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INTERNATIONAL COMMODITY AGREEMENTS AND EXPORT EARNINGS: SIMULATION OF THE 1968 "DRAFT INTERNATIONAL COCOA AGREEMENT"*

This study presents a model which simulates the world cocoa market under free and controlled market conditions and permits an introduction of institutional complications into general microeconomic analyses. It is hoped that it will contribute to our knowledge of the design and the technical administrative operations of international commodity agreements, and also to our knowledge of determining whether the gain from such an agreement is likely to justify the costs of establishing and operating it. The international cocoa agreement considered in this paper was prepared by the secretariat of the United Nations Conference on Trade and Development (UNCTAD) in 1968, as a result of the United Nations Cocoa Conference in Geneva, in November 1967 (*20*). The 1968 version of the "Draft International Cocoa Agreement" was based, in part, on several earlier versions prepared by the Food and Agricultural Organization (FAO) between 1956 and 1965 (see *11*).

Primary products currently account for close to 90 percent of the exports of less developed countries (*18*, p. 233). Since foreign exchange earnings from exports of primary products underpin the development programs of low income countries, it becomes necessary to resolve the problems associated with the marketing and pricing of these products, if we are to raise incomes. The literature on the dependence of low income countries on the exports of primary products distinguishes and stresses two types of problems which have been responsible in part for influencing adversely external earnings of less developed countries: Fluctuations in prices and export earnings and a long-run downward trend in export

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earnings. These two problems may together be characterized as the "commodity problem." Although the commodity problem has been studied for a long time, no universally acceptable solution has been found. However, it is claimed that the "commodity problem" might be ameliorated by international commodity agreements (ICA's) (*3, 15*).

Theoretical work on commodity agreements has failed to contribute appreciably to our knowledge of the design, operations, and worth of an agreement or of the desirability of price or income stabilization. Some economists have advised against price stabilization and the use of buffer stocks to stabilize international food prices (*16*, p. 63; *21*, pp. 602–14). Others have found that "price stabilization, brought about by buffer stocks, provides a net gain to producers and consumers taken together" (*14*, p. 297).

Most of the empirical work has been devoted to the relationship between fluctuations in export proceeds and long-term growth rate of gross national product (GNP). One such work is that of A. I. MacBean (*12*). H. G. Johnson summarizes MacBean's empirical work by stating that "these findings, which are contrary to what MacBean himself had expected, lead him quite justifiably to the position that international schemes for stabilizing primary product prices or the export earnings of less developed countries are very unlikely to contribute much to the economic welfare of less developed countries, and in particular are unlikely to contribute enough to justify the costs of establishing and operating them, . . ." (*10*, p. 143). A. Maizels, however, attacks the soundness of MacBean's methodology and also economists who use the same approach (*13*, pp. 579–80):

> Their major drawback is their implicit assumption that there is a single, unique relationship between a given degree of fluctuation in exports and the resultant change in the growth rate of GNP for all countries. Because of differences in economic structures, in the degree of dependence of different economies on the foreign trade sector, particularly for supplies of capital equipment, and in the ways in which they adjust to short-term changes in foreign exchange earnings, the impact of a given fluctuation in export earnings on the long-term growth rate of GNP is likely to vary substantially between different developing countries. For this reason, none of the regressions presented in this part of the book can be accepted as meaningful, and the author's conclusions are equally suspect.

It seems that we need to perform a cost-benefit analysis of an agreement in operation, in order to evaluate the worth of an ICA. Lacking this, we may simulate a market to shed some light on the effects of an agreement.

