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## A Framework for Evaluating the Impact of Pricing Policies for Cocoa and Coffee in Côte d'Ivoire

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*This article presents an approach to evaluating pricing policies for perennial crops. A flexible computational model is developed, which incorporates important features of perennial crop production that are not captured by other (usually static) frameworks. This framework produces sensible and plausible scenarios for pricing cocoa and coffee in Côte d'Ivoire, as well as descriptions of revenue tradeoffs. Key issues arise from considering major changes in the rules used to set domestic producer prices. An unambiguously best policy is not determined, but several policies improve substantially on the present situation. Most of these alternatives indicate the desirability of lowering the tax on coffee relative to cocoa.*

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Many low-income developing countries depend heavily on tree crops, or perennials, for export and tax revenue, so that the health of the perennial sector and the overall state of the economy are closely connected. The most important perennials are coffee and cocoa, but rubber, tea, and oil palm are sometimes also significant. It is expected that most of these countries will continue to depend heavily on these crops for export tax revenue, and many will retain policies fixing both producer prices and exchange rates. Thus the choice of the appropriate tax rate and producer price, given government objectives, will remain of key importance. The research reported here evaluates alternative tax and price policies quantitatively, with specific reference to cocoa and coffee production in Côte d'Ivoire. Côte d'Ivoire was chosen for this analysis because it currently faces serious economic problems, whose resolution is closely entwined with its pricing policies for cocoa and coffee.

The objective of the study was to develop an operational approach for quantitatively evaluating pricing and tax policies for perennials over the short and

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medium run (7 to 15 years). An "operational" approach is one that is computationally implementable and that quantifies the implications for production, exports, and tax revenues of different price rules under alternative assumptions about related variables such as the exchange rate, age-yield profiles, new plantings, supply elasticities, and minimum feasible producer prices. Because of the dynamics of perennial supply response, projections should cover a time horizon of 10 years or more. The revenue implications of a policy change are not fully revealed over a shorter period, so that focusing on short-term revenue flows will lead to myopic policies. Long-term projections, however, can be made only conditionally on projections of world demand and supply for the crop.

The framework developed here is an alternative to other approaches, including both ad hoc and partial evaluations concerned largely with the short-term impact and other model-based equilibrium approaches that do not project the time paths of important variables. This study is limited in scope; it does not consider dynamic price uncertainty in the face of credit constraints and attempts by governments to stabilize prices to overcome such problems, nor does it consider the policy credibility and reputation of the policymakers.

Section I provides a brief literature review of several alternative frameworks. Section II contains the essential institutional and factual background concerning pricing policies for cocoa and coffee in Côte d'Ivoire. Section III provides an overview of the structure of the model and discusses the measurement of the impact of policy changes on welfare. Section IV summarizes simulations of the model and gives the results of model sensitivity exercises. Section V discusses the choice between alternative policies, and Section VI concludes.

## I. A REVIEW OF THE LITERATURE

Alternative pricing policies for perennial crops are evaluated in two stages. First, theoretical and computing frameworks must be developed to generate time paths for the relevant critical variables. Second, a criterion for choosing among alternative policies that differ in their impact on various sectors of the economy must be established. The second aspect is conceptually more difficult because it involves many of the classic normative issues of applied welfare analysis.

The first stage requires a careful integration of a priori assumptions and factual information. Broadly speaking, there are three approaches to developing an analytical framework: the static, general-equilibrium approach related to the optimal tax literature (Stern 1987); the static, partial-equilibrium approach rooted in the optimal tariff literature (Repetto 1972; Imran and Duncan 1988); and the dynamic, multimarket, partial-equilibrium approach of this study. Each of these approaches requires different types of inputs and provides different kinds of output.

The analytical framework used by Repetto and by Imran and Duncan is fairly straightforward, but it necessitates some strong assumptions, including that of a constant supply elasticity. This approach does not shed light on issues of income

distribution between cocoa and coffee producers. It is complemented by other analyses, such as that of Deaton and Benjamin (1988), who examine the desirability of adjusting the relative producer price of coffee and cocoa in Côte d'Ivoire by bringing them both in line with world prices. On average, the administered coffee price has been around 36 percent of the world price, and the cocoa price has been about 47 percent of the world price. Deaton and Benjamin consider the outcome of this price adjustment under several different assumptions about the degree of linkage between world and domestic producer prices and the degree of risk sharing between producers and the government. But they (correctly) remain neutral about the likely consequences in the absence of greater knowledge of producer response. They emphasize, as others have before them (see Newbery 1987), that supply response is crucial to the issue; however, their own framework and method is of a partial-equilibrium type.

In discussing the same set of issues for Côte d'Ivoire, Akiyama (1988) takes the approach that is closest to that of this study. The new-planting and replanting responses of cocoa and coffee producers under alternative tax rules are specified in detail, and potential production is calculated using the vintage matrix approach previously used in studies of perennials by Akiyama and Bowers (1984) and Akiyama and Trivedi (1987a, 1987b). The world price of the crop is projected using reduced-form versions of global commodity models, and the tax revenue consistent with both period-by-period price equilibration in the world market and the exchange rate policy being pursued is calculated. The model is simulated for each year of the relevant time horizon to generate the long-term consequences of a policy for producers' revenue, government revenue, and export revenue.

This computational framework, however, does not allow for the comparison of alternative policies or the evaluation of possible tradeoffs between producers' incomes and government tax revenue with different policies. Because Akiyama's approach does not use an algorithm to make relevant comparisons and does not calculate producer welfare, it needs to be extended and refined. Furthermore a better computational framework is needed to permit greater speed and flexibility in evaluating policy. Flexibility is especially important because developing-country data are frequently fragmentary and of poor quality so that they cannot support precise estimation of key structural parameters. Consequently, sensitivity and fragility analyses are essential.

## II. COCOA AND COFFEE PRODUCTION IN CÔTE D'IVOIRE

Cocoa and coffee together have accounted for about 50 percent of total exports, 40 percent of agricultural gross national product, and more than one-half of the employment of Ivoirien farmers in recent years. Although the contribution of cocoa and coffee to the Ivoirien economy was quite significant during the 1970s, the weakening and subsequent collapse of world prices of the two crops after 1985 and the sharp appreciation of the CFA franc relative to the U.S.

dollar after 1985 dramatically changed the picture. Government revenues declined sharply, and, because of aggressive exchange rate policies pursued by Côte d'Ivoire's competitors, the country's international competitiveness weakened.

These changes have motivated a reexamination of current policies. The main alternative policy under consideration would reduce administered producer prices and relative producer prices of the two commodities so that prices would more accurately reflect marginal export revenues. The future world price outlook for coffee is brighter than for cocoa; therefore, such a price restructuring implies significant costs in terms of foregone producer and tax revenues.

The Caisse de Stabilization et de Soutien des Prix des Produits Agricoles (CSSPPA) controls the marketing of cocoa and coffee primarily through two policy instruments. First, at the beginning of each crop year it specifies the payment system (*bareme*), which details producer prices and domestic and external marketing costs along the entire marketing chain. Second, it uses an export price reference system to stabilize the price received by exporters. Exporters receive the world market price, but, if the world price exceeds the reference price, the exporter pays the CSSPPA the difference between the two. If the world price is lower than the reference price, the exporter is paid the difference between the two by the CSSPPA, which draws from its financial reserves.

