Volume Title: Commodity Markets and Latin American Development -- A Modeling Approach

Volume Author/Editor: Walter C. Labys, M. Ishaq Nadiri, and Jose Nunez Del Arco, eds.

Volume Publisher: UMI

Volume ISBN: 0-88410-481-0

Volume URL: http://www.nber.org/books/laby80-1

Publication Date: 1980

Chapter Title: An Econometric Approach to Measuring the Impact of Primary Commodity Price Fluctuations on Economic Development: Coffee and Brazil

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Chapter URL: http://www.nber.org/chapters/c1753

Chapter pages in book: (p. 159 - 183)

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F. GERARD ADAMS and ROMUALDO A. ROLDAN

An Econometric Approach to Measuring the Impact of Primary Commodity Fluctuations on Economic Development: Coffee and Brazil

That fluctuations in primary commodity export market have significant impacts on the economies of the producing countries is intuitively clear and widely accepted. But there is little consensus on the direction and significance of these impacts on economic growth and development. Do fluctuations in primary commodity markets slow down or accelerate the economic growth? This is a difficult question to answer not only because of the conflicting empirical results, but also because of the multiplicity of ways in which the developing economies

Manuel Lasaga made contributions in a number of areas of this research. Computational and programming aspects were handled by Armando Gayoso.

are affected by their primary commodity export industries. In many countries these industries account for a disproportionate share of employment, wage income, export earnings, and government revenues. Fluctuations in the value of primary commodity production and export that may originate in the world market or in the developing producing economy itself have the potential for affecting the growth path through a number of channels. This chapter is concerned with delineating these channels of influence and with establishing quantitative dimensions for the effects. As an illustration, we focus on coffee production and marketing in relation to the economy of Brazil. The relationships between the coffee sector and the national economy are established econometrically and integrated into a macromodel of the Brazilian economy. Various alternative scenarios for coffee production and exports illustrate the nature of the impacts throughout the macroeconomy and the potential effects on Brazilian growth.

STRUCTURAL APPROACH TO COMMODITY MARKET—MACROECONOMY INTERACTIONS

A structural representation of the linkages between world commodity markets and the economy of the producing country is an essential ingredient to an analysis of the impact of commodity market fluctuations. The numerous empirical studies of the correlation between export market performance and economic growth reach equivocal conclusions.[1] Moreover, their ad hoc regression approach obscures the ways in which the economy of the producing country is affected. What, for example, are the forward and backward linkages; what are the impacts on fiscal and external balance; what is the effect on income distribution? Only an explicitly structural analysis, which disentangles the channels of impact and feedback in the economy, can provide a satisfying representation of the relevant phenomena.

Such an analysis must be quantitative in order to measure the various effects and to evaluate their combined impact. Econometric modeling is an ideal tool for this purpose. It is possible, within the limits of the available data, to represent the linkages explicitly and to establish their parameters.

A number of econometric model studies have recognized the impact of particular export-producing sectors in the context of developing country models. These studies include work by Lira in Chapter 8 on copper in Chile, Palma (1976) on petroleum in Venezuela, Jul (1976)

on Brazil and the coffee industry, and Acquah (1972) on Ghana. Only the last of these studies is explicitly focused on the impact of the world commodity market on growth of the producing economy. It showed that fluctuations in the world cocoa market generated internal fluctuations in the Ghanaian economy and that, if these fluctuations could be smoothed, the growth potential would be increased. In the other studies the linkage between the commodity market and the producing economy is quite limited, and only a limited range of interactions is considered. Thus, the models explore the relation between commodity production and employment and revenues, but they do not study the concept of the commodity-producing sector as an "engine of growth" for the other parts of the economy. They do not recognize the two-way relationship between the producing country and the world commodity market. Nor do they take into account the possibility for policy intervention by the producing country to smooth the impact of commodity market fluctuations or even to intervene in the operation of the market. These are important considerations, as we shall see.

An essential point in this work is to provide more than a broad aggregative link between the world commodity market and the country economy. Instead, in the context of country macromodels, the specific commodity-producing sector must be broken out and the linkages to the other sectors of the economy must be represented in the model structure. We will refer to this as the micro aspect. It is frequently the more difficult modeling task to accomplish. While the theory of sectoral behavior and linkage is not complex, the data requirements may be hard to meet. Needed are detailed statistics, preferably in time-series form at the sector level. Even when these are available, they require reconciliation with aggregate statistics. Often the timing will be different (crop years rather than calendar years), the units will be different (bags of coffee as compared to deflated value data), and trade statistics may not correspond (customs data as compared to quantity export data). In all cases, the commercial, technical, and government regulation aspects must be known and integrated into the model. It is essential, for example, to use realistic producer prices in the supply function rather than a world market price since the price realized by the producer after exchange (including domestic currency taxes, handling, and transport costs) may be very different from the world price. There are also special challenges to microsector modeling. These will be considered when we discuss the coffee sector and its linkages to the Brazilian macromodel below.

Another important consideration is the recognition that the relationships between the country model and the world commodity market are two-way linkages. If the exporting primary producing sector

plays only a small role in the world market, it is possible to carry on the analysis in what is sometimes called a "satellite" model. This means that the world commodity market influences the country economy, but there is no significant backward influence from what happens at the country level to the world commodity market. However, if the producing sector is relatively important in the world commodity economy there will be important feedbacks. Brazilian coffee has traditionally accounted for one-fourth to one-third of world coffee production. A frost in Brazil will affect the Brazilian harvest and it will influence the world price of coffee. Indeed, such an event may be beneficial to Brazil. The 1975–1976 frost sharply increased Brazilian earnings from coffee exports. The two-way interaction is likely to have important dynamic aspects—a price rise today will influence supply and price many years later.[2] It is essential to develop the capability for two-way interaction between the producing country model and the world commodity market. The phenomena examined in Chapter 8 have been studied on a one-way basis, assuming that the world market impacts on the domestic sector, but other analyses are likely to require a fully interactive model system.

