sample period- coffee prices in the world market have experienced dramatic changes in 1953, 1956, 1963, 1967, 1969, 1975, 1981 and 1986, all of them associated with frosts and/or droughts generally occurring in southern Brazil[9].

Table 3 presents aggregate and sectoral information about the cyclical behavior of the Colombian economy over the 1952-1992 period. Reported statistics provide information about some important second moments of basic macroeconomic variables: their volatilities and their contemporaneous correlations with output, with the relative price of coffee and with the relative price of nontradables. To compute statistics, data -except for employment shares, Solow residuals, and relative prices- have been expressed in per capita terms by using the employed population; then, all series -except employment shares, net exports to output ratio and relative prices- have been logged and all detrended using the Hodrick-Prescott filter

[9] For more details, see Bacha (1992) and the Economist Intelligence Unit (1991).

with smoothing parameter set at 500[10].

Interestingly, the Colombian economy shares the broad features that characterize aggregate fluctuations in developed economies in the postwar period (Backus and Kehoe, 1992): consumption is roughly as volatile as aggregate output, and investment is more volatile than output; in addition, consumption and investment are procyclical. The magnitude of output fluctuations in Colombia is not very different from the levels estimated for developed countries while investment is much more volatile: the standard deviation of the Hodrick-Prescott filtered logarithm of investment is 9.47% while it ranges from 2.01% to 5.50% in the sample of nine developed countries reported by Backus and Kehoe (1992).

An important difference is found in the behavior of the trade balance. Backus, Kehoe and Kydland (1994) report that the ratio of net exports to output is countercyclical in every of the 11 developed countries included in their sample while in Colombia net exports tend to behave procyclically, although the correlation is small.

From a sectoral perspective, the Colombian economy is assumed to be composed of three sectors: a coffee sector, which plays the role of the booming sector of the preceding section, a tradable sector and a nontradable sector. Sectoral categorization of GDP data by kind of activity is realized following freely Kravis, et. al. (1982). Value added from agriculture (excluding coffee output), manufacturing (excluding coffee threshing), and mining make up the tradable sector while the remaining (non-coffee related) activities constitute the nontradable-producing industry.

Table 3 shows that the volatility in aggregate GDP understates the action that exists at the sectoral level. For all sectors the volatility is larger than that of the aggregate: the coffee sector is highly volatile with a standard deviation of its production ranging from 9.64% to 9.76%; the volatilities in the tradable and nontradable sectors, on the other hand, are 3.03% and 2.79%, respectively.

In spite of the fact that the coffee sector plays an important role in the economy, it is worth noting that none of the coffee-related variables (coffee output, employment share, and the relative price of coffee) turned out to be highly procyclical. All of them are barely acyclical[11] which calls into question the standard

[10]When using annual data it is standard in the literature to set the smoothing parameter at 100 or 400. In this case it was set at 500 because the filtered GDP series conformed more appropriately with well-known cyclical episodes associated with coffee booms.

[11]It is well-known that the detrending of a stochastic process to extract its stationary business cycle component may introduce distortions into the correlation patterns across time series.

interpretation of the country's business cycle as a demand-driven phenomenon accounted for by fluctuations in the purchasing power (either of prices or of export earnings) of coffee growers and exporters[12].

Finally, the study of the cyclical behavior of the relative price of nontradables is of particular interest since it guides consumption and production allocation decisions across sectors. Table 3 shows that the correlation between the relative price of coffee and the relative prices of nontradables is nil; the relative price of nontradables is highly countercyclical and volatile, with a standard deviation of 3.97%, and that the trade balance ratio is negatively correlated with the price of nontradables, though the relationship is weak.

### 3.2. Calibration and Solution Method

The model is fully parameterized once values are assigned to the following set of parameters:

Growth rates: $\eta_H$, $\eta_L$
Preferences: $\tilde{\beta}$, $\omega$, $\sigma$, $\mu$
Technologies: $\alpha^B$, $\alpha^T$, $\alpha^N$, $\bar{A}^B$, $\bar{A}^T$, $\bar{A}^N$, $\bar{\phi}^B$, $\bar{\phi}^T$, $\bar{\phi}^N$, $\bar{\psi}^B$, $\bar{\psi}^T$, $\bar{\psi}^N$
Depreciation rate: $\delta$
Foreign borrowing cost: $r^*$, $\pi$, $\kappa$
Adjustment costs parameters: $\xi_L^B$, $\xi_L^T$, $\xi_L^N$
Forcing processes: $\mathbf{\Omega}$, $Var\left[\boldsymbol{\varepsilon}\right]$

The lack of empirical evidence on the possible values that most of these parameters may take on in the case of the Colombian economy prevents the use of the methodology commonly employed in the literature since Kydland and Prescott's (1982) work. Except for the adjustment cost parameters and the specification of the exogenous shock processes, the strategy followed here is to pick parameter

However, note that other commonly used filters, the linear (deterministic) trend and the first difference filters, yielded exactly the same qualitative results.