The "Caisse" system has significant limitations. It is clear that the system will perform poorly when the CFA franc appreciates or when the world price declines for an extended period, because these circumstances necessitate prolonged revenue outflows from the CSSPPA. The resulting liquidity problems may force delays or suspension of payments to producers, and eventually the producer price may have to be reduced. The CSSPPA has run large deficits since the mid-1980s, and, for the 1989/90 crop year, producer prices for cocoa were reduced by 50 percent and for coffee by 40 to 50 percent.

Administered producer prices can create a domestic relative price structure that is out of alignment with domestic production costs if changes in these costs are not taken into account. This has occurred in Côte d'Ivoire; cocoa was priced too high relative to coffee, thus leading to large increases in cocoa production. Recent economic analyses of pricing policies have typically concluded that producer prices need to be realigned to eliminate the difference in favor of cocoa. Any such change will affect the distribution of income, so that an informed discussion of the merits of altering current relative prices must consider detailed information on the current income distribution among Ivoirien cocoa and coffee producers as well as the links between changes in relative prices and the distribution of income.

Deaton and Benjamin (1988) have examined the links between prices and farmers' incomes by using data from the 1985 Living Standards Measurement Study. Their analysis emphasizes several facts that have an important bearing on the interpretation and use of the simulation results presented below. First, cocoa and coffee farmers are not mutually exclusive groups. In fact coffee farmers

derive more net income from cocoa than from coffee. Second, cocoa farmers have average household incomes close to the national average, whereas those of coffee farmers are 13 percent below the average. Third, agricultural income constitutes about 65 percent of total income for these farmers, and cocoa and coffee account for about a third of agricultural income on average. Home-produced food is the most important source of income, accounting for 44 percent of net agricultural income.

### III. STRUCTURE OF THE MODEL

The Ivoirien cocoa and coffee sectors are represented within the model by a detailed specification of output supply. Because both crops are cultivated in the same area, it is reasonable to postulate considerable output substitution between cocoa and coffee by farmers. Furthermore it is reasonable to postulate that substitution between annual food crops and perennials may be especially important. Because of the lack of data, however, this latter possibility has been ignored here (see Weaver 1989). Cocoa and coffee are viewed as substitutes from the producer's viewpoint, and the interaction between the two sectors is embedded in parametrically specified short-run supply equations and new-planting equations. It is assumed that the entire output of these sectors is exported. The interaction of the two sectors with the government is represented by a set of equations linking export prices with producer prices and export revenues with production and world prices as well as equations detailing the government's revenue and cost structure. The model does not include the interaction between the cocoa, coffee, and government sectors, on the one hand, and the rest of the Ivoirien economy, on the other. In other words the model can evaluate only the impact of macro policies, such as exchange rate adjustment, from a sectoral viewpoint.

The model used is nonlinear but essentially recursive and hence easy to solve. In broad terms the calculations proceed as follows. First, a regime for cocoa and coffee producer prices is specified together with assumptions about the exchange rate, age-yield profiles for both crops, and the time paths of Ivoirien production and world prices in the absence of production shocks in Côte d'Ivoire. An example of a policy regime is a cut of 30 percent in the producer prices of cocoa and coffee from base levels. It is also assumed that producers believe the announced price policy to be permanent and nonreactive and that they base their expectations and new-planting and production plans on the announced policy. That is, there are no issues of government credibility in the discussion.

Second, given producer prices, the model determines new plantings and the potential and actual production of cocoa and coffee. Third, given the cocoa and coffee supply curves, the production and profits of producers can be immediately obtained because, under the export price reference system, they do not depend upon yet-to-be-determined world prices. Next, together with world supply and demand, the policy-induced deviation of Ivoirien production from its

base production determines the deviation of the world price from its base. For a specified exchange rate this then determines the Ivoirien export revenue and, given the cost structure for marketing and transportation, the size of government deficit or surplus in any given year. One simulation consists of solving the model, year by year, for a time horizon of up to 14 years (1987–2000) under specified initial conditions and a selected policy rule. To compare alternative policies, the results are aggregated for the entire horizon; to study the impact of any one policy, the results are presented as a time series. All ingredients for a welfare evaluation are available at this stage.

The model is calibrated using historical data and parameter estimates that are subject to considerable uncertainty because of the limited time series data used in their estimation. It should be emphasized that data constraints preclude the use of a fully econometric model. A not-inaccurate description of the model would be that it is a numerical model that has been calibrated using econometric evidence and a priori restrictions. Most of the important restrictions have been subjected to sensitivity analysis, which will be noted where appropriate.

### *The Supply Sector*

The heart of the model is the specification of cocoa and coffee supply. For each crop, the block of supply equations is based on the vintage capital approach, which uses data on new plantings, the age-yield profile, and death rates of trees by age group. A distinction is drawn between high-yielding and traditional varieties. For the assumptions made in constructing vintage matrices, see Akiyama (1988).

A simple sketch of the supply sector is as follows. Let  $Q^p(t)$  denote aggregate potential or expected average output and  $Q(t)$  denote actual output, at time  $t$ , where  $Q^p(t) \geq Q(t)$ . Actual output is related to potential output via the short-run output supply equation

$$(1) \quad Q(t) = g_1[Q^p(t)]g_2[p^d(t-i)], \quad i = 0 \dots m$$

where  $g_1$  is a measure of the percentage of potential production that is actually produced in any year, and the second term  $g_2 p^d(t-i)$ , represents the current and lagged effects of own and substitute output prices, denoted by the vector  $p^d$ . Aggregate potential output is the sum of potential output from each of the different surviving age classes, assuming that the productivities of these cohorts remain at their historic level, that is,

$$(2) \quad Q^p(t) = \sum_v Q^p(t, v)$$

where  $v$  denotes the vintage or age class.

Given an age-yield profile,  $\delta(t, v)$ ,  $Q^p(t, v)$  depends upon the size of the surviving stock of vintage  $v$  trees,  $K(t, v)$ , through a production function relation

$$(3) \quad Q^p(t, v) = \delta(t, v) K(t, v)$$

where  $K(t, v)$  is given by the accumulation equations

$$(4) \quad K(t, v) = K(t - 1, v) - R(t, v)$$

$$(5) \quad K(t, t) = N(t)$$

where  $R(t, v)$  denotes removals, death, and losses from the stock exiting at  $t - 1$  and  $N(t)$  denotes new plantings. New planting of cocoa is a function of real producer cocoa and coffee prices, and the equation for new plantings of coffee is specified analogously:

$$(6) \quad N(t) = N[p^d(t - 1)]$$

where  $[p^d(t - 1)]$  is a proxy for the expected future real producer prices. (It would be desirable to restrict the form of the new-planting equation, for example, to impose constant returns to scale, but this would require data on planted areas by age class (Trivedi 1988), which are unavailable for Côte d'Ivoire.) The new-plantings specification implies static expectations, which is a strong assumption, but which has considerable appeal in the context of a study that explores the revenue and cost implications of particular fixed producer price regimes.