The potential for domestic policy response is another complicated element. It would be easy to assume that there are no ways in which the producing country can respond to fluctuations in commodity markets. There are probably few cases where the producing country can influence the world commodity market with unilateral policy actions—the case of Brazil and coffee is said to be one exception. But commodity market fluctuations may not always be allowed to affect the domestic economy without policy intervention. Domestic policy may be used to offset fluctuations, for example, in export taxes, neutralization of foreign exchange earnings, and trade restrictions. The patterns of impact on the domestic economy of the producing country may be quite different from what would be apparent from simple simulations that disregard government intervention.

STRUCTURE OF THE BRAZILIAN ECONOMETRIC MODEL

As a central vehicle for the present study, we have used an econometric model of Brazil developed at Wharton EFA and the University of Pennsylvania. This model, originally developed as a doctoral dissertation, is currently the basis of the Wharton EFA Brazilian forecasting service. In this section, we describe the structure of the macromodel. In subsequent sections, we elaborate the coffee sector and the linkages from this sector to the macromodel.

This model recognizes the need to modify standard macromodel structures to incorporate particular constraints or features of a developing economy such as Brazil. This point is illustrated in particular by the formulation of the private investment function that, besides utilizing elements of the flexible accelerator theory, incorporates the availability of capital goods imports as an explanatory variable, recognizing the dependence of capital formation on machinery and technology not available internally but only through the international markets. The interest rate, usually introduced in the investment function to reflect the cost of capital, is not appropriate in a country such as Brazil where capital markets are not fully developed and interest rates have been subject to artificial ceilings. In those circumstances, investment funds are allocated through credit rationing, and a credit flow variable seems more appropriate than a measure of the cost of capital.

The functions for government and private consumption depend basically on a relevant measure of income—tax revenue for the government and disposable income for private consumption—while inventory accumulation depends on output variations and some measure of speculative behavior. Another component of the aggregate demand, government investment, is considered an exogenous variable in the model and a main channel through which fiscal policy is carried out. However, an important part of government-sponsored investment, that of quasi-public enterprises, which has become increasingly important in the last decade, is included in private investment.

In the foreign trade block of the model, the treatment of coffee exports deserves a special mention and will be discussed in the next section. Exports of manufactures are determined endogenously as a function of a world trade activity variable and of relative exporters' prices (after adjustment for exchange notes). Other commodity exports are determined exogenously. Imports have been divided into four separate categories: consumption goods, raw materials, capital goods, and fuels. Each one of them is endogenously determined as a function of a proper relative price variable, some domestic activity variable (such as industrial output for raw materials), and the capacity to import. The capacity to import is an important consideration in a country like Brazil where trade policy management is used to maximize the productive potential of imported goods. Payments to foreign factors, particularly in recent years the interest on the foreign debt, is another strategic variable that is explained endogenously.

The productive structure of the economy has been disaggregated into four sectors: the coffee sector (with which we will deal in the next section), the noncoffee agricultural sector, the industrial sector, and the services sector. Agricultural sector value added is specified in the

model basically as a supply function whose arguments are relative prices of farm products both in current and lagged terms (which incorporate the formation of price expectations) and government investment in order to take into account the improvement in infrastructure such items as roads, irrigation, and flood control. The latter play an important role in determining the output capacity of the agricultural sector in developing countries.

The specification of the behavioral equation for the industrial sector differs considerably. It is demand-driven, having as independent variables total consumption, total investment, exports of manufactures, and a measure of import substitution taking place in the economy. This type of formulation for the industrial sector value added assumes that productive capacity constraints are not effective. This is in accord with the persistent underutilization of industrial capacity found in Brazil as in other developing economies. The present formulation must be though of as a reduced form equation of an input-output system in which value added can be expressed as a transformation of input-output technical coefficients and the final demand vector. The services sector has a somewhat similar formulation, although here we recognize explicitly the intermediate character of the demand of many of the services, e.g., transport and commerce.

The employment and income distribution sector of the Brazilian macromodel distinguishes the urban wage bill (urban meaning the activity of the industrial and services sector), the nonwage urban income, and the total rural income. The urban wage rate entering the determination of the urban wage bill is assumed to be an exogenous variable largely to reflect the strong controls that government policy has exerted on this variable. In practice, the movement of this variable should reflect indexing for increases in consumer prices and labor productivity gains. But, as is well known, Brazilian indexing is "imperfect," and wage policy contains a large component of government decision about the appropriate distribution of the gains of economic progress.[3]

Urban employment is obtained through an equation for urban labor productivity whose arguments are the present and lagged values of the urban wage rate and the level of the industrial and services value added. Wage income is then computed from urban employment and the wage rate. Nonwage urban income is determined as a function of total urban sales and a markup factor of the industrial and services sector product prices over the urban wage rate. The rural income (obtained directly from the agricultural value added) is added to the urban income to obtain disposable income, after allowing for direct taxes and net government transfers.

The money supply is treated in the forecast model in a substantially exogenous way, making the change in the monetary base an exogenous monetary policy variable. For simulation purposes, endogenous treatment of the money supply becomes essential. We will discuss the way this has been done.