THE 1968 "DRAFT INTERNATIONAL COCOA AGREEMENT"

Cocoa has a relatively high year-to-year instability index amongst primary commodities (*6*, pp. 45–46; Table 3–7). The New York Cocoa Exchange spot prices which averaged about 5 cents a pound in the 1930s, and about 8 cents a pound in the 1940s, jumped to a record average of 58 cents a pound in 1954. On August 6, 1954, the Exchange recorded a spot price for Ghana cocoa at 72.90 cents a pound, the highest price in a single day in the history of the commodity. The spectacular rise in prices was due not only to low supplies as a result of heavy

TABLE 1.—INSTABILITY INDEXES OF PRICES AND EXPORT PROCEEDS OF SELECTED PRIMARY COMMODITIES, 1950–58*

Commodity	Instability index	
	Prices	Value of exports
Cocoa	49.4	23.5
Coffee	25.3	18.6
Sugar	25.0	15.3
Tea	21.4	17.2
Wheat	16.2	24.5
Tobacco	3.2	12.6

* Adapted from Table 3-7 of J. D. Coppock, *International Economic Instability* (New York, 1962), p. 46. Instability index is a measure of the degree of short-term fluctuation in, say, prices or exports, where the trend term has been removed. The trend term correction is necessary to avoid taking a constant year to year increase or decrease as indicating instability. Coppock's "log variance index" for measuring instability is one of the many indexes available (pp. 23–25). Other methods are based on average deviations from a moving average and average deviations from a straight-line trend fitted by least-squares regression.

capsid damage and the swollen shoot disease but also to increased demand resulting from the official announcement in the United Kingdom in February 1953 that rationing and price control would be ended for chocolate and sugar confectionery. One may also argue that the pressure on the prices in these periods was compounded by the exercise of the oligopoly power of the Statutory Marketing Boards of West Africa, which were authorized to begin operation in the 1947/48 season (*9*). The high prices of 1954 affected the operations of cocoa manufacturers adversely. Some of the small firms, especially in Belgium and Switzerland, were caught with short supplies of cocoa and were forced out of business.

International organizations such as the Moral Rearmament Association voiced their concern over the high prices and demanded to see the accounting books of the Statutory Marketing Boards of West Africa.[1] The Swiss and Belgian governments approached the Organization for European Economic Cooperation (OEEC) and the United Nations (UN), and asked them to look into the cocoa price crisis. The UN consulted with the Interim Coordinating Committee on International Commodity Arrangements (ICCOICA), who recommended that FAO initiate a study of cocoa price instability. The work of the FAO Cocoa Study Group culminated in a conference called by the UN to negotiate an international commodity agreement on cocoa in 1963. There have been two subsequent conferences, in 1966 and 1967. None succeeded in ratifying an international agreement. However, these conferences led to considerable changes in the Draft Cocoa Agreement of 1963. In this study, our simulation of the cocoa market price stabilization scheme will be based on the 1968 Draft International Cocoa Agreement, the latest version of the 1963 Draft (see *11*, *20*).

The 1968 Draft International Cocoa Agreement combines export restriction and buffer stock operations. At the beginning of the season, the Cocoa Council, representing producers and consumers, meets to determine sales quotas for the

[1] Sir Eric Tansley, who was the head of the Cocoa Marketing Boards of British West Africa, divulged the above information to the author during a personal interview with him in London, in 1968.

year.[2] The buffer stock authority then takes over the rest of the control mechanism in order to keep the prices within the agreed upper and lower limits, 29 and 20 cents per pound respectively. The buffer stock authority is allowed to hold inventories not to exceed a quarter of a million tons. Excess purchases are to be earmarked for nontraditional uses. The authorized activities of the buffer stock manager are spelled out in the Memoranda of Agreement (see Appendix 1).

Simulation used as a tool of economic analysis and model building allows us to study the dynamic behavior of economic systems over time. Thus, we could incorporate the buffer stock authority's decisions in a cocoa price determination model and study its effects on prices over time. The construction of such a model is presented next.