#### *Calibration of the Model*

Potential production in the model is determined by the stock and age composition of the trees. Figures for these do change, of course, as new planting occurs. Attempts at estimating these new planting equations using time series were summarized in Akiyama (1988). Although econometrically reliable estimates are difficult to obtain, there is evidence that aggregate new plantings respond to changes in real prices of the two commodities. Hence the equations used are based on the assumption that the two crops compete and that new planting in each sector responds to the relative price ratio. The best estimates for the own-price elasticity of new plantings of coffee are around 4.0 and for the cross-price elasticity are around  $-1.5$ . For cocoa the corresponding elasticities are 1.9 and  $-0.6$ , respectively.

On a priori grounds, however, the model uses variable, rather than fixed, new-planting elasticities. The rationale for this has been given elsewhere (Trivedi 1988), the essential idea being that the new-planting response to relative prices will be nonlinear in real prices. At a low relative price the elasticity will be small, and at a high relative price it will be high. The nonlinearity is calibrated to produce own- and cross-price elasticities similar to those given above at the real prices prevailing in 1986. When simulations incorporate a period of comparatively low real prices, however, planting elasticities are significantly reduced. Although it would be desirable to specify new-planting elasticities that decline as the supply of suitable land declines and as additional expansion uses agronomically inferior land, most of the policy options explored involve expan-

sion in only one of the two sectors, usually coffee. Given the assumption that the two crops compete, it seems consistent to assume that the decline in one sector releases land usable in the other so that expansion is not limited or halted by the exhaustion of suitable land.

The supply equations used for cocoa and coffee contain a multiplicative factor that depends upon feasible or potential production. The construction of vintage capital matrixes allows one to estimate the feasible production from each age cohort using a fixed age-yield profile. Aggregating these provides a measure of potential (expected average) production in any period. Assuming that potential and actual production differ by a scale factor, this scale factor may be obtained by regression of actual on potential production. The scale factors thus determined for cocoa and coffee are 1.02 and 0.99, respectively.

Time series regressions yield imprecise estimates of (Marshallian) own- and cross-price supply elasticities. Akiyama (1988) used point estimates of 0.22 for own-price elasticities of both coffee and cocoa, 0.08 for cocoa-coffee cross-price elasticity, and 0.04 for coffee-cocoa cross-price elasticity, these being close to values obtained using a short time series. Although the assumption of constant output supply elasticities is restrictive, the data needed for estimating a more flexible elasticity specification are not available. Instead an a priori belief is imposed that the supply response decreases as the actual price approaches the "shut-down" price, below which no production will take place. The 1982/83 average cost of production for coffee and cocoa for different plantation types (de Graaff 1986, table 9.8) is used as the minimum price below which production will not occur. The elasticities are specified as functions of prices such that at the real prices prevailing in 1986 the implied elasticities are close to the time series estimates given above, but at higher or lower prices their values change. These functions are given in table 1. The actual numerical values in those functions with such properties were obtained by a grid search of elasticities around the sample mean value estimated using a time series regression.

In the context of a static market-clearing model of demand and supply, the (absolute value of the) demand elasticity for Ivoirien production, denoted by  $E^d$ , is given by

$$(7) \quad E^d = [E^{w,d} + (1 - s)E^{w,s}]/s$$

where  $E^{w,d}$  and  $E^{w,s}$  denote the rest-of-the-world demand and supply elasticities and  $s$  denotes the Ivoirien share of the world market. Let the domestic price,  $P^d$ , and the world price,  $P^w$ , be linked by  $P^d = (1 - T)P^w$  where  $T$  is the export tax rate; then the relation between the (policy-induced) domestic price perturbation and the change in the world price is

$$(8) \quad dP^w/dP^d = -[1/(1 - T)]\{SE^s/[E^{w,d} + (1 - s)E^{w,s}]\}$$

where  $E^s$  is the domestic elasticity of supply.

The world price of coffee is taken as exogenous, because the average Ivoirien share of world exports is only around 5 percent. The world price of cocoa,



Table 1. *Production and Planting Elasticity Equations*

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$$\begin{aligned} EP1CF &= \exp(-BCF * MCF) * \exp(BCF * RFP) \\ EP2CF &= 0.0012 * RFP \\ EP1CC &= \exp(-BCC * MCC) * \exp(BCC * RCP) \\ EP2CC &= 0.00058 * RCP \\ ETA1CF &= 1.0 + 0.0434 * RFPMA/3 \\ ETA2CF &= 0.0236 * RFPMA/3 \\ ETA1CC &= 1.0 + 0.013 * RCPMA/3 \\ ETA2CC &= 0.00869 * RFPMA/3 \end{aligned}$$


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*Notation:*

MCC: Estimated minimum cost of production of cocoa/kg  
MCF: Estimated minimum cost of production of coffee/kg  
RFP: Real producer price of coffee  
RCP: Real producer price of cocoa  
RFPMA: Lagged 3-period moving sum of RFP  
RCPMA: Lagged 3-period moving sum of RCP  
EP1CF: Own-price production elasticity of coffee  
EP2CF: Cross-price production elasticity of coffee  
EP1CC: Own-price production elasticity of cocoa  
EP2CC: Cross-price production elasticity of cocoa  
ETA1CF: Own-price new-planting elasticity of coffee  
ETA2CF: Cross-price new-planting elasticity of coffee  
ETA1CC: Own-price new-planting elasticity of cocoa  
ETA2CC: Cross-price new-planting elasticity of cocoa  
 $BCC = -1.514/(69 - MCC)$   
 $BCF = -1.514/(65 - MCF)$

however, cannot be treated as exogenous, because Côte d'Ivoire has close to 30 percent of the world share of cocoa exports. Ivoirien production and the world price are linked using a static market-clearing model of the world cocoa market. The rest-of-the-world supply elasticity is taken to be 0.30 and the demand elasticity  $-0.27$ , both close to those estimated in time series regressions. Furthermore, given a time series of the world cocoa price representing the base price, deviations from it can be computed using the above elasticities together with the assumption that a change in the world price arises when Ivoirien production deviates from its base level. The impact of an Ivoirien production shock on the world price is inversely related to the size of the shock relative to world production. The computation of the world price is done period by period; hence the generated perturbed solution incorporates the interdependence of the world price and policy-induced supply changes in Côte d'Ivoire.

*Measures of Policy Impact and Welfare Evaluation*

The key consideration in the evaluation of the impact of policy is the induced change in the distribution of income. The numerical model detailed above can be used to calculate the tradeoffs in terms of discounted net revenues that would

accrue to cocoa producers, coffee producers, and the government under alternative hypothetical pricing policies. An important qualification is that cocoa and coffee producers do not constitute mutually exclusive groups; therefore, they may be aggregated into a single "private sector," and the tradeoff between the government and the private sector can be considered.

Changes in producer prices directly affect production and profits in the cocoa and coffee sectors. At an aggregate sectoral level, the conventional measure of welfare change is the change in the producer surplus, or net profits of the producers. In the static production model, producer surplus is conventionally measured as the area bounded by the price and the supply function. Given the parametric specification of the supply function and the potential production for year  $t$ , the producer surplus,  $\Pi(t)$ , can be calculated as

$$(9) \quad \Pi(t) = \int Q(p^d) dp^d$$

where the range of integration is from the shut-down price to the government's current set price. This integral has an explicit, closed-form solution for the parameterization of the supply function used here and can be readily evaluated. A complication arises, however, from the dynamic adjustment process modeled here, which shifts the supply function intertemporally.