The model determines one central price to which other model prices and deflators are linked. The basic price considered is the gross domestic product price deflator. In its determination, monetary as well as cost-related variables are taken into account. Price increases are viewed as a function of increases of the money supply relative to output, of increases in the urban unit labor costs, and of the increases in indirect taxes and price of imported goods. Finally, the government sector of the model determines the main sources of government revenue: direct and indirect taxes.

LINKAGES OF THE COFFEE MARKET TO THE BRAZILIAN ECONOMY

The linkages between a commodity-producing sector and the macroeconomy are relatively straightforward. We will limit ourselves here to an enumeration of the main impacts, emphasizing the ones that seem more relevant for the case under study. The empirical estimates will be considered in detail in the next section.

The principal impacts of the coffee sector and the macroeconomy can be summarized as follows:

1. The production-income link. Variations in coffee output affect the gross domestic product of the economy, disposable income, and may affect export earnings[4] and government revenues.
2. Production-employment and input linkages. Additional coffee production impacts on labor requirements and on needs for inputs from other productive sectors of the economy.
3. Export value-balance of payments effect. The value of exports (resulting from changes in volume exported or of international price) have significant impact on the Brazilian balance of payments and, consequently, on the ability to import.
4. Export tax revenue. Taxes are imposed on coffee exports and their impact on the coffee fund revenues is of importance. The latter disburses part of its revenues to the government where they may affect public spending.
5. Monetary effects. Monetary effects are through the impact of coffee earnings on foreign exchange receipts and the net balance of the coffee fund operations.

6. Investment impacts. Coffee activity affects the level of aggregate investment. In view of the simultaneity of the model and its numerous complex dynamic feedback channels, the variations in the coffee market has broad effects on the economy. For Brazil, coffee now represents a relatively small sector, particularly compared to its dominance half a century ago. Consequently, we expect it to have only a relatively small impact on the aggregate economy. This situation would make it relatively easy for Brazilian policymakers to neutralize the impacts originating in the coffee sector.

MODELING THE COFFEE SECTOR AND ITS INTERACTIONS WITH THE MACROMODEL

In the following pages, we present the econometric estimates of the direct linkages between the coffee sector and the macroeconomy. The simultaneous nature of the model also insures the existence of widespread indirect linkages whose operation can be traced back to consider the general macromodel structure conceptually. These indirect linkages will be noted where appropriate, and their magnitudes can be measured in the dynamic multiplier analysis of the following section.

In the disaggregation of the coffee production activity, our model has used the specifications utilized by Derek Ford in the world coffee model.[5] Ford distinguishes five different productive zones according to geographical areas: Espiritu Santo, Minas Gerais, Parana, Sao Paulo, and other states. The yield and acreage that jointly determine production in each region are calculated endogenously. The general functional form for acreage in region i is as follows:

$$\text{Acreage}_i = f \text{ (ratio of producers coffee price index over agricultural price index other than coffee, dummy variables)}$$

Relative prices are introduced in these equations with lags of up to ten years in order to reflect both the formation of price expectations and the lag between the planting decision and the time trees become productive.

The yield equations conform to the following general form:

$$\text{Yield}_i = f \text{ (time trend, rainfall index, dummy variables)}$$

Brazilian statistics do not provide data on the intermediate inputs required by the coffee sector. This has precluded the introduction of such a variable as one of the elements determining the industrial sector value added. As for the services sector, however, coffee enters

explicitly in its determination, demanding marketing, transport, and other services both for the actual production process and for the activities required to carry out the exports of coffee. These two influences are registered in the following behavioral equation for the services sector by means of the introduction of the agricultural sector value added and the total volume of foreign trade, variables that include coffee production and coffee exports, respectively.

$$X3R = \underset{(7.44)}{0.89155}\ X2R + \underset{(14.88)}{0.74422}\ X1R + \underset{(4.00)}{0.0348}\ KR + \underset{(3.39)}{0.000523}\ (MCGIFR + EGR)$$

$$\bar{R}^2 = 1.00 \qquad DW = 1.97 \qquad SEE = 0.736$$

where

$X3R$	= services sector value added
$X2R$	= industrial sector value added
$X1R$	= total agricultural sector value added
KR	= capital goods
$MGCIFR$	= total imports
EGR	= total exports

Coffee-related employment is highly seasonal, and statistical information about it is unavailable. We have chosen to utilize a priori information that relates labor requirements per unit of output ($LACF$) to various yield levels (International Coffee Organization, 1972). Employment requirements (LCF) in the coffee sector are then calculated

$$LCF = LACF * PRCFTON$$

where

$PRCFTON$ = volume of coffee production

Wages in the coffee sector (WCF) correspond closely with minimum wages in the different production zones and are assumed to be exogenously determined by general government wage policy.