[12]See, for example, Kamas (1986), Ocampo (1989) and Cárdenas (1991). Very importantly, the standard interpretation is also at odds with a well-established nominal fact for Colombia. While this type of interpretation predicts that the price level is procyclical, it is countercyclical in the data. The correlation between price-level and output fluctuations is -0.43, -0.40 and -0.06 whether the price level is measured by the (log of the) GDP deflator, the consumer price index or by the producer price index, respectively. On the contrary, countercyclical prices are easily delivered by a model economy driven by supply-side shocks, like the one presented in this paper. The endeavor of explaining the nominal features of the business cycle is not pursued since the focus of the paper, in the same way as the RBC literature, is on the role of real factors.

values that are consistent with the model economy hitting certain quantitative targets observed in the Colombian economy. In other words, with the help of the first order conditions for the household maximization problem -conditions evaluated at the steady state- and some quantitative targets, it is possible to parameterize the model economy. The following calibration targets are imposed:

- Gross rates of growth of per capita output, $\eta_H$, and population, $\eta_L$. The former rate (1.0136) is calculated as the geometric rate of growth of per capita GDP between 1952 and 1992. GDP data are taken from the NIPA and expressed in per capita terms using employed population; the source being the Departamento Nacional de Planeación (DNP). The average annual rate of growth of the employed population is 3.24%.

- Capital-output ratio. It is set at 2.39 which corresponds to the average ratio for the 1952-1992 period. Capital stock figures are from the DNP.

- Investment-output ratio. The average value of this ratio in the period under study is 0.197. Investment is defined as total gross capital formation from the NIPA.

- Nontradable investment to output ratio. I set this ratio at 0.084. This is the average ratio in the 1970-92 period. The numerator includes the following items of the NIPA's gross fixed capital formation: residential buildings, nonresidential buildings, other constructions and land improvement and plantation and orchard development.

- Real rate of return. The real rate of return on capital is set at 0.10. This is the number calculated by Harberger (1973).

- Sectoral composition of the GDP. Based on the NIPA and following, in a loosely manner, Kravis et al. (1982) methodology. Sectoral GDP data are divided into three categories: nontradables, which comprises about half of output in the 1952-1992 period; tradables, which roughly represent 44% of output; and the rest, 6%, is taken up by the coffee or booming sector.

- Sectoral distribution of employment $\left(\bar{\psi}^B, \bar{\psi}^T, \bar{\psi}^N\right)$. Sectoral shares in employment were set at $\bar{\psi}^B = 0.065$, $\bar{\psi}^T = 0.385$ and $\bar{\psi}^N = 0.55$. These correspond to the average shares for the 1970-92 period. Data taken from the DNP, Errázuriz (1987) and Errázuriz, et al. (1994).

- (Intratemporal) Elasticity of substitution between tradables and nontradables, $\frac{1}{1+\mu}$. This elasticity is set at 0.678 adopting the estimates presented in Ogaki, Ostry and Reinhart (1996).

- Intertemporal elasticity of substitution, $\frac{1}{\sigma}$. This parameter is set at $\frac{1}{\sigma} =$ 0.588 which is the estimate obtained by Ogaki, Ostry and Reinhart (1996).

- Foreign debt-output ratio. Its average value is 0.25 for the 1970-1992 period. The source of foreign debt and exchange rates data is the Banco de la República, central bank of Colombia.

Furthermore, the expression for the cost of foreign loans (7) is parameterized as follows:

$$r_t = r^* + \exp\left(\pi\left[\frac{d_t}{\bar{d}}\right] + \kappa\right) \tag{15}$$

$\bar{d}$ represents the steady state level of debt and $\pi$ measures the debt elasticity of the risk premium component. To calibrate parameters in (15) it is required this additional information.

- World real interest rate, $r^*$. The real risk-free lending rate was set at 6.5% per year.

- Debt elasticity of the risk premium, $\pi$. There is no evidence on the magnitude of this elasticity: from Senhadji (1993) parameterization it is possible to derive a value of $\pi = 5.1$, which is used here as a first approximation.

In addition, the production function scale constant $\tilde{A}^B$ is normalized at $\tilde{A}^B =$ 1.