The presence of a multiplicative shift factor in the output supply equation means that as new planting occurs and potential output expands, the supply function shifts out, or the supply function is time-indexed. Aggregate producer surplus for the full time horizon is the discounted sum of the producer surplus in each year. The output supply function specified in equation 9 reflects only variable production costs and ignores the fixed costs of purchasing land and establishing a planted area, that is, the cost of capital inputs. This may be appropriate for a short-run analysis but will result in overestimation of producer surplus in the long run. To correct for this, Just, Hueth, and Schmitz (1981) suggest that the imputed value of the cost of preplanned capital inputs into current production can be subtracted from the static annual measure of producer surplus. This is roughly equivalent to subtracting the amortized value of capital costs from the producer surplus calculated in the conventional way and takes into account the costs of shifting resources into an expanding sector. Producer surplus was thus calculated as

$$(10) \quad \Pi(t) = \int Q(p^d) dp^d - Z(t)$$

where  $Z(t)$  denotes annual amortized establishment cost of new plantings.

Most of the policies simulated here result in either an expansion of coffee production and a contraction of cocoa production or an increase in net government balance and a reduction in producer surplus. Choosing the optimum pricing policy, defined as that which maximizes aggregate social welfare, involves implicit or explicit weighing of the gains and losses of different groups. Explicit welfare weights will not be assigned here; instead the tradeoffs generated by alternative pricing policies will be presented. The choice of any point on the

tradeoff implies some social valuation of the relative gains and losses of all affected sectors. Deaton and Benjamin (1988) have concluded that the income distribution effects that resulted from shifts in the relative prices of cocoa and coffee were probably rather small. Assuming that this conclusion is valid, the key consideration in the choice of pricing policy is the social valuation of government tax revenue versus aggregate private revenue.

#### IV. ALTERNATIVE PRICING POLICIES

Several simulations were carried out using the model, four of which are reported here. In the base case simulation it is assumed that the current pricing policies are continued. Then a policy of reducing both prices, along with a reduction in the relative price of cocoa, is simulated. Next the exchange rate is altered (the CFA franc is devalued), but absolute and relative producer prices remain unchanged. Finally, the effects of a system of nonfixed producer prices, which vary according to changes in the world price, are simulated. The projected time paths of relevant variables for these cases are illustrated in figures 1–6.

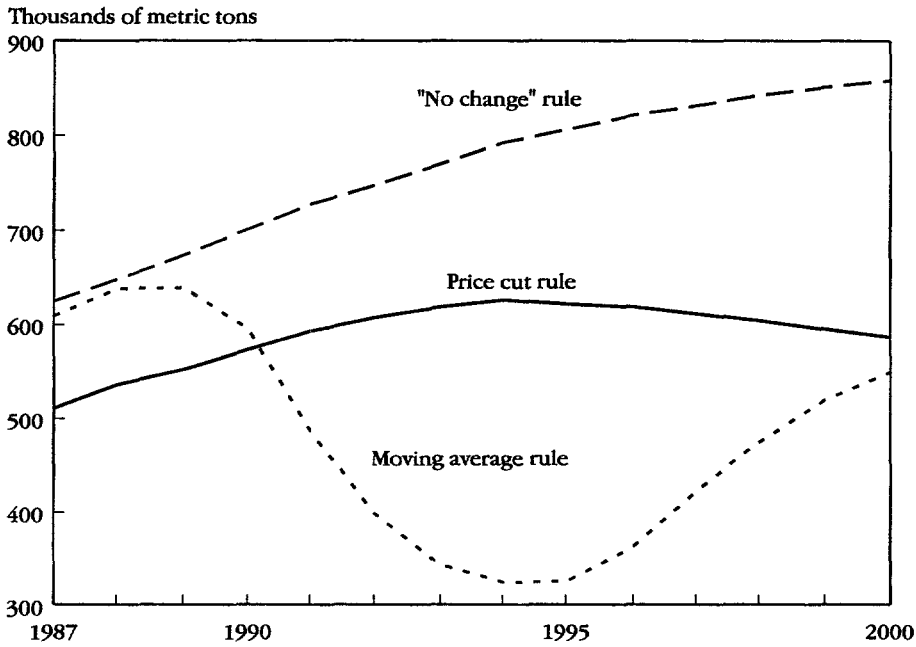
##### *Base Case Projections and Simulation Results*

The assumptions made to generate the base case projections are summarized in table 2, and the main results are as follows: annual cocoa production rises from about 620,000 tons in 1987 to 861,000 tons in 2000, while annual coffee production falls significantly, from 244,000 tons to 191,000 tons (figures 1 and 2). The cocoa sector's annual producer profit increases from CFAF146 bil-

Table 2. *Assumptions Underlying the Base Run*

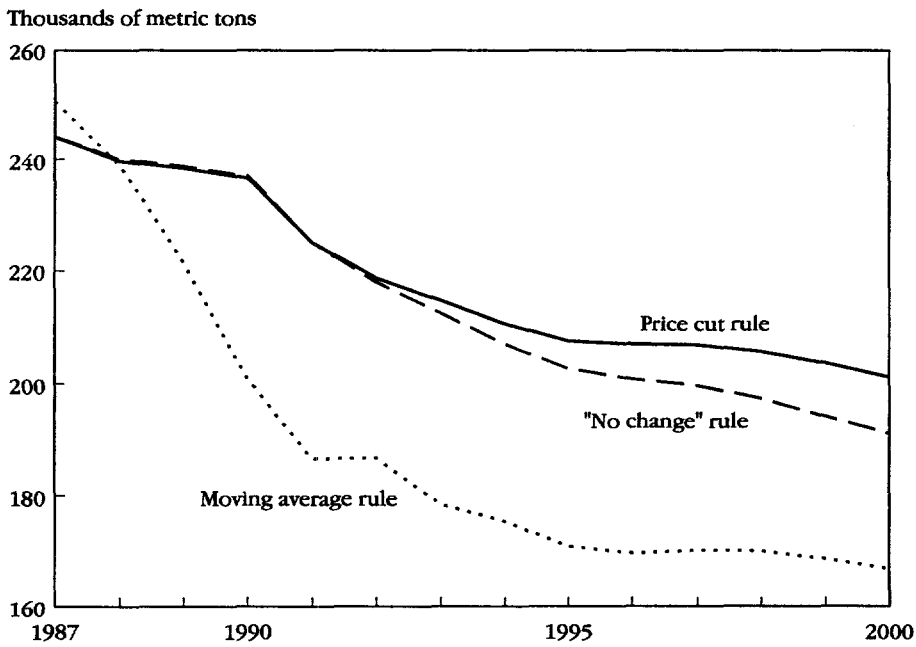
Exchange rate (CFAF/\$)	330.00
Producer price for cocoa	400.00
Producer price for coffee	377.00
World c.i.f. price	Endogenous
Domestic marketing and transportation (CFAF/kg)	111.20
Freight and insurance (CFAF/kg)	73.00
Export tax (CFAF/kg)	100.00
Cost to CSSPPA (CFAF/kg)	691.00
Cost to government	590.00
Cocoa: minimum production cost/kg (1987 CFAF)	45.725
Coffee: minimum production cost/kg (1987 CFAF)	67.14
World cocoa demand elasticity	-0.27
Rest-of-the-world cocoa supply elasticity	0.30
Annualized cocoa establishment cost/ha (thousands of 1987 CFAF)	16.80
Annualized coffee establishment cost/ha (thousands of 1987 CFAF)	22.40

Figure 1. *Projected Cocoa Production under Three Price Rules*



Source: Authors' calculations.