The wage bill ($WBILLCF$) for the coffee sector is then calculated

$$WBILLCF = WCF * LCF$$

and the wage share of the coffee sector value added ($WXCFC$) is then obtained from

$$W/XCFC = WBILLCF/XCFC$$

where

$XCFC$ = value added of the coffee sector, nominal terms

The next set of equations relate to domestic consumption of coffee and volume of exports. Domestic consumption ($CDCF$) is determined by relative coffee prices ($VACFR$) and disposable income ($YDFR$).

$$\begin{aligned} ln\ CDCF = {} & 2.19256 + 0.17713\ ln\ YDFR \\ & (3.22) \qquad (1.17) \\ & - 0.3077\ ln\ VACFR + 0.8739\ ln\ CDCF\ (-1) \\ & (2.01) \qquad\qquad (7.42) \end{aligned}$$

$$\bar{R}^2 = 0.79 \qquad DW = 2.46 \qquad SEE = 0.076$$

As for exports, different specifications are possible. First, one assumes that exports (ECF) are exogenous to the model, determined in world markets by broad demand and price considerations. This alternative implies that production in excess of exports and domestic consumption will find its way into inventory accumulation ($CHICF$):

$$CHICF = PRCFTON - ECF - CDCF$$

Second, one assumes that coffee exports are determined within the model by internal policy measures regarding private and officially held inventories. This approach would apply, for example, if a country simply marketed the excess of coffee production over domestic requirements. It would also apply in the situation, sometimes visualized in Brazil, where sales from or purchases by the official coffee stockpile are used to determine the volume of coffee exports. In this alternative we have

$$ECF = PRCFTON - CDCF - CHICF$$

The distinction between these two alternatives becomes a significant issue when the country model is linked to a world commodity model, a case in which they can be regarded as two opposite views of the determination of the volume of exports (there are, of course, a

number of intermediate alternatives). For our practical purposes—dealing here only within the framework of a single country model—we have chosen the first formulation in which we additionally distinguish private and officially held inventories. Making these inventories an exogenous policy-determined variable, the changes in private coffee inventories (*CHICFP*) become the variable calculated through the identity

$$CHICFP = PRCFTON - CDCF - ECF - CHICFG$$

where

$$CHICFG = \text{change in government coffee inventories}$$

The coffee export tax system in Brazil was centered around the existence of an overvalued exchange rate for exports in general. The difference between this rate and a higher one for imports was retained by monetary authorities, and much of it was used to finance the purchase of coffee for the stockpile. This policy had an adverse impact on the generation of alternative sources of foreign exchange. It was abandoned by 1961 when the exchange rate and coffee pricing policy were separated.

The present system establishes a tax per bag of coffee exports, called "contribution quota," whose proceeds are not for direct fiscal use. They are managed as an independent fund by monetary authorities. This coffee fund also handles resources derived from the sale or purchase of government-held stocks and a number of programs dealing with technology improvements in the coffee sector, financing programs of eradication of coffee trees or replantings, and so on.

The total coffee export taxes (*CFCCONT*) are calculated as a product of the coffee export tax rate (*CONTRRATEC*) times the volume of coffee exports.

$$CFCCONT = CONTRRATEC * ECF$$

The coffee export tax rate is assumed in the model to be an exogenous policy-determined variable. As it will be shown later, this variable also plays an important role in determining the level of coffee producers' prices and, hence, indirectly affects the level of output. Since these tax revenues are earmarked for the coffee fund, their impact on the rest of the economic system depends on the net balance of the coffee fund operations (*CFACCNET*). This balance results as the difference between export tax revenues, net stock sales, and other coffee fund outlays

$$CFACCNET = CFCCONT + SSTOCKNET - CFACCNETEXP$$

where

$SSTOCKNET$ = net sales of coffee stocks
$CFACCNETEXP$ = net expenses of the coffee fund

The net sales of coffee stocks are merely the changes in official coffee inventories valued in current terms. The net expenses of the coffee fund are calculated endogenously in the model as a function of the revenues accruing to the fund:

$$CFACCNETEXP = \underset{(0.03)}{12.15} + \underset{(4.23)}{0.9578}\ (CFCCONT + SSTOCKNET)$$

$$\bar{R}^2 = 0.53 \qquad DW = 1.07 \qquad SEE = 1006.8$$

The net balance of the coffee fund has a direct effect in the expansion of the monetary base and, hence, money supply. A surplus will have a contractionary effect on the monetary base and vice versa. The balance will also have a fiscal impact increasing indirect taxes, and through this channel, coffee export revenues can find their way into having an impact on government expenditures. The change in the monetary base ($FDMBC$) has been made endogenous to the model to allow the registration of the monetary impact of the coffee export tax system. It is treated as a "behavioralized" identity in which the arguments are the change in foreign reserves ($BOPC$), and the credit from monetary authorities to government ($FCRDGMAC$), to the private sector ($FCRDPMAC$), to the commercial banks ($FCRDCBMAC$), and the net balance of the coffee account ($CFACCNET$):

$$FDMBC = \underset{(1.54)}{393.43} + \underset{(8.72)}{0.490}\ BOPC$$
$$+ \underset{(6.46)}{0.886}\ FCRDGMAC + \underset{(12.20)}{0.655}\ FCRDPMAC$$
$$+ \underset{(3.76)}{2.565}\ FCRDCBMAC - \underset{(2.38)}{0.615}\ CFACCNET$$

$$\bar{R}^2 = 0.99 \qquad DW = 2.37 \qquad SEE = 548.6$$

In view of the relative magnitudes of the variables involved, although the causalty is well established, the elasticity of $FDMBC$ with respect to $CFACCNET$ is small, only -0.0035.

The positive fiscal impact of the coffee export taxes is registered on the indirect taxes (*TINDC*) by the following behavioral equation:

$$\begin{aligned} TINDC = {} & \underset{(1.10)}{0.00082599}\ CFACCNET + \underset{(0.76)}{0.0225023}\ X123C \\ & + \underset{(9.93)}{0.0898424}\ X123C(-1) + \underset{(4.05)}{0.109539}\ X123C(-2) \\ & + \underset{(3.30)}{0.07859}\ X123C(-3) \end{aligned}$$

$$\bar{R}^2 = 0.99 \qquad DW = 1.90 \qquad SEE = 1.924$$

The included Almon Lag is <2,4 *FAR*>

where

$X123C$ = value of total output

Here again, since the magnitude of *CFACCNET* is small compared with *TINDC*, the elasticity obtained is only of 0.0007.