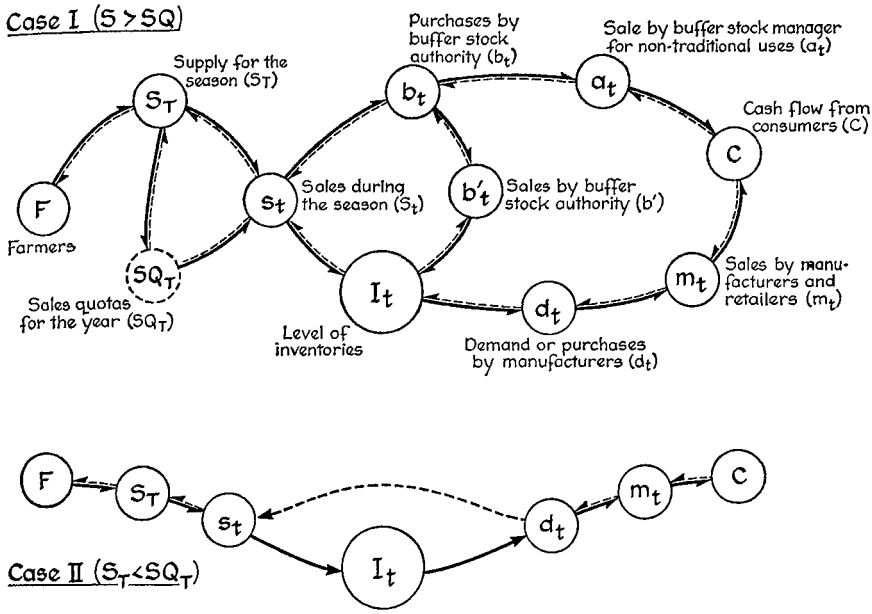
DESCRIPTION AND CONSTRUCTION OF THE SIMULATION MODEL

The buffer stock type market simulation model, which was deduced from the Cocoa Draft Agreement of 1968, is shown schematically in Chart 1. It involves nine simplified behavioral equations and one identity:

$S_T = f(P_{T-n}, E_i)$	Supply for the crop year function	(1)
$s_t = f(S_T)$	Monthly supply function	(1i)
$s_t = f\left(P_t, \frac{dP_t}{dt}, I_t\right)$	Dynamic monthly supply function	(2)
$D_T = f(P_{t-n}, E_i)$	Aggregate yearly demand function	(3)
$d_t = f(D_T)$	Monthly demand function	(3i)
$d_t = f\left(P_t, \frac{dP_t}{dt}, I_t\right)$	Dynamic monthly demand function	(4)
$SQ_T = f(S_T, D_T)$	Yearly sales quotas function	(5)
$b_t = f\left(P_{t-1}, \frac{dP_t}{dt}, SQ_T\right)$	Dynamic buffer stock purchases function	(6)
$b'_t = f\left(P_t, \frac{dP_t}{dt}, b_t\right)$	Dynamic buffer stock sales function	(7)
$a_t = f\left(P_{t-1}, \frac{dP_t}{dt}, b_t\right)$	Sales for nontraditional uses function	(8)
$\frac{dP_t}{dt} = f(I_t)$	Monthly average futures prices via supply of storage function	(9)
$I_t = I_{t-1} + s_t - d_t$	Identity equation	(10)

[2] The "sales quotas" and "basic quotas" concepts are simple but highly confusing: At the beginning of the year the Cocoa Council will decide, by negotiations, on the level of cocoa exports. This will be the aggregate world supply to be fed into the world market for that season, i.e., the aggregate world sales quota. If the world sales quota is less than the estimated world production for the season, the Agreement will be fully functioning since the buffer stock control mechanism will be called into operation. The world sales quotas are shared among the producing countries according to historical market shares which are computed from the "basic quotas." (This computation is shown in Table 2.) Thus from the "basic quotas" concept we arrive at ratios which, multiplied by the aggregate world sales quotas, give us the sales quotas for each country, which in turn is the amount of cocoa the country is obligated to sell for the season. For our simulation model basic quotas were used as sales quotas. It was based on the highest production for the previous eight years. Thus each country's sales quota was set equivalent to its highest production in the past eight years.

CHART 1.—SCHEME OF DEPENDENCE OF BUFFER STOCK PRICE SYSTEM*



* If $S_T > SQ_T$ then buffer stocks will be accumulated for the quota year and the dependence relationship is shown in Case I. If $S_T < SQ_T$ all sales will be made directly to the market and there will be no control mechanism at work. This normal market condition is shown in Case II. It is conceivable that prices might be below the floor price of 20 cents even though $S_T < SQ_T$. In such a case the Cocoa Council will meet, in an emergency session, to renegotiate SQ_T to a lower figure and force producers to sell to the buffer stock authority.