Figure 2. *Projected Coffee Production under Three Price Rules*



Source: Authors' calculations.

lion<sup>1</sup> to CFAF203 billion, measured in 1987 prices. The cumulative surplus for cocoa is CFAF2,524 billion. For the coffee sector, annual producer profit falls from CFAF48 billion to CFAF34 billion, in 1987 prices. The cumulative surplus is CFAF537 billion. The net government balance from cocoa is in deficit in most years (figure 3), with the projected cumulative deficit for the full horizon being a massive CFAF1,957 billion. The annual deficit becomes smaller from 1992 onward, when the world cocoa price is projected to improve. For coffee the cumulative deficit is just CFAF26 billion (figure 4). Real cocoa export revenues are projected to increase from \$743 million in 1990 to \$1,340 million in 2000, while real coffee export revenues are expected to decline from \$436 million to \$406 million during the same period. Figures 5 and 6 show net producer revenue from cocoa and coffee. Quantitatively, these results indicate a considerably worse outlook than in Akiyama (1988), especially for government revenue (figures 3 and 4). The difference from Akiyama's results arises partly because lower average projected cocoa prices are used here. The continuation of current pricing policies implies massive deficits and, consequently, serious liquidity problems for the government.

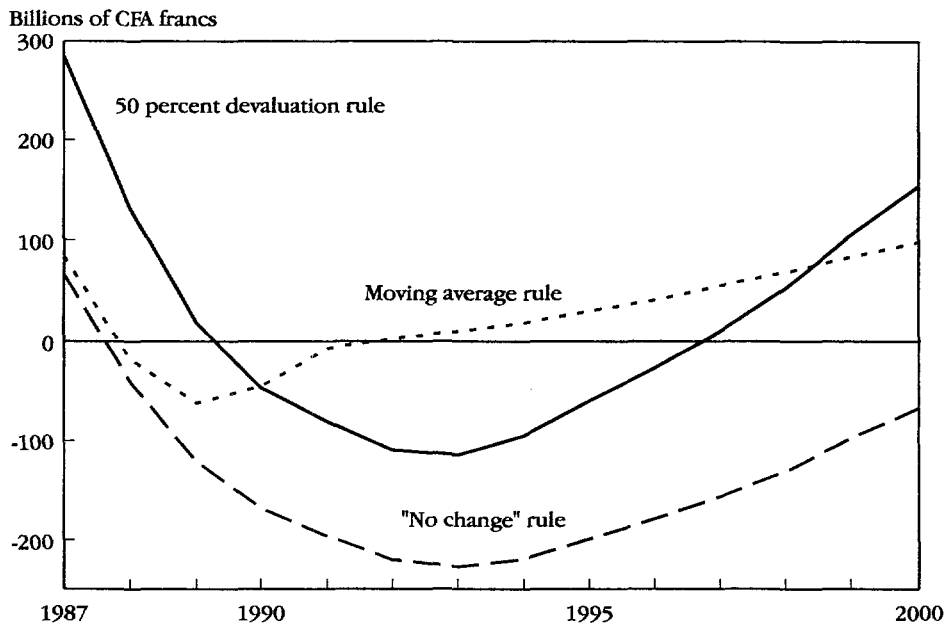
*Simulation of producer price changes at an unchanged exchange rate.* The simulation reported here is for a policy of reducing the producer price of cocoa by 40 percent and of coffee by 10 percent. These reductions appear to be the minimum required, at an unchanged exchange rate, to produce modest government surpluses (of CFAF113 billion and CFAF90 billion for cocoa and coffee, respectively) for the full 14-year period and to lead to a diversification away from cocoa and into coffee and other crops.

Under this pricing policy, the sum of revenue for the government and profits for the cocoa and coffee producers for the full 14 years is CFAF2,292 billion compared with CFAF1,078 billion in the base run. Although this is an aggregate improvement, it is accompanied by massive changes in the relative sizes of the cocoa and coffee sectors, thereby precluding unambiguous statements about the welfare effects of such a policy. The cocoa sector's accumulated profit declines from CFAF2,524 billion in the base run to CFAF909 billion, while the coffee sector's accumulated profit increases from CFAF537 billion to CFAF1,179 billion. The net government balance from cocoa is not positive in every year, but for the period as a whole it is a surplus of CFAF113 billion, compared with an accumulated deficit of CFAF1,957 billion in the base run.

Cocoa production declines sharply with the change in relative prices, peaking at 623,000 tons in 1995 and declining to 585,850 tons in 2000. Relative to the base simulation, cocoa production is 38 percent lower by 2000. Côte d'Ivoire's share of the world cocoa market falls to 24 percent in the year 2000 compared with nearly 33 percent in the base run. Coffee production increases and by 2000 exceeds the base case by about 5 percent. As a consequence of the reduction in Ivoirien cocoa production, world prices throughout the period are significantly

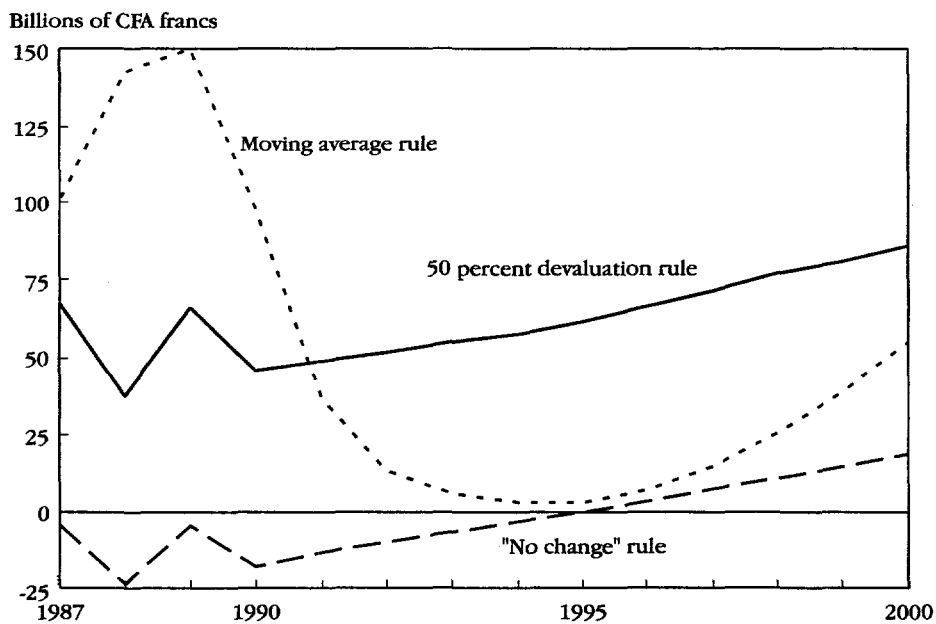
1. A billion is 1,000 million.