The coffee price determination in the model is another area in which we find linkages to the rest of the economy as well as to the coffee world markets. There are two coffee-related prices whose determination is of interest within the country model: the Brazilian export price in dollars and the Brazilian producers' price. The first determines the dollar export revenues obtained by coffee. This price does not coincide with the prices quoted in international markets because of discounts or premiums that are added to the quoted price and because of lags between the sales contracts and actual delivery of the coffee. Consequently, the export price is determined as a function of the coffee price quoted in the New York market (*PNYBRCFD*):

$$\begin{aligned} ln\ VECFD = {} & \underset{(8.88)}{0.1997} + \underset{(23.48)}{0.9535}\ ln\ PNYBRCFD \\ \bar{R}^2 = 0.97 \qquad & DW = 1.73 \qquad SEE = 0.412 \end{aligned}$$

The determination of the producers' price takes into account a number of considerations. This price will be influenced by the Brazilian export price and the export tax rate. In particular, we have considered the producers' price to be a function of the difference between the export price—translated into cruzeiros (*VECFD/C*)—and the coffee export tax rate. The price equation also considers a stock adjustment element in which the relevant variable is the ratio of coffee sales

(exports plus domestic consumption) over total domestic stocks (*S/STOCKCF*), and production costs. The latter are represented, for lack of anything better, by the gross domestic price deflator (*PGDP*). The resulting equation is as follows:

$$\ln VACFC = \underset{(6.59)}{3.276} + \underset{(1.16)}{0.204} \ln (VECFD/C - CONTRRATEC) + \underset{(2.32)}{0.4340} \ln S/STOCKCF + \underset{(6.61)}{0.9813} \ln PGDP$$

$$\bar{R}^2 = 0.99 \qquad DW = 2.33 \qquad SEE = 0.136$$

Finally, we have tried to isolate the effect of the income originating in the coffee sector on private consumption. The real disposable income generated in the coffee sector would be the appropriate variable to include from a theoretical point of view. However, the chronic tendency to overproduction and the consequent accumulation of inventories not only in the hands of government agencies but more significantly in the hands of producers makes the income generated by current production activity inadequate to measure the purchasing power originated in the sector. When excess production occurs, part of the "income" generated immediately finds its counterpart as inventory accumulation. Inversely, when the market situation makes possible a depletion of inventories, the proceedings are added to the disposable income stream and are subject to the usual saving-consumption decision process. To register this particular condition, we have included as an argument in the consumption function the sales of coffee (*SCF*)

$$CPR = \underset{(1.28)}{-7.2986} + \underset{(89.70)}{0.8425}\, YDFR + \underset{(1.86)}{0.005978}\, SCF + \underset{(1.68)}{0.04227}\, PCP^*$$

$$\bar{R}^2 = 0.95 \qquad DW = 2.16 \qquad SEE = 2.164$$

where

$YDFR$ = real disposable income of the economy
PCP^* = percentage change private consumption implicit deflator

The consumption elasticity for *SCF* is 0.068.

One additional linkage does not need elaboration since it is already an integral part of the Brazilian macromodel. This is the impact of the coffee exports on export earnings and on the ability to import. This latter variable is explicitly introduced in the import equation for con-

sumption goods and capital equipment, finding through this last variable an impact on the rate of capital formation of the Brazilian economy.

A final adaptation of the Brazilian macromodel has been to make government investment—traditionally an exogenous, policy-determined magnitude—an endogenously determined variable, as a function of total government revenues, in order to register more fully the impact, however small, of coffee export taxation on the government expenditure patterns. The equation used for that effect is

$$IGR = \underset{(4.71)}{2.205} + \underset{(14.54)}{0.142315}\ TGREVR$$

$$\overline{R}^2 = 0.93 \qquad DW = 1.42 \qquad SEE = 0.878$$

where

$TGREVR$ = government revenues in real terms

DYNAMIC MULTIPLIER ANALYSIS

The simultaneous nature of the model insures the existence of widespread indirect or secondary linkages among different variables of the country model and its coffee sector. The full extent of the interaction between the coffee sector and the rest of the economy is captured by solving the model in a simultaneous fashion. The dynamic multiplier analysis establishes numerical magnitudes for these linkages.

The experiments that follow have been designed to illustrate different aspects of the interaction between the commodity-producing sector, the developing economy, and the world commodity markets. In each case, multipliers are calculated by comparing the results of a disturbed solution (multipliers solution) with a base solution.

The first experiment will deal with an increase of 10 percent in the volume of Brazilian coffee production for the production figures obtained in a control simulation for every year of the simulation period. This increase in production is translated into inventory accumulation, and exports therefore remain unchanged. The second assumes the same increase in coffee production, but this time the increase is fully translated into export expansion. In both cases, we are making simplifying assumptions about world coffee markets, in particular, that world coffee prices are not affected by these changes in Brazilian variables.

These two scenarios may not be entirely realistic from the perspec-

tive of the interaction of the Brazilian economy and the world commodity markets. However, maintaining coffee exports constant allows us to concentrate solely on the magnitude of domestic economy linkages between the commodity-producing sector and the rest of the economy. These are regarded as key variables in development economics, used to explain the existence of a dualistic economic structure in a particular developing economy. The second simulation example, allowing exports to grow by the amount of the production increase, makes it possible to examine the next issue, that is, whether the expansion of the commodity exports make possible higher rates of growth for the domestic economy above the rates that the purely domestic production effect implies.