Table 4 summarizes the calibrated parameter values consistent with the described parameterizing strategy. Assigned parameter values imply that the tradable sector is the most capital-labor intensive, followed by the coffee and nontradable sectors, respectively.

Disturbances are assumed to follow first order Markov processes. The process for the relative price of coffee is estimated independently of sectoral productivity processes since prior testing showed evidence of no spillover effects from the coffee price to sectoral technology shocks and viceversa. Coffee price data correspond to producer prices published by the National Federation of Coffee Growers.

Using calibrated technology parameters, productivity shock processes were obtained by computing (the log of) sectoral Solow residuals[13] using annual data from 1952 to 1992 and then fitting a vector autoregressive process. Sectoral capital and employment series were taken from the DNP. The estimated autocorrelation matrix for the vector of shocks is (standard errors in parentheses):

$$\boldsymbol{\Omega} = \begin{bmatrix} \underset{(0.110)}{0.733} & 0 & 0 \\ 0 & \underset{(0.054)}{0.943} & 0 \\ 0 & 0 & \underset{(0.058)}{0.893} \end{bmatrix}$$

Spillover effects turned out to be unimportant at conventional significance levels, denoting the lack of transmission of technology shocks across industries. In consequence, as a first approximation, off-diagonal elements were set to zero. Obviously, the eigenvalues of $\boldsymbol{\Omega}$ are inside the unit circle and on that account the steady state of the system is stable for all initial conditions. The estimates show that all shocks are highly persistent, in particular those to sectoral productivities.

The diagonal elements of the variance-covariance matrix are calibrated so as to match the observed standard deviations of the Hodrick-Prescott filtered logarithms of the coffee price and Solow residuals in the tradable and nontradable sectors.

$$Var[\boldsymbol{\varepsilon}] = \begin{bmatrix} 0.02745 & 0 & 0 \\ 0 & 0.00122 & 0 \\ 0 & 0 & 0.00071 \end{bmatrix}$$

Shocks to the coffee price are substantially bigger than shocks to sectoral productivities. Due to the lack of evidence on the parameters that describe technological processes in the country, or in any other comparable developing countries, to guide our parameter choice, discretion is minimized by setting off-diagonal elements to zero.

Only adjustment cost parameters remain to be determined. $\xi_L^N$ is set to zero and $\xi_L^B$ and $\xi_L^T$ are pinned down by forcing the model economy to mimic the volatilities of employment in the coffee and tradable sectors, respectively.

The solve for the competitive equilibrium of the model economy, the highly nonlinear programing problem is transformed into a linear-quadratic one. The solution method consists of substituting all nonlinear constraints into the return

[13] In computing sectoral Solow residuals no correction is made to take account for adjustment costs.

function defined in section 2.2. and the resulting function is then approximated around the nonstochastic steady state by a quadratic function. Then, a variant of the method of successive approximations developed by Kydland and Prescott (1982) and Cooley and Hansen (1989) is used until the sequence of approximations to the value function obtained from the standard Bellman mapping converges to the optimal value function. The variant is directed at determining endogenously the relative price of nontradables. Once obtained the optimal value function, it is straightforward to compute (linear) decision rules and the pricing function that satisfy our recursive competitive equilibrium concept. The following feedback rules were calculated.

$$\begin{bmatrix} \ln\phi^T \\ \ln\phi^N \\ \ln\psi^T \\ \ln\psi^N \\ \ln i^* \\ \ln k' \\ \ln d' \\ \ln p^N \end{bmatrix} = \begin{bmatrix} -0.444 & -0.158 & -0.260 & 0.081 & 0.076 & 0.192 \\ -1.165 & 0.032 & 0.559 & -0.115 & -0.080 & -0.272 \\ -0.797 & -0.089 & -0.330 & 0.081 & 0.066 & 0.192 \\ -0.714 & 0.039 & 0.259 & -0.058 & -0.044 & -0.137 \\ -3.351 & 0.257 & 0.809 & -0.070 & -0.108 & -1.422 \\ 0.008 & 0.019 & 0.192 & 0.018 & 0.893 & -0.103 \\ -0.956 & -0.002 & 0.046 & -0.069 & -0.185 & 0.022 \\ -0.266 & 0.036 & 1.182 & -1.042 & 0.119 & -0.100 \end{bmatrix} \begin{bmatrix} 1 \\ \ln p^B \\ \ln\lambda^T \\ \ln\lambda^N \\ \ln k \\ \ln d \end{bmatrix}$$

### 3.3. Simulation Results

This section computes equilibrium time paths for the artificial model economy with the help of the preceding feedback rules and compares its cyclical behavior, as summarized by its second-moment implications, to that of postwar Colombia. Table 5 presents the simulation results. This table reports averages of standard deviations and contemporaneous correlations across 300 simulations, each being 244 periods long and where the first 203 periods are ultimately discarded so that each simulation has exactly the same length as the sample data (41 observations from 1952 to 1992). Simulated time series associated with each simulation are Hodrick-Prescott filtered before computing the corresponding second moments. Standard deviations of average statistics are in parentheses.