**Figure 3. Projected Net Government Balance from Cocoa under Three Price Rules**



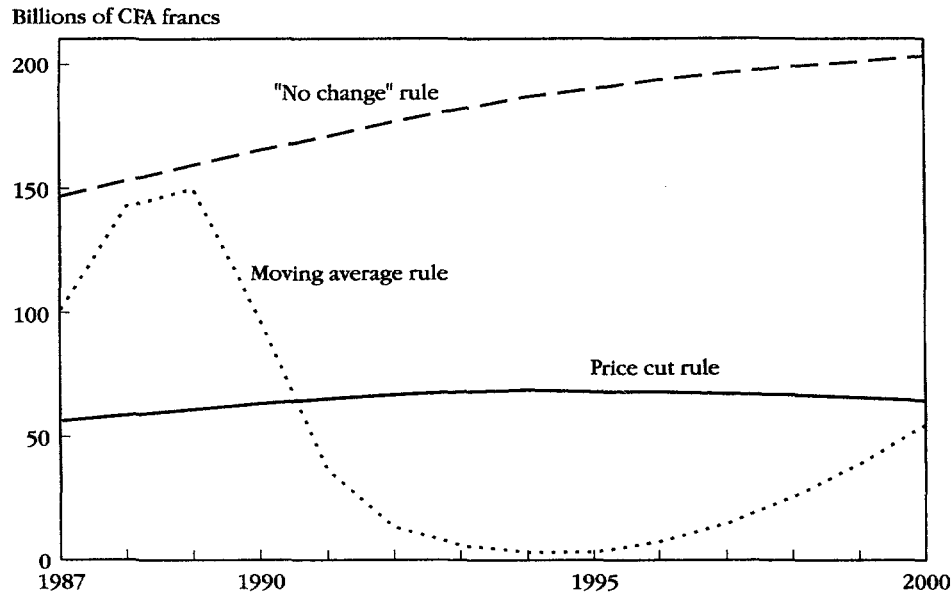
Source: Authors' calculations.

**Figure 4. Projected Net Government Balance from Coffee under Three Price Rules**



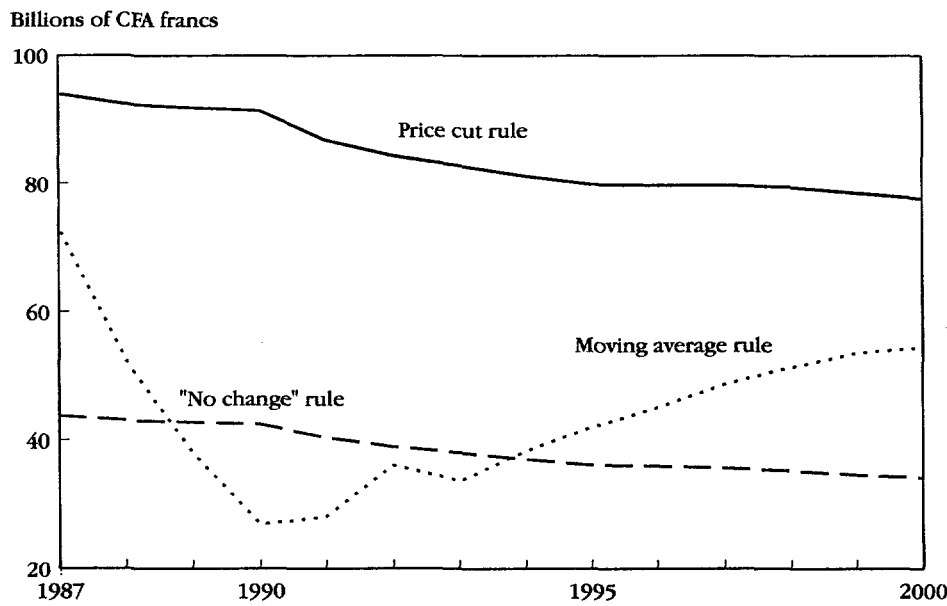
Source: Authors' calculations.

**Figure 5. Projected Net Producer Revenue from Cocoa under Three Price Rules**



Source: Authors' calculations.

**Figure 6. Projected Net Producer Revenue from Coffee under Three Price Rules**



Source: Authors' calculations.

higher than those in the base simulation, exceeding the base world price by 9.4 percent in 2000.

*Simulation of a 50 percent devaluation with no change in producer prices.* If a 50 percent devaluation is adopted, there will be an immediate improvement in the net government balance. Because relative prices are unchanged, the sizes of the cocoa and coffee sectors are unaffected. The cocoa surplus is nearly CFAF350 billion in 1987; it declines steadily (as the world price declines) to a deficit of CFAF2.3 billion in 1992 and then improves steadily to a surplus of more than CFAF260 billion in 2000. Similarly, the coffee surplus also improves sharply; between 1990 and 2000 it rises steadily from about CFAF56 billion to about CFAF94 billion. The cumulative surpluses over the simulation period are CFAF226 billion for cocoa and CFAF872 billion for coffee. Indeed the surplus would persist even if the coffee producer price were raised by 10 percent, 20 percent, or even 30 percent over the base case price. Therefore devaluation of the CFA franc represents a powerful option for dealing with the problem of persistent net government deficits.

*Simulation of a moving average producer price system.* To reduce producer price variability, some economists, for example, Mirrlees (1988), have suggested various forms of price adjustment in which changes in the producer price are some small fraction of the change in the expected world price; that is, producers are offered high, but not full, insurance. An example of such an adjustment rule is a moving average price in which the producer price equals a proportion of the moving average of the expected world price.

The effects of instituting a three-year lagged moving average pricing rule were simulated, with producers receiving 70 percent of the average world price. A strong assumption is made that the supply response and the rest of the model will remain unchanged by such a switch in the pricing rule. Although the supply response may change, the absence of any historical experience makes it difficult to make concrete alternative assumptions. Without the price insulation previously provided by the government, the producer surplus and the government deficit will be reduced when the market price falls below the price guaranteed in the base run. This rule amounts to paying the producers in some years approximately one-third of the price of cocoa in the base run. Relative to the base run there is a sharp reduction in cocoa producer surplus and an increase in the average annual coffee surplus. On average the government runs surpluses on its cocoa and coffee accounts.

#### *Sensitivity Analysis*

To examine the robustness of the conclusions of the simulations, sensitivity analysis was undertaken. Variations in the length of the policy horizon, the use of discounting when aggregating revenues over time, and variations of the assumption about the shutdown price did not lead to significant changes in simula-



tion results. The main focus of sensitivity analysis is on alternative settings of the key elasticities. However, the use of a simulation design in which the key elasticities are varied over a grid of values, one at a time, typically leads to a large volume of simulation output. To summarize this, a response surface was estimated. This involved estimating regression equations that described how the changes in certain key parameters generated changes in the variables of interest. The regression coefficients and their *t*-statistics indicated the size and statistical significance of the sensitivity. The key parameters in the present context were the sum of the absolute values of world supply and demand elasticities, the Ivoirien supply elasticities for cocoa and coffee, the planting elasticities for cocoa and coffee, and the percentage reductions in the producer prices of cocoa and coffee.