The next two experiments focus on the impact of coffee market developments external to Brazil. For this purpose, we utilize the world coffee model, even though a full simultaneous linkage between the two models is not yet available.

A world coffee simulation in which a blight in coffee production in Africa is considered provides a simultaneous determination of the higher world price needed to equilibrate demand with lower supplies, and the corresponding increase in Brazilian exports, that helps to compensate the drop in African supplies to the world market. The third experiment consists in introducing exogenously in our Brazil model, the new international prices and the resulting coffee exports for Brazil.

A fourth simulation evaluates the impact of the coffee export tax as an economic policy mechanism that Brazil can operate to compensate or isolate the economy from fluctuations in the external markets. And finally, we consider the effects of an offsetting monetary policy.

Autonomous Increase in the Volume of Coffee Production

Table 7–1 presents the main multipliers of the simulation in which coffee production has been exogenously increased by 10 percent over the figures attained in a base solution for each year of the simulation period.[6] The main channels by which the impact is transmitted to the rest of the economy is the generation of demand for transport and commercial services from the tertiary sector. The increase in output generates consumer demand and higher investment that, in turn, also calls for additional increases in production. Increased economic activity also implies larger tax revenues that make possible an expansion of government outlays on consumption and investment.

The extent of the linkages between the Brazilian economy and its coffee sector can be summarized by the result that shows a 0.44 percent (yearly average in the simulation period) increase in the economy's

Table 7–1. Average Percentage Differences Between Disturbed and Base Solutions (10% Higher Coffee Production Over the Base Solution—Dynamic Simulation 1976–1987)

		% Difference
GDPR	Gross Domestic Product	0.44
PGDP	Deflator Gross Domestic Product	−0.05
CPR	Real Private Consumption	0.50
IPR	Real Gross Private Investment	0.45
CGR	Real Government Consumption	0.34
IGR	Real Government Investment	0.56
X2R	Industrial Output	0.36
X3R	Services Output	0.40
TDC	Direct Taxes	0.59
TINDC	Indirect Taxes	0.36
LCF	Coffee Sector Employment	3.69
VACFC	Coffee Producers Price	−7.47
MKCIFR	Capital Goods Imports, real terms	0.98
ECF	Coffee Export, real terms	0.0
S/STOCKCF	Ratio of Coffee Sales Over Stocks	15.85

Source: Based on the authors' computations.

gross domestic output when coffee production increases by 10 percent (also yearly average). Coffee production accounts roughly for 0.8 percent of the gross domestic product in the sample period. This implies that the direct impact of the increase in coffee output accounts for merely 0.08 percent of the 0.44 percent increase in the gross domestic product. The difference of these two magnitudes gives an idea of the indirect repercussions that the coffee activity has on the rest of the economy.

Other results in Table 7–1 suggest that the higher level of coffee production generates a slightly larger output response from the services sector than from the industrial sector. This fact is explained partly by the more direct technical linkages and input requirements existing between coffee production and the generation of services such as transport, storage, and commerce. Our results show 3.69 percent higher employment in the coffee sector at the higher production level. This estimate is, in fact, a lower bound, since we have assumed in this simulation that the increase in coffee production was generated solely by an increase in the yield per hectare instead of by a combination of higher yield and expanded acreage. Expanded acreage would produce greater labor requirements.

For the aggregate demand categories, Table 7–1 shows that the expansion in economic activity, as a consequence of the higher coffee output, has a large impact on government investment, followed by

private consumption, private investment, and government consumption.

The producers' coffee price appears to decrease by 5 percent in the simulation period. This result is due mainly to the excess supply situation domestically because higher production does not have a counterpart in greater exports. As a result, there is excessive accumulation of stocks. The ratio of total coffee sales over stocks increases by an average of 15.9 percent in this simulation.

Exogenous Increase in Coffee Production with Corresponding Expansion of Coffee Exports

The assumption that the increase in production goes completely into exports implies that coffee exports increase by 17 percent in the simulation period, both in volume and value. The average annual increase in coffee revenues is $528 million, which implies approximately a 2.2 percent increase in total annual export revenues.

As the foreign trade variables are allowed to operate in this solution, the main channels through which they have an impact on the domestic economy are the increased capacity to import and the increase in government revenues accruing through the coffee export taxes.

The increased capacity to import stimulates capital equipment purchases abroad that are seen to increase by 2.0 percent on average in this simulation. This makes possible a higher rate of capital formation in the economy with its corresponding multiplier effect on general economic activity. Other imports—raw materials, fuels, and consumption goods—also increase. Coffee export tax revenues increase by the same percentage as coffee exports, making possible larger expenditures in government current consumption and government investment. The expansion of these aggregate demand elements also has a positive multiplier effect on the level of general economic activity.

The combination of the increased coffee output and export of the additional output increases the impact of the coffee sector on the economic system. Gross domestic product is greater on an average of 0.81 percent in this simulation, as compared with only 0.44 percent obtained from the simulation that assumes coffee output expansion without an increase in exports.