The ability of the model economy to mimic key qualitative and some quantitative aspects of aggregate and sectoral cyclical behavior of the Colombian economy is remarkable. Even if the model slightly overstates the volatility of aggregate output, the model matches quite well the volatility of consumption and the huge volatility of investment, as well as the procyclical nature of both aggregates. The net exports to output ratio is not as volatile as in actual data, but its not very common feature of a positive correlation with output fluctuations is accurately captured. The evidence seems to suggest that the country's fluctuations may be explained by a small set of real shocks, two technology shocks and one shock to the price of coffee.

At the sectoral level, the model is successful in predicting broad facts with regard to the dissimilar behavior over the business cycle of the three industries. The model correctly predicts that each of the three sectors is more volatile than aggregate output and that the coffee sector is by far the most volatile of all, followed by the tradable and the nontradable sectors, in that order. By the same token, the model correctly predicts the natural tendency of the booming sector output to behave countercyclically and the strong procyclical nature of the other two industries, with the nontradable one being more so. Another sectoral dimension along which the model's performance is successful is in matching the striking feature that there is a weak cyclical comovement between aggregate output and all coffee-related variables.

Turning to the behavior of the endogenous price of nontradables, table 5 shows that the model economy overestimates its volatility and fails to replicate its countercyclical nature. The model predicts a correlation of -0.14 between the trade balance ratio and the relative price of nontradables, so the model matches this feature quite well and, in addition, comes close, in a statistical sense, to mimic the correlation between this price and the relative price of coffee. Despite the generally good performance of the model economy, there are, however, numerous dimensions along which predictions miss targets. The model is unable to generate as much volatility of foreign debt as the actual data and the predicted structure of correlations involving relative prices is sometimes troublesome. Similarly, the model predicts that all coffee-related variables (relative price, output and employment share) are highly correlated (not all statistics reported in table 5) between each other while in the actual economy those correlations are much lower.

### 3.4. Sensitivity Analysis

A number of experiments were conducted to assess the sensitivity of previous findings to small perturbations ($\pm 5\%$, one parameter at a time)in calibrated parameter values. Recomputed second moments (not reported) showed that none of these experiments changed the qualitative behavior of the model economy. One additional experiment is worth mentioning. This assumes that the price of coffee is the only source of randomness.

A number of papers (Cárdenas, 1991; Ocampo, 1989) have characterized the country's business cycle as a phenomenon purely associated with the behavior of coffee in international markets; for this reason, it is interesting to obtain the model's predictions when the economy is driven solely by shocks to the price of the commodity. In this experiment technology shocks are made extremely tiny by multiplying realizations of the corresponding innovations by $10^{-6}$. How much of the variation in output can be accounted for by coffee price shocks? Simulation results (not reported) show that the resulting economy is far from being as volatile as the actual economy: the model renders a standard deviation of output equal to 0.25 percent, which represents only 14% of the volatility in actual GDP. The model considerably underestimates the volatilities of the tradable output (2.0 vs. 3.03), nontradable output (0.63 vs. 2.79), and the relative price of nontradables (0.60 vs. 3.97). The model also unsuccessfully predicts that the price of coffee is almost perfectly correlated with the price of nontradables (0.98), with the production of coffee (0.94) and nontradables (1.00), with aggregate investment (0.98) and with the trade balance ratio (0.89).These results suggest that the standard interpretation of the business cycle fails to give a faithful account of the story.

## 4. Coffee Booms and Resource Allocation

Booming sector and Dutch Disease economics predict intersectoral shifts and relative price changes in response to commodity booms. This literature has conjectured that a boom is accompanied with a decline in employment and production in the tradable sector and a real appreciation, understood as an increase in the relative price of nontradables in terms of tradables. This prediction is readily obtained from a simple static general equilibrium model with specific factors. The so-called "spending effect" and the "resource movement effect" (Corden and Neary, 1982; Neary, 1985) of a boom reinforce each other in their pressure towards appreciation and deindustrialization while the impact on the nontradable sector is ambiguous, depending on the relative strength of the involved income and substitution effects. This section deals with the positive question of whether the predictions of these simple, static theoretical models hold in actual experiences, but where more structure is imposed in order to assess the predictions of the model economy.