Each quantity is represented by a circle. The unbroken arrow lines indicate the flow of the physical commodity, whereas the broken lines show cash flows.

where

T = Years or crop years
n = Lagged years
t = Months, weeks, or days
S_T = Supply for the entire crop year or season
s_t = Supply or sales within the season (the crop is harvested and the sales spread over a year)
D_T = Demand for the entire crop year or season
d_t = Demand or purchases within the season
SQ_T = Sales quota for the year
b_t = Purchases by buffer stock authority
b'_t = Sales by buffer stock authority
a_t = Sales by buffer stock authority for nontraditional uses (excess supply over buffer stock capacity)
P_t = Spot market prices (unless stated otherwise)
I_t = Level of inventories
E_t = Exogenous variables (in the case of supply, the variables are rainfall, yield function; for demand, income, population growth, etc.).

The behavioral equations presented on the preceding pages need to be put in the form of an econometric model, a system of mathematical equations which

describe in aggregate terms the economic model process.[3] If we estimate the parameter values we can use the model to simulate the behavior of the endogenous economic variables over time by solving the model for times t, $t + 1$, and so forth. The econometric model describes in aggregate terms the economic behavior of cocoa producers, marketing boards, middlemen, and manufacturers who are linked by flows of information, cash, and goods (see Chart 1). The model consists of: (1) a monthly average futures market price determination equation which is based on the theory of "supply of storage" (*4, 25*); (2) yearly supply and demand forecasting equations; and (3) monthly supply and demand indexes. These indexes may be considered as indexes of sales (supply) and purchases (demand), and may be updated every month. Fortran programming is used to make behavioral decisions under a free market model and under a controlled price stabilization market model, according to the agreements in the 1968 cocoa buffer stock stabilization scheme. We now explain our mathematical equations, the reasons behind the forms, and the statistical methods used to calculate the parameters, which allow us to simulate the economic processes.

Yearly Supply and Demand Equations

Quantitative attempts to estimate the supply function for cocoa have met with limited success.[4] It is generally believed that cocoa production is a function of past and expected future prices, farmer income, the yield function of the tree, acreage of bearing trees, and other exogenous factors such as rainfall, humidity, and disease. However, the functional relationships between production and these variables are hard to specify. Besides, adequate data are not available, since peasant farmers do not keep records on acres planted. This difficulty in estimating a world supply forecast equation is not a drawback for the present study, for, as will be explained later, we do not need the long-run forecasts for the time period involved in the simulation study.[5]

[3] In some cases the behavioral equations described were simplified to make them mathematically manageable. For example, the monthly supply (s_t) and demand (d_t) functions were represented by seasonal indexes instead of elaborate dynamic equations.

[4] The earliest attempt at estimation of the supply function for cocoa was done by Peter Ady in 1949 (*1*). Ady related production to real prices lagged 9 years, since it takes about 7 to 9 years before a planted tree bears fruit. However, a drawback in Ady's model is that for a tree crop, production is not a function of prices in any one year, but of some form of distributed lag function of past prices. In 1965, R. M. Stern related current annual level of production to number of bearing acres, current real price, and a linear time trend (*19*). Since the number of bearing acres was not available, this had to be calculated indirectly. The annual change in the current number of bearing acres was approximated by the average real price of cocoa eight years earlier. One of Stern's equations took the following form [my notation]: $\Delta S_T = \alpha_1 + \beta_1 \bar{P}_{T-8} + \beta_2 \Delta P_T$. Stern estimated the above equation for seven of the leading producer countries at different time intervals from 1919 to 1964. Only those for Ghana for the period prior to the end of the Second World War were significant, and even here only ΔP_T was significant, i.e., the short-run profitability variable. The indicator of long-run expectations, variable $\bar{P}_{T-8}$ was not significant. M. J. Bateman has built a more sophisticated model (2). In this model increases in acreage planted are seen as a problem in capital theory. The supply response is related to Nerlovian price expectations, farmer income, yield potential, and climatic conditions. Bateman, in concluding his study, said: "The basic conclusion at which one must arrive concerns the folly of trying to estimate an aggregate cocoa supply function for the entire forest zone of Ghana" (2, p. 399). These studies indicate that estimation of long-run supply response on a worldwide basis will be a herculean task.