The monetary effects of the increase in coffee export tax revenues through the coffee account are not significant. Although there is an increased collection of coffee export taxes because of the higher export volume, the higher domestic coffee prices make necessary larger disimbursements to finance the accumulation of official coffee stocks. This results in a larger deficit for the coffee account and, hence, in an

expansionary effect on the monetary base. Tax rates and export tax revenues can be increased to give a surplus in the coffee account that could have a contractionary effect on the monetary base. However, in the context of this simulation, the monetary impact of the coffee account is negligible. It is offset by other developments taking place simultaneously in the economy, in particular, by the increase in foreign reserves resulting from the more favorable trade situation.

The expansion of the money supply that results from higher foreign reserves in this experiment has an inflationary impact. Measured by the gross domestic product deflator in Table 7–2, it is shown to be an average of 0.77 percent higher than in the control solution. This situation can be contrasted with the first simulation in which the foreign trade situation remains unaltered for the control solution. As shown in Table 7–1, the prevailing effect on prices is then in a downward direction (−0.05 percent), resulting from an increase in productivity and thus creating lower cost pressures.

International Coffee Price Increase and Brazilian Export Expansion

A consistent set of assumptions about international coffee price movements and changes in Brazilian coffee exports can be obtained through a simulation of the world coffee model. The scenario of that simulation consisted in assuming a blight for African coffee production

Table 7–2. Average Percentage Differences Between Disturbed and Base Solutions (10% Higher Coffee Production over the Base Solution and Corresponding Higher Export Expansion—Dynamic Simulation 1976–1987)

		% Difference
GDPR	Gross Domestic Product	0.81
PGDP	Deflator Gross Domestic Product	0.77
CPR	Real Private Consumption	1.27
IPR	Real Gross Private Investment	0.74
CGR	Real Government Consumption	0.55
IGR	Real Government Investment	0.74
X2R	Industrial Output	0.72
X3R	Services Output	0.80
TDC	Direct Taxes	1.54
TINDC	Indirect Taxes	1.54
LCF	Coffee Sector Employment	4.68
VACFC	Coffee Producers Price	4.72
MKCIFR	Capital Goods Imports, real terms	2.01
ECF	Coffee Export, real terms	17.43
S/STOCKCF	Ratio of Coffee Sales Over Stocks	9.09

Source: Based on the authors' computations.

beginning in 1979 and continuing all through the rest of the simulation period. This scenario then results in higher world prices and expanded Brazilian exports. Based on Table 7–3, column (1), world coffee prices are on average 26.5 percent higher than in the control solution for the period 1979–1987. The volume of Brazilian coffee exports increases by 8 percent on the average, and 34.6 percent in revenues over the base solution. By the same token, total export revenues are higher by 4 percent over the base solution figures.

The higher international prices and the increase in export sales drive producer prices up by 10.7 percent over the base solution figures. Higher prices bring a decrease in domestic coffee consumption (−6.1 percent) and an expansion of coffee production by an average of 1.3 percent over the base solution numbers.

The increase of 0.31 percent on an average for the gross domestic product over the control solution, shown in Table 7–3, column (1), summarizes the net positive impact derived by Brazil from this particular set of events assumed to take place in the world markets.

Coffee Export Tax Policy

Brazil has applied a vast array of policy measures with varying degrees of success, in order to offset some of the destabilizing influences that world market conditions could introduce in the economy. Limitation of the coffee acreage through the eradication of coffee trees has been the most direct measure to limit the expansion of production. Domestic coffee consumption has been guaranteed at low prices by the establishment of export quotas and other mechanisms. The impact of

Table 7–3. Average Percentage Differences Between Disturbed and Base Solutions (Increase of International Coffee Prices and Export Expansion—Dynamic Simulation 1979–1987)

		Without Economic Policy Intervention (% Difference)	*With Export Tax Policy (% Difference)*
GDPR	Gross Domestic Product	0.31	0.23
PGDP	Deflator Gross Domestic Product	1.71	2.49
PNYBRCFD	New York Price Brazilian Coffee	26.46	26.46
VACFC	Coffee Producers Price, Brazil	10.74	8.77
PRCFTON	Coffee Output	1.30	0.99
LCF	Coffee Sector Employment	1.27	0.97
CDCF	Domestic Coffee Consumption	−6.11	−4.62
ECF	Coffee Exports, Volume	8.00	8.00
ECFD	Coffee Exports Dollar Terms	34.60	34.60
S/STOCKCF	Coffee Sales Over Stocks	9.05	10.42

Source: Based on the authors' computations.

these direct administrative measures can be introduced in a simulation exercise, but we have preferred to deal here with the manipulation of the coffee export tax rate, that is, a more market-oriented policy measure.

In the experiment analyzed previously, the higher level of the world coffee price ultimately leads to a supply response in Brazil. Since planting and maturing of coffee trees is involved, the new supply does not reach the market for many years, possibly at a time when additional coffee production is no longer needed. In the absence of some kind of market intervention by Brazilian authorities, this could accentuate the decline in world coffee prices or force the coffee fund to make large stockpile purchases. Consequently, it may be desirable to reduce incentives for coffee planting by offsetting the higher world coffee price through a higher coffee export tax. Distributional considerations may also suggest that Brazilian authorities might levy a higher export tax.

The simulation analyzed previously assumed a coffee export tax (cruzeiros per 60-kilo bag) to be constant for the period. We have assumed in the present simulation that besides the price increases in world markets and larger Brazilian coffee exports, there is an active tax policy aimed at keeping the tax at a fixed percentage (15 percent) of the coffee export price (translated in cruzeiros). In Table 7–3, column (2), we present the results of this simulation, which can be compared with the results of the previous simulation that appears in column (1). Domestic coffee prices increase less rapidly; consumption appears to decrease less; and the effect on production is to decrease the production expansion. The results show that export tax policy can be an important policy instrument. It can presumably be utilized to eliminate completely the coffee price impact in the internal economy and, therefore, keep production and domestic consumption at the same levels as in the base solution, or at some intermediate levels.