The sensitivity of key variables to parameter variation within and between two regimes—the fixed producer price (FPP) regime and the moving average price (MAP) regime—was investigated. For the FPP case, beginning with the base run setting, the sum of world supply and demand elasticities was varied from 0.10 to 0.60 in steps of 0.05, the cocoa price reduction was varied from 0 to 70 percent in steps of 10 percentage points, and the coffee price reduction was varied from 30 to 60 percent, also in steps of 10 percentage points. Thus 800 combinations were used. These changes also induced variation in Ivoirien planting and supply elasticities because these elasticities vary with the producer price, as described in tables 1 and 2. For the MAP case the procedure used was similar except that the percentage of the lagged three-year moving average world price that is paid to the cocoa and coffee producers was varied from 40 to 80 percent in steps of 10 percentage points—a procedure that, together with the 10 settings of the sum of world supply and demand elasticities, yielded 250 distinct parameter combinations. Post simulation, response surface regression equations were estimated with four dependent variables: aggregate net government balance from cocoa and from coffee and aggregate net producer profit from cocoa and from coffee. The regression results are shown in tables 3 and 4. A tight fit of the regression indicates that the included parameter settings provide a good explanation of the simulation variance of the variables of interest, and large *t*-statistics indicate that sufficient independent variation in parameter settings was allowed for in the simulation design.

In the fixed-price case (table 3) producers are sheltered from variations in the world price, so that only the net government balance from cocoa is sensitive to variations in the sum of world supply and demand elasticities. The higher this sum, the lower the tax yield is from a given reduction in producer price relative to the base run. Similarly, the higher the own-price supply elasticity, the lower the tax yield is for a given tax setting. Relative to the other elasticities, sensitivity to the planting elasticities was found to be quite small. The sensitivity of net government balance for cocoa and coffee to cross elasticities, while statistically significant in the case of cocoa (but not coffee) is smaller than for own-price elasticities. For the producer profit regressions, there is again significant sensitivity to the value of supply elasticities, with larger absolute values of these

Table 3. Estimation Results for the Response Surface Regressions for Fixed Producer Price Regime

<i>Dependent variable</i>	<i>Explanatory variable</i>					<i>R</i> <sup>2</sup>
	<i>Percentage fall in cocoa price</i>	<i>Percentage fall in coffee price</i>	<i>Sum of world supply and demand elasticities</i>	<i>Ivoirien cocoa supply elasticity</i>	<i>Ivoirien cocoa planting elasticity</i>	
Net government balance from cocoa	1.02×10 <sup>4</sup> (7.23)	-2.17×10 <sup>2</sup> (9.83)	-1.16×10 <sup>3</sup> (22.89)	-1.04×10 <sup>4</sup> (45.86)	-1.89×10 <sup>3</sup> (1.18)	0.978
Net government balance from coffee	-21.18 (0.026)	8.67×10 <sup>2</sup> (83.51)	0.0 (0.0)	1.83 (0.0197)	-0.37 (0.0)	0.930
Net cocoa producer profit (in logs)	-12.90 (8.60)	1.51 (64.06)	0.0 (0.0)	-12.49 (61.59)	-19.42 (11.21)	0.980
Net coffee producer profit (in logs)	6.18 (1.08)	-4.72 (60.50)	0.0 (0.0)	-2.23 (4.15)	2.77 (0.43)	0.900

*Note:* Absolute values of *t*-statistics are in parentheses.

*Source:* Authors' calculations.

Table 4. Estimation Results for the Response Surface Regressions for Moving Average Price Regime

Dependent variable	Explanatory variable					R <sup>2</sup>
	World price of cocoa	World price of coffee	Sum of world supply and demand elasticities	Ivoirien cocoa supply elasticity	Ivoirien coffee supply elasticity	
Net government balance from cocoa	-4.43 × 10 <sup>3</sup> (72.07)	-94.09 (1.11)	2.40 × 10 <sup>2</sup> (12.78)	-4.41 × 10 <sup>3</sup> (55.70)	8.01 (0.08)	0.993
Net government balance from coffee	-37.48 (21.41)	-1.74 × 10 <sup>3</sup> (495.00)	3.09 (3.48)	23.90 (9.45)	-1.55 × 10 <sup>3</sup> (389.00)	0.999
Net cocoa producer profit (in logs)	0.47 (6.98)	-2.52 (17.68)	0.57 (18.34)	-5.82 (61.73)	1.20 (7.39)	0.997
Net cocoa producer profit (in logs)	-2.29 (12.32)	-4.13 (14.71)	0.51 (5.64)	-0.58 (2.40)	-13.23 (36.82)	0.994

Note: Absolute values of *t*-statistics are in parentheses.

Source: Authors' calculations.

elasticities leading to larger reductions in producer revenues when producer price is reduced.

The most obvious difference between the MAP case (table 4) and the FPP case is that in the MAP case, all government and producer revenues are sensitive to the sum of world supply and demand elasticities; larger values are associated with higher (not lower) revenues. Because the moving average rule generates a different time path of producer prices from the fixed price cases, however, caution must be exercised in comparing the regimes. Once the government no longer provides full-price insurance to producers, export tax revenues are less sensitive to the sum of world supply and demand elasticities, whereas producer revenues are considerably more sensitive. As in the fixed price case, government and producer revenues are again sensitive to the domestic supply elasticities.

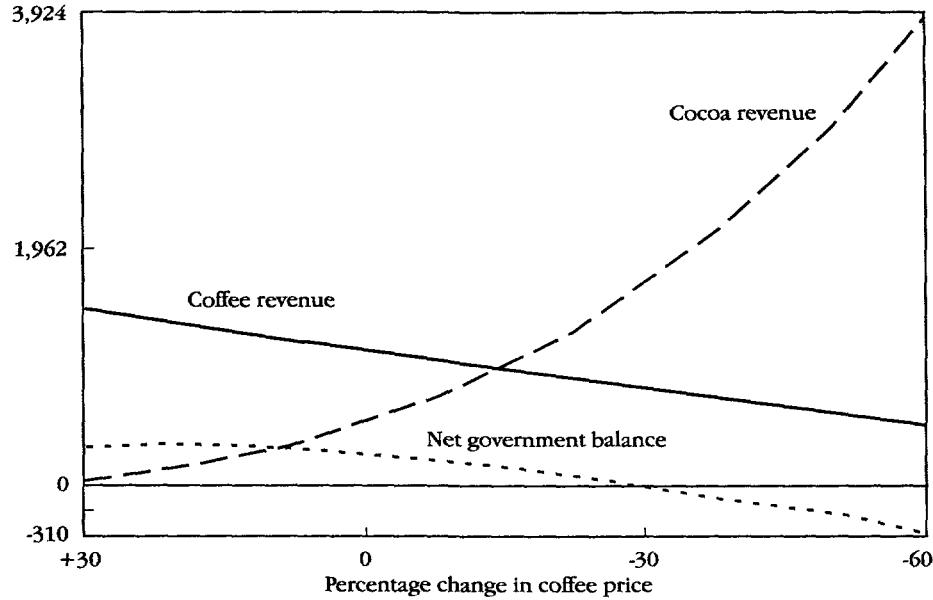
The response surface estimates indicate that comparisons of producer and government revenues under alternative tax rates in the MAP regime are sensitive to the elasticity assumptions. Only government revenues are sensitive to elasticity assumptions in the FPP regime, but even that sensitivity is greater in the MAP case relative to the FPP case. This conclusion does not invalidate the exercise undertaken here but warns of the importance of the numerical assumptions in this article.