[5] The drawback does not prevent using the model effectively for short-run price forecasting. It is believed in the industry that crop estimates in the short run (a few months before harvest) are reasonably accurate. A sampling technique of counting the average number of pods per tree is used: the change in production from year to year is a function of the relative average pod counts per tree.

The aggregate annual world demand for cocoa beans is derived from the demand for cocoa grindings. The form of our demand forecast equation relates grindings to past prices and a time trend variable is introduced to explain consumption increases due to rise in world population and disposable income. The demand relation that we found appropriate is given by

$$D_T = \alpha_2 + \beta_2 P_{T-1} + \gamma T + e_{D_T}. \tag{11}$$

Prices are lagged because manufacturers generally carry stocks of cocoa beans covering from about three months to a year or more in the case of some big concerns such as the Hershey Chocolate Company. We tried various distributed lag forms in estimating the price parameter and found that prices lagged by one year explained the largest amount of variance in cocoa grindings.

Monthly Supply (Sales) and Demand (Purchases) Functions

The time increment chosen for our simulation is in monthly intervals. We therefore need to specify aggregate monthly behavioral equations which determine the monthly demand for and supply of cocoa so that we can generate simulated monthly prices via the price equation. The cocoa market is seasonal. Consumption in the temperate zone is higher in the winter, and most cocoa is harvested from September through March.[6] Thus, we need a way of isolating and measuring periodic fluctuations in a time series within a year. There are many methods that can be used to derive the dynamic monthly supply and demand behavior: multiple regression methods and moving average methods. We used the "ratio-to-moving-average method," because the indexes are easier to compute and we can easily update them.[7] With monthly sales and purchases data, a 12-month total, or average, eliminates seasonal influences. A seasonal effect for a month is isolated by dividing the average into the actual figure for a given month. The result reflects only seasonal and erratic effects. The seasonal effect

Other short-run variables included in such heuristic methods of estimation are: average diseased pods per tree in the sample, use of insecticides, rainfall, etc. We tried to estimate a world supply function, despite data limitations, in order to make the model complete and suitable for long-run forecasting.

The general form of the annual supply forecast equation we tried was given by

$$S_T = \alpha_1 + \beta_1 P_{T-n} + \omega S_{T-n} + \mu T + e_{S_T}$$

where α_1 is a constant term; P_{T-n} is real average New York Cocoa Exchange spot price (prices deflated by U.S. wholesale price index) and was used as a proxy for worldwide producer prices; S_{T-n} is production lagged and T is a linear time trend representing increasing acreage utilization and other unspecified phenomena; e_{S_T} is the error term. We tried various forms of distributed lags for both prices and production but were not able to find any indication that supply has been sensitive to price variations. The real price coefficient showed a negative sign consistently for the period after World War II (see footnote 4). In order to get good results, it seems that we must estimate the supply response on regional bases in each country, using the relevant prices and other indicators and summing up the results for all the regions, in order to get the world supply response (see 2, p. 399). Thus, the only explanatory variables readily available to us for estimating long-run world supply response are lagged supply and time trend.

[6] The harvesting periods for the major producing countries coincide: In West Africa the main crops are harvested in the months of October through March and the mid-crop from May through June. In Brazil the main crop months are October to March and the mid-crop months are May through September. Thus, about 80 percent of the world's harvest is from September through March.

[7] This method generates 12 indexes or ratios which necessarily sum up to one over the season. Thus, given the supply and demand forecast for the year, we can predict the probable sales and purchases within the year. In the short run, we can update these indexes every month or so depending on new information and also on personal judgment. However, for long-run forecasting or short-run forecasting by an official body such as a buffer stock authority, where updating by subjective judgment may be questioned, we can internalize the updating of these ratios by a process of automatic prognosis.