The experiment conducted in this section is to study dynamic responses of macroeconomic aggregates to a coffee bonanza -to a two-standard-deviation coffee price shock- while ignoring innovations in tradable and nontradable technologies.

Figure 1.a shows that the export windfall persists for a number of periods reflecting the high Markov coefficient (0.733) fitted for the stochastic process of the relative price of coffee. Households want to smooth consumption adjustment (figure 1.c) and for that reason they try to separate the sequence of consumption from output and export streams by increasing savings in the short run and dissaving in the future. Looking at the behavior of stocks (figure 1.j), the pro-saving effect is substantiated in a lower net foreign debt, which improves the country's creditworthiness and reduces the endogenous spread charged by foreign creditors. At the same time, a smaller interest rate makes more room for domestic capital accumulation which experiences a boom induced by the wealth effect, as well. In terms of flows, savings, which by definition equal to the trade balance plus investment, rise rapidly on impact. Net exports (figure 1.c) improve thanks to an increase of exports greater than imports of consumption and capital goods but soon deteriorate under the pressure of the demand for tradables and the appreciation of the real exchange rate (figure 1.g). On the other hand, investment also booms on impact. Figure 1.h illustrates that aggregate investment reflects the complementary relationship existing between nontradable and tradable investment goods.

Despite the limited participation in international capital markets for consumption smoothing purposes, households have met this goal through physical investment in either of the economy's sectors, in accordance with Tesar's (1995) result, which maintains that the mere existence of the domestic investment channel significantly reduces the potential gains from international risksharing. However, the ability to insure against country-specific shocks with the help of domestic portfolios does not prevent intersectoral movements of resources as would be the case of an unrestricted access to state-contingent securities. A transient coffee shock gives rise to a shift in the production structure towards the booming and nontradable sectors. Figures 1.b, 1.d, 1.e, and 1.f reveal the squeeze on tradables, as capital and labor are drawn away and employed in the above mentioned sectors, in the case of capital services, and hired in the nontradable sector mainly, in the case of labor input. This reallocation occurs in combination with an increase in the relative price of nontradables and an appreciation of the real exchange rate, calculated with the implicit aggregate output deflator (figure 1.g).

The model economy conforms exactly the pattern of resource allocation predicted by simple theoretical models. But here the symptoms of Dutch Disease arise as an equilibrium phenomenon, as the optimal response of agents facing an stochastic and intertemporal environment. The idea, popular among development economists, that deindustrialization and real appreciation are the appropriate responses only when the increase in commodity prices is permanent, needs to be considered equally valid and the right course of action when export booms are temporary.

## 5. Implications of Price Stabilization Policies

The response of allocations in a Dutch Disease manner has been considered by a voluminous literature as an unfortunate consequence of commodity booms even though this literature does not carefully spell out the origin, nature, and quantitative relevance of the transitional costs[14]. Related to this diagnosis has arisen the normative question about government intervention and corrective actions. Among the numerous policy recommendations, commodity price stabilization has been widely implemented. In the case of Colombia, advocates of the explanation of the business cycle as depending on the purchasing power of coffee growers have attributed important macroeconomic effects to domestic producer price intervention. This section assesses the role of price stabilization policies in stabilizing the business cycle and evaluates their welfare benefits for society.

Greenwood and Huffman (1991) have studied the role of stabilization policies in the context of a RBC model for the US economy by simulating an artificial stabilization scheme. Such a stabilization program automatically sets a subsidy paid on firms in an amount contingent on the realizations of the aggregate state, in order to eliminate recessions. This plan, albeit insightful, is hardly seen operating in reality. In contrast, the focus here is on the role of actual policies.

Since 1940 Colombia has operated a stabilization fund endowed with the power to buy the production and to set producer prices. The coffee price notion used in section 3 corresponds to the stabilized price effectively paid at producers' farm-gates or at established collection points. Now, a counterfactual experiment is conducted to explore the economy's likely behavior in absence of a stabilization policy. Under these circumstances, producers are remunerated at world prices and bear entirely the risk of price instability. To incorporate this regime into our model economy it suffices to replace the domestic price rule, estimated in section 3, by th[illegible]ess for the world price of coffee in terms of tradables, $(p_t^{*B})$. The following [illegible]1) process was fitted with yearly data from 1952 to 1992[15]:

[14]Many examples can be found in Neary and van Wijnbergen (1986) and more recently in Little, Cooper, Corden and Rajapatirana (1993).