Coffee Export Tax Policy and Sterilization of Foreign Reserves

As we have mentioned previously, the increase in coffee exports will result in higher inflation as the more favorable trade situation is translated into accumulation of reserves. This experiment will assume that monetary authorities, besides raising the coffee export tax as in the last experiment, will offset the monetary expansion caused by the increase in reserves, thus sterilizing the additional reserves.

A lower rate of inflation stimulates additional aggregate demand, resulting on the average in a larger rate of growth when compared with the control solution than the rate attained by the simulations in

Table 7–4. Comparisons of Solutions with Various Policy Options and an Increase in International Coffee Prices and Export Expansion (Average Percentage Differences Between Disturbed and Base Solution Dynamic Simulation 1979–1987)

Experiment	*Gross Domestic Product (GDPR)* (% Difference)	*Deflator of Gross Domestic Product (PGDP)* (% Difference)
No Economic Policy Intervention	0.31	1.71
Coffee Export Tax Policy	0.23	2.49
Coffee Export Tax Policy plus Offsetting Monetary Policy	0.43	1.00

Source: Based on the authors' computations.

which the expansion of the money supply is left unchecked. A comparison between the last three solutions is made in Table 7–4.

CONCLUSIONS

The computations described in this chapter indicate that fluctuations in the coffee market have a magnified impact on the macrostatistics of the Brazilian economy. Increases in coffee output or in the value of coffee exports translate into a higher real product with an effect on other parts of the economy—on income, government revenues, secondary and tertiary sector activity, investment, foreign exchange earnings, imports, and so on. Aggregate growth is increased by more than the contribution of greater coffee output.

In order to establish the nature and magnitude of these effects, we have modeled the coffee sector and have traced through the linkages from this sector to other parts of the Brazilian economy. These computations suggest that the principal linkages operate through:

1. The effect of coffee production on requirements for tertiary sector output.
2. The impact of earnings from coffee production on consumer demand.
3. The impact of coffee export tax payments on the government revenues and subsequently on government spending for consumption and investment.
4. The effect of increased foreign exchange earnings (in cases where the value of coffee exports increases) on imports and subsequently on capital formation and on higher prices.

The predominant effects in the present version of the model system are through the demand linkages although there is some supply impact from capital formation. The predominance of the demand effect is not altogether surprising. The Brazilian macromodel does not contain a capacity constraint in the industrial and tertiary sector output functions, reflecting the significant underutilization that occurs in Brazil as in many other developing economies. The simulations thus assume either that a capacity constraint, as in the industrial and service sectors, does not operate or that a sufficient supply side response occurs but is not modeled explicitly.

The results described above suggest a number of priorities of the next stage of the Coffee-Brazil project. Concerning model specification, we are reasonably content with the specifications obtained. In general, they seem to describe the structural aspects of the Brazilian coffee sector and its linkages to the rest of the economy. Some relatively small model modifications may improve the system, though it is unlikely that they will produce very different simulation results. These changes involve:

1. Further elaboration of the supply side aspects of the model. As we have indicated, the supply side constraints have not been operational in Brazilian industry because of underutilization although it would be useful for simulation purposes to make additional efforts to model these phenomena.
2. Endogenization of the wage rate. The latter is normally a policy variable, but for simulation purposes it will be useful to explain wages endogenously in terms of growth of productivity and the consumer price level.
3. Attempts to link income distribution in some broad measures. Needless to say, this poses some serious problems of data development.

In addition, we expect shortly to establish the computer system to permit fully linked simultaneous simulation of the coffee model and the Brazil model. This is basically a programming task, since the two systems already exist in compatible form. It is an important step because it will make possible simulations of production and policy changes in Brazil that take into account their impact on the world market. It will also facilitate simulations of changes in world market conditions and their impact on the Brazilian economy. Such a system is necessary for stabilization scenarios. The simultaneous system will also be useful in tracing out the dynamics of the interaction of the world economy and the Brazilian coffee market. This is particularly interesting because of the long lags between changes in coffee prices and the response of coffee production.

As soon as possible, the linked system will also contain models for other coffee producers, Central America and the Ivory Coast. Finally, we expect to focus, using the above system, on a variety of policy simulations. These simulations fall into two classes:

1. Simulations of world coffee market policy and its impact on the developing economy. In particular, the policy questions to be investigated involve various stabilization alternatives and their impact on the growth path of the producing countries.
2. Simulation of alternative policy responses by the producing country. In this connection, we may envision policies intended to affect the world market—for example, the purchases or sales by the Brazilian Coffee Fund Stockpile. In addition, we may consider the impact of offsetting macropolicies such as neutralization of foreign exchange earnings. Finally, as in the discussion above, we may consider policies that have direct distributional impact such as the coffee export tax.

NOTES

1. See the discussion by Lord in Chapter 9.
2. For a discussion on such dynamics, see Adams and Behrman (1978) and Ford (1977).
3. However, for simulation purposes an endogenous wage rate equation is being formulated.
4. We will consider alternative cases where variations in coffee output are offset by inventory changes and where they affect Brazilian coffee exports.
5. This is important from the point of view of consistency once we run the coffee and the Brazil model simultaneously.
6. The base solution is one in which the econometric model projects a reasonably steady growth path for the Brazilian economy for the period 1976–1987. The alternative simulations are, of course, run for the same period.

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