TABLE 2.—BASIC QUOTAS AND PERCENTAGE MARKET SHARES, 1959/60 TO 1968/69*

Country	Highest production criteria		Average production criteria	
	Thousand long tons	Percentage market share	Thousand long tons	Percentage market share
Brazil	198	12.37	142.7	11.60
Cameroon	90	5.62	81.3	6.62
Ivory Coast	147	9.18	120.2	9.78
Ghana	557	34.79	410.1	33.37
Nigeria	294	18.36	209.4	17.04
Rest of the world	315	19.68	265.1	21.59
Total	1,601	100.00	1,228.8	100.00

* In the 1968 Cocoa Draft Agreement the market share of a producing country will be based on its highest production for the past eight years. Column 1 presents the highest production of each country between 1959/60 and 1968/69. Column 2 shows the percentage market shares which will be used to compute sales quotas. Average production for the same period is shown for comparison. The ratios are almost equal.

Data used for computation is from Gill and Duffus Ltd., *Cocoa Market Reports* (various issues, 1959/60 to 1968/69, London).

is isolated by taking a mean of all the quotients for the particular month, as the erratic effects are eliminated. Monthly seasonal indexes or ratios were thus generated. The monthly data used in computing the indexes were the aggregate monthly sales of Ghana and Nigeria, from the 1960/61 to 1967/68 seasons, which were obtained by the author from the marketing boards in these countries. The data for the other major producing countries were not available, but since 1960, Ghana and Nigeria have produced consistently over 50 per cent of the world supply of cocoa and this harvest period is more or less the same as Brazil's. The monthly sales indexes computed for the two large African producers were therefore assumed to be the indexes for the entire industry.

The monthly purchases indexes were derived from the aggregate world grindings. Time series are available for aggregate world quarterly grindings only. A simple moving-average linear interpolation method was used to derive monthly grindings. We then computed the monthly seasonal purchases indexes by using the "ratio-to-moving-average method" described previously.

Futures Spot Price Determination Equation

The regression equation used for determining cocoa spot market prices is based on the "supply of storage" theory, first conceived by Holbrook Working and developed further by M. J. Brennan and F. H. Weymar (*24, 4, 23*). The supply of storage theory explains the behavior of intertemporal differences in price expectations in terms of the expected inventory behavior. Working says that "the origin and prevalence of the term 'carrying charge' in trade usage reflects the fact that hedgers commonly regard the designated price differences as in fact equivalent to a price for 'carrying' the commodity, or what may be called for the purpose of economic analysis a *price of storage*" (*24*, pp. 17–18). Working's point here is that intertemporal price spread is a function of inventories. Brennan de-

veloped the theory further so that it could be tested empirically. Brennan envisioned that during any period there will be firms such as producers, wholesalers, speculators who possess title to stocks in warehouses and carry stocks of a commodity from one period to the next. These firms supply storage of commodities as inventories. "On the other hand there will be groups who want to have stocks carried for them from one period (in which they do not want to consume them) to another period (in which they do intend to consume them). These consumers may be regarded as demanding storage" (*4*, p. 51). Brennan thus related intertemporal price spread, in the two-period case, to demand and supply of storage, i.e. inventories or stocks. The price equation took the form $\Delta P_t = \alpha + \beta \Delta I_t$. Weymar, however, introduced expectations into the model formally: "the spread between the price and the price expected at some future time is a function of expected inventory behavior over the intervening interval" (*23*, p. 1228):

$$\frac{P_t^{*h} - P_t}{h} = \frac{1}{h}\int_0^h f(I_t^{*h})dh \tag{12}$$

where h = time horizon in months
P^{*h} = expected spot price h months in the future
I^{*h} = inventory level expected h months in the future
P = spot price.

In 1961 the FAO Cocoa Study Group constructed a cocoa price determination equation which related monthly average cocoa futures prices on the New York Exchange to stocks as a percentage of grindings and to annual forecast of production and grindings (*7*). Weymar constructed an equation which related prices to a complicated form of inventory expectations (*22*, pp. 61–92). For our simulation model, however, we would like the price variables to be endogenously determined. We therefore used a simple variant of the supply of storage model by relating expected fractional change in price to expected changes in inventory level as a function of annual world grindings:

$$\frac{P_t^* - P_t}{P_t} = \beta\left[\frac{I_t}{D_T}\right] + e_p \tag{13}$$

where P_t^* may be regarded as a constant estimate of the equilibrium price over the season. We may rewrite the above equation as