[15]Cárdenas (1991) argues that only after 1958 price stabilization became an explicit objective of the National Coffee Fund. However, estimations based on the sample period 1958-1992 yield

$$\ln p_{t+1}^{*B} = 0.7607 \ln p_t^{*B} + \varepsilon_{t+1}^{*B} \qquad \text{with } \varepsilon_t^{*B} \sim NIID\,(0\ ,\ 0.07784) \qquad (16)$$

As before, the variance of innovations is calibrated to match the observed volatility of the Hodrick-Prescott filtered relative price of coffee. Coffee price data correspond to the New York quotation of Colombian Milds, published by the National Federation of Coffee Growers. In comparison to the process estimated in section 3, this one exhibits slightly more persistence and much more volatility. The stabilization effort is remarkable judging by the fact that only 35% of the variance of world prices is inherited by domestic prices. The unconditional mean of the coffee price is 1 under both regimes, so differences in simulation results reflect solely the effect of the stabilization policy, leaving aside the problem that domestic price setting is also used to extract resources from coffee growers.

Simulation results (not reported) show that in absence of a stabilization scheme the qualitative properties of the business fluctuations are preserved though the economy is obviously more volatile. Higher volatility is displayed by most macroeconomic variables with the exception of the relative price of nontradables. The volatility of aggregate output rises to 2.35% while that of consumption rises to 2.02%, which represents an increase of 23% in consumption volatility relative to the situation where the stabilization fund is put in action. Also, in absence of a stabilization policy, the correlations of most aggregates and output become weaker while those with the relative price of coffee tend to become stronger.

How different is the behavior of the economy under the two alternative regimes? One possible answer is to measure the welfare benefits of the stabilization policy. The welfare effect of coffee price stabilization is measured as the value of $\varpi$ that solves the following equation:

$$E_0 \left\{ \sum_{t=0}^{\infty} \tilde{\beta}^t \frac{1}{1-\sigma} c_t^{1-\sigma} \right\} = E_0 \left\{ \sum_{t=0}^{\infty} \tilde{\beta}^t \frac{1}{1-\sigma} \left[ (1+\varpi)\, c_t^* \right]^{1-\sigma} \right\} \qquad (17)$$

where the left-hand side expression is the household's expected lifetime utility when coffee prices are stabilized and the right-hand side is the expected lifetime utility under the regime of no stabilization. $\{c_t\}_{t=0}^{\infty}$ and $\{c_t^*\}_{t=0}^{\infty}$ are the associated aggregate consumption streams under each of the alternatives, respectively. $\varpi$ is interpreted as the increase in consumption required to make the household as well off under stabilization as under no stabilization. Assume that $c_t$ follows

the same results.

the following stationary process $c_t = \overline{c}e^{-\frac{1}{2}s^2}e^{v_t}$ where $v_t \sim NIID(0, s^2)$. $s^2$ can be interpreted the variance of the cyclical component of aggregate consumption. When the world price of coffee is paid to coffee growers, consumption follows a similar process: $c_t^* = \overline{c}e^{-\frac{1}{2}s^{*2}}e^{v_t^*}$ where $v_t^* \sim NIID(0, s^{*2})$ and $s^{*2}$ is interpreted as the variance of the cyclical component of aggregate consumption in the case of no stabilization. Plugging these expressions into (17) it is possible to obtain:

$$\varpi = \frac{1}{2}\sigma\left(s^{*2} - s^2\right) \tag{18}$$

The information required to make this welfare calculation is known. $\sigma = 1.70$ is taken from table 4, $s^2 = (0.0164)^2$ is from table 5 and $s^{*2} = (0.0202)^2$ is just mentioned in the preceding paragraphs. These figures imply that the welfare gains from coffee price stabilization are negligible ($\varpi = 0.00012$): households are willing to live without a coffee stabilization policy if they are compensated with a gift equivalent to 0.012% of their consumption expenditures. This result is consistent with other findings reported in the literature for developed countries (Lucas, 1987; Greenwood and Huffman, 1991), suggesting that the potential gains from business-cycle stabilization policies are very small.

## 6. Concluding Remarks

This paper proposes a dynamic, stochastic, multisector growth model which integrates the real business cycle literature and booming sector and Dutch Disease economics with the aim of explaining aggregate fluctuations, intersectoral allocation of resources and relative price changes in small open (developing) economies subject to terms of trade shocks. The descriptive power of the model is assessed with disaggregated Colombian data.

The results in the paper suggest that the model's predictions are largely consistent with aggregate and sectoral cyclical behavior of the economy, and rationalizes, as an efficient outcome, the symptoms of Dutch Disease. Despite the extensive theoretical work, little empirical evidence is found in the literature on an economy's response following a commodity boom in an intertemporal setting. The behavior of the economy in a Dutch Disease manner along the dynamic equilibrium path challenges the wisdom of the traditional view of this response as an undesirable development and forces its advocates to be more explicit about the costs of adjustment to transient commodity booms, the need and form of government intervention and very importantly, to test their empirical relevance.