#### V. THE CHOICE BETWEEN ALTERNATIVE POLICIES

In choosing a pricing policy, several tradeoffs must be considered. First, if the relative producer price is varied in Côte d'Ivoire, there will be short- and long-run changes in the producer revenues in the two sectors. The difference between short- and long-run changes reflects the latter's incorporation of the supply response. Second, there will be both a direct and an indirect impact on short- and long-run government revenues; the direct impact comes from changes in production and exports at the constant world price, and the indirect impact comes from a change in the world price resulting from the change in Côte d'Ivoire's share of world cocoa production. To illustrate the tradeoffs, two cases were considered. In the first the cocoa producer price was cut to 40 percent below the base price and kept at that lower level, while the coffee price change was varied between a cut of 60 percent and an increase of 30 percent. In the second case the coffee price was cut to 10 percent below the base price and kept at that lower level, while the cocoa price cut was varied between 0 and 70 percent. Figures 7 and 8 show the effect of each combination of price changes on sectoral revenues during the 14-year time horizon. From these figures one can easily infer the tradeoff between the revenues of the two producing sectors and the tradeoff between the government revenue, on the one hand, and total producer revenue, on the other. Because the net government balance schedule is steeper in figure 8 than in figure 7, we can infer that revenue is more readily affected by a given change in the price of cocoa rather than of coffee. Furthermore, because devaluation of the CFA franc will shift the net government balance

**Figure 7. Aggregate Sectoral Revenues with Cocoa Price Cut Held at 40 Percent**

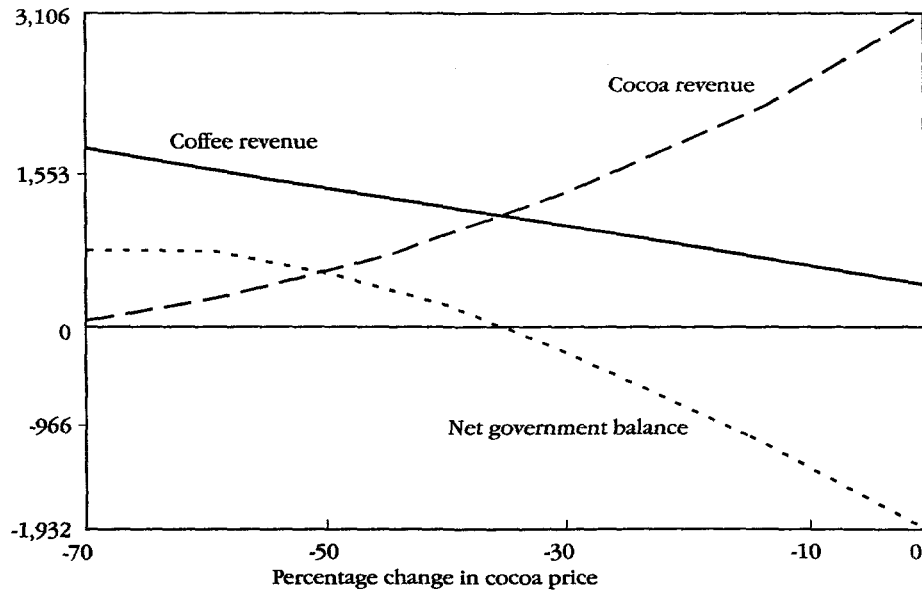
Billions of CFA francs



Source: Authors' calculations.

**Figure 8. Aggregate Sectoral Revenues with Coffee Price Cut Held at 10 Percent**

Billions of CFA francs



Source: Authors' calculations.

schedule to the right, it will always improve the tradeoff between government and producer revenues.

In analyzing these tradeoffs, however, the possibilities for substituting alternative productive activities for cocoa and coffee production must be considered. There is a danger of exaggerating the impact of pricing policy on producers' welfare. Analogously, there is a danger of underestimating the impact on net government revenues as a consequence of producers shifting out of cocoa and coffee because of (say) reductions in prices. The empirical importance of this point depends upon the extent of substitute activities.

The analysis offered here may be combined with the optimal tax approach, in which the optimal tax rate is the reciprocal of the country's demand elasticity for a commodity, defined earlier as  $E^d$ . With Côte d'Ivoire's world cocoa market share at 0.3, the world elasticity of demand at 0.25, and the world elasticity of supply at 1.2, the optimal cocoa tax rate is estimated to be 27 percent. For coffee, if the market share is 0.04, the world elasticity of demand 0.25, and the world elasticity of supply 0.8, the optimal tax rate for coffee is 4 percent. (Because the period is 14 years, the supply elasticities are relatively large.) Thus this approach leads to substantially different tax rates for cocoa and coffee.

## VI. SUMMARY

This article has presented an approach to evaluating pricing policies for perennial crops. The main contribution is the development of a flexible computational model, which incorporates important features of perennial crop production that are not captured by other (usually static) frameworks. Applied to cocoa and coffee pricing in Côte d'Ivoire, the framework has produced sensible and plausible scenarios as well as useful descriptions of revenue tradeoffs. The study has highlighted many of the key issues that arise from considering major changes in the rules used to set domestic producer prices. It has not produced an unambiguously best policy but has identified several that improve substantially on the present situation, thus generally indicating the desirability of a lower tax on coffee than on cocoa.

The conclusions about Côte d'Ivoire policy are necessarily conditional on the assumptions about the future time paths of world cocoa and coffee prices and the choice of a 14-year policy horizon. The base scenario is characterized by massive deficits in the government cocoa account, rising cocoa production, and declining coffee production. If this scenario is to be avoided, clearly policy changes are needed. At an unchanged exchange rate, reducing the cocoa price about 40 percent and the coffee price about 10 percent would eliminate the government deficits on cocoa and coffee. To generate positive tax revenue, therefore, the price cuts would have to be larger. The devaluation of the CFA franc in conjunction with price cuts, or even on its own, would be a powerful way to reduce government deficits. This is, not surprisingly, a robust finding.

In October 1989 the Ivoirien government announced changes in the pricing of

cocoa and coffee, which, beginning with the 1989/90 growing season, would reduce the nominal cocoa producer price by 50 percent and the nominal coffee price by about 45 percent. A simulation of this policy shows that if it is maintained, the cocoa sector would continue to grow, but coffee production would decline even though the projected world price outlook for coffee is relatively more favorable than that for cocoa. Also, whereas the net government balance will be much improved, the deficit on cocoa will not be eliminated in every year, given the current projection of world cocoa price.

The scenario generated by the newly announced policy has some undesirable features, such as maintaining domestic relative prices or perhaps even distorting them further from their respective marginal export revenues. The consequences of this policy would be especially unfortunate if the projections of future cocoa and coffee prices do in fact materialize. The new policy may yield more tax revenue than would result from the adoption of the moving average price rule, with cocoa and coffee producers receiving 73 and 96 percent of the world price, respectively, but at the cost of a significant decline in coffee production. It is possible that aggregate producer and government revenues could be substantially lower. The simulation results based on the three-year moving average price rule show that such a policy effectively eliminates the large government deficits. However, since the projected outlook for cocoa prices is poor until the mid-1990s, the production of cocoa would decline very significantly under such a policy, even if the producers were paid a high proportion of the world price.

The system of setting producer prices in Côte d'Ivoire has parallels in many other countries and with many other crops (Varangis, Akiyama, and Thigpen 1989). Therefore the method and the results of this report have relevance extending beyond Côte d'Ivoire. Given a suitable data base, the present approach, suitably modified, can be applied to other countries with important perennial crops.

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