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Table 6.1: **Relative Importance of the Coffee Sector in the Colombian Economy**

| | Share in Agricultural GDP | Share in Aggregate GDP | Share of Threshing Activities in GDP | Coffee Exports Share in Exports |
|---|---|---|---|---|
| 1951-60 | 21.5 | 9.6 | | 77.7 |
| 1961-70 | 23.0 | 6.8 | | 65.6 |
| 1971-80 | 14.1 | 3.1 | | 55.9 |
| 1981-90 | 13.2 | 2.5 | 2.8 | 36.7 |

Notes: Data in columns 1, 2 and 3 are taken from the NIPA. Coffee exports and total exports in column 4 are from the yearly report of the central of bank of Colombia (Banco de la Republica).

Table 6.2: **Commodity Price Facts: 1900-1987**

| | First Order Autocorrelation Coefficient | Persistence | Coefficient of Variation |
|---|---|---|---|
| bananas | 0.91 | 0.52 | 0.17 |
| cocoa | 0.83 | 0.24 | 0.54 |
| coffee | 0.80 | 0.11 | 0.45 |
| copper | 0.84 | 0.22 | 0.38 |
| cotton | 0.88 | 0.13 | 0.35 |
| jute | 0.71 | 0.09 | 0.33 |
| maize | 0.76 | 0.10 | 0.38 |
| palm oil | 0.73 | 0.05 | 0.48 |
| rice | 0.83 | 0.08 | 0.36 |
| sugar | 0.62 | 0.06 | 0.60 |
| tea | 0.78 | 0.28 | 0.26 |
| tin | 0.90 | 0.18 | 0.42 |
| wheat | 0.86 | 0.11 | 0.38 |

Notes: Price indexes correspond to the average prices for each year deflated by the US CPI. Persistence is the normalized spectral density at zero. It uses a Barlett window with a width of 40 years.

Source: Taken from Deaton and Laroque (1992).

Table 6.3: **Business Cycle Properties of the Colombian Economy (1952-1992)**

| | Standard Deviation (%) | Contemporaneous Correlation with: GDP | Relative Price of ...: Coffee | Nontradables |
|---|---|---|---|---|
| **Basic Aggregates** | | | | |
| GDP | 1.77 | 1.00 | 0.17 | -0.45 |
| Consumption | 1.67 | 0.78 | 0.03 | -0.19 |
| Investment | 9.47 | 0.34 | -0.09 | -0.07 |
| Net exports-output ratio | 2.22 | 0.16 | 0.62 | -0.14 |
| **Sectoral Output** | | | | |
| Coffee GDP(agric.) | 9.64 | -0.11 | -0.24 | -0.15 |
| ... including threshing | 9.76 | 0.11 | -0.38 | -0.29 |
| Tradable GDP | 3.03 | 0.45 | 0.50 | -0.13 |
| Nontradable GDP | 2.79 | 0.77 | -0.01 | -0.18 |
| **Employment Shares** | | | | |
| Coffee sector | 0.23 | -0.07 | 0.73 | -0.29 |
| Tradable sector | 0.72 | 0.37 | -0.25 | 0.04 |
| Nontradable sector | 0.66 | -0.38 | 0.02 | 0.06 |
| **Solow Residuals** | | | | |
| Tradable sector | 3.67 | 0.10 | 0.48 | -0.05 |
| Nontradable sector | 2.80 | 0.71 | -0.03 | -0.08 |
| **Relative Prices** | | | | |
| Coffee (to tradables) | 17.48 | 0.17 | 1.00 | -0.08 |
| Nontradables (to tradables) | 3.97 | -0.45 | -0.08 | 1.00 |
| **Assets** | | | | |
| Capital in Tradable sector | 3.45 | 0.46 | 0.08 | -0.37 |
| Capital in Nontradable sector | 2.53 | 0.43 | -0.05 | -0.33 |
| Foreign Debt | 18.34 | 0.26 | 0.03 | 0.04 |

Notes: Annual data from 1952-1992, with the exception of employment shares, consumption and foreign debt figures for which the sample period is 1970-1992.
Data, except employment shares, Solow residuals and relative prices, have been expressed in per capita terms by using the employed population. All variables, except employment shares, net exports ratio and "relative prices, have been logged; and all detrended using the Hodrick-Prescott filter with smoothing parameter set at 500.
Consumption only includes nondurables. The tradable sector includes non-coffee agriculture, manufacturing and mining; the remaining GDP, once excluded the coffee sector, represents nontradable output.
"

Table 6.4: **Calibrated Parameters**

| Parameters | | Values |
|---|---|---|
| Growth Rates | $\eta_H$ | 1.0136 |
| | $\eta_L$ | 1.0324 |
| Preferences | $\tilde{\beta}$ | 0.9513 |
| | $\omega$ | 1.1401 |
| | $\sigma$ | 1.7007 |
| | $\mu$ | 0.4749 |
| Technologies | $\alpha^B$ | 0.2682 |
| | $\alpha^T$ | 0.4090 |
| | $\alpha^N$ | 0.2570 |
| | $\bar{A}^B$ | 1 |
| | $\bar{A}^T$ | 0.8376 |
| | $\bar{A}^N$ | 1.0102 |
| | $\bar{\phi}^B$ | 0.0496 |
| | $\bar{\phi}^T$ | 0.5545 |
| | $\bar{\phi}^N$ | 0.3959 |
| | $\bar{\psi}^B$ | 0.0650 |
| | $\bar{\psi}^T$ | 0.3850 |
| | $\bar{\psi}^N$ | 0.5500 |
| Depreciation rate | $\delta$ | 0.0358 |
| Spread on foreign loans | $r^*$ | 0.0650 |
| | $\pi$ | 5.1000 |
| | $\kappa$ | -10.2607 |

Note: A period in the model is meant to represent one year.

Table 6.5: **Business Cycle Properties of the Baseline Model Economy**

| | Standard Deviation (%) | Contemporaneous Correlation with: GDP | Relative Price of ... : Coffee | Nontradables |
|---|---|---|---|---|
| **Basic Aggregates** | | | | |
| GDP | 2.25 (0.42) | 1 | -0.04 (0.23) | 0.27 (0.23) |
| Consumption | 1.64 (0.34) | 0.74 (0.13) | 0.14 (0.27) | -0.20 (0.25) |
| Investment | 8.57 (1.89) | 0.71 (0.11) | 0.45 (0.18) | 0.60 (0.14) |
| Net exports-output ratio | 0.07 (0.01) | 0.13 (0.15) | 0.18 (0.16) | -0.14 (0.14) |
| **Sectoral Output** | | | | |
| Coffee GDP(agric.) | 10.07 (3.27) | -0.16 (0.23) | 0.87 (0.07) | -0.06 (0.22) |
| Tradable GDP | 3.41 (0.56) | 0.69 (0.13) | -0.56 (0.18) | 0.54 (0.16) |
| Nontradable GDP | 2.98 (0.53) | 0.86 (0.07) | 0.20 (0.21) | -0.12 (0.24) |
| **Employment Shares** | | | | |
| Coffee sector | 0.23 (0.04) | -0.20 (0.24) | 0.94 (0.05) | -0.08 (0.23) |
| Tradable sector | 0.75 (0.12) | -0.34 (0.20) | -0.76 (0.09) | -0.64 (0.13) |
| Nontradable sector | 0.63 (0.11) | 0.47 (0.18) | 0.56 (0.15) | 0.79 (0.08) |
| **Solow Residuals** | | | | |
| Tradable sector | 3.69 (0.61) | 0.73 (0.12) | 0.01 (0.23) | 0.82 (0.08) |
| Nontradable sector | 2.81 (0.51) | 0.60 (0.16) | 0.00 (0.21) | -0.54 (0.17) |
| **Relative Prices** | | | | |
| Coffee (to tradables) | 17.47 (3.24) | -0.04 (0.23) | 1 | 0.11 (0.22) |
| Nontradables (to tradables) | 5.43 (1.20) | 0.27 (0.23) | 0.11 (0.22) | 1 |
| **Assets** | | | | |
| Capital in Tradable sector | 3.47 (0.56) | 0.02 (0.22) | -0.77 (0.10) | -0.30 (0.21) |
| Capital in Nontradable sector | 2.77 (0.66) | 0.63 (0.16) | 0.16 (0.23) | 0.72 (0.12) |
| Foreign Debt | 0.43 (0.10) | 0.01 (0.22) | 0.07 (0.22) | 0.42 (0.20) |

Notes: Reported statistics correspond to averages across 300 simulations of 41 observations each (41 periods is the length of the Colombian sample data). Simulated time series associated with each simulation are Hodrick-Prescott filtered (with smoothing parameter set at 500) before computing the corresponding moments. Standard deviations of average statistics are in parentheses.

Figure 6.1: Dynamic Responses to a Coffee Boom