$$ln\ P_t = \alpha_3 + \beta_3(I_{t-1} + s_t - d_t)/D_T + e_{p_t}\,. \tag{14}$$

The data used in estimating the parameters of equation (14) were the monthly average New York Cocoa Exchange spot prices, the world yearly supply and demand, and yearly inventory carryover information provided by Gill and Duffus Ltd., London.[8] The monthly supply and demand values were generated from the yearly values by using the seasonal indexes. In addition to equation (14), we are also interested in the prices which the marketing boards or farmers receive for their produce so we can calculate their aggregate incomes. There are well-defined relationships between the prices in the vertical market structure—farmer's

[8] In the world cocoa industry there are four futures markets: New York, London, Paris, and Amsterdam. The New York Cocoa Exchange is the biggest and acts as the price-leader. Hence, the New York Cocoa Exchange spot prices were assumed to be the world spot prices.

price (FP), cocoa marketing board's price ($CMBP$), manufacturer's price (MP), futures price (P_f), and spot price (P). Sellers and buyers use the futures and spot prices as their basic guide in setting prices, plus or minus a differential for transport, handling, and insurance. These price differences exist because the middlemen perform useful services and are compensated by them. For our purposes we are only interested in the spot price and the cooca marketing board price. We assumed a linear relationship between them:

$$CMBP_t = \alpha_1 + \beta_1 P_t + e_{CMBP_t}. \tag{15}$$

The data used in estimating the parameters of equation (15) were the monthly average New York Cocoa Exchange spot market prices and the $CMBP$ prices were the monthly average sales prices of the cocoa marketing boards in Ghana and Nigeria, for the period 1962 to 1968. Since Ghana and Nigeria produce over 50 percent of the world cocoa production, their monthly average sales prices were assumed to be equivalent to the monthly average world prices for cocoa beans.

Table 3 shows the results of the statistical estimates of the various equations and ratios comprising the econometric model. Unless specified otherwise, the estimation period covered 1947 to 1969. We are now in a position to proceed with the computer simulation of the market model that we have constructed, by using as a simulator the seasonal ratios and the regression equations which we have estimated.[9]

Further Comments on the Simulation Model

The flow chart which explains the computer program is shown in Appendix 2. An explanation of the simulation algorithm—how the computer programming and computation process was accomplished—is shown in Appendix 3. The simulation algorithm was set up under the assumption that a commodity agreement was in effect. Hence the conditions under which the buffer stock authority will make decisions to buy from or sell to the market were incorporated into the program. The program as set up forecasts yearly demand and supply values for cocoa, decides on monthly sales and purchases by using the seasonal indexes and taking into account the buffer stock authority decisions, and finally, uses the supply of storage price determination equation to determine the futures prices and producer revenues. To use the program to forecast free market prices, one sets the sales quota levels and the agreed floor and ceiling prices hypothetically high, so that decisions to implement a quota year or enforce decisions by the buffer stock authority are bypassed.

One of the main purposes of this study is to determine the "worth" of an ICA: to find out if the gains from an ICA on a particular commodity justify the cost of establishing and operating it. As far as the cocoa industry is concerned, one of the ways to do this will be to assume that the 1963 ICA conference on cocoa was successfully negotiated, ratified, and implemented. Under this assumption, we can simulate the market from the 1963/64 to 1968/69 seasons, and compare the

[9] As pointed out already, for long-term operations, it would be necessary to update the structural parameters. For our study the structural parameters and the seasonal ratios were not updated. However, a manager may find it advisable to update the monthly seasonal ratios as new information becomes available, in using this model for monthly forecasts (see footnote 6).

TABLE 3.—SIMULATION MODEL EQUATIONS AND SEASONAL RATIOS FOR COCOA*

A: Simulation Model Equations

Description	Equation	R^2
Price equations		
Supply of storage	$ln\ P_t = 3.9295 - 2.5636\ (I_{t-1} + s_t - d_t)/D_T + e_{p_t}$ (.1695)	.66
Cocoa Marketing Board[a]	$CMBP_t = -3.3051 + 1.0647\ P_t + e_{CMBP_t}$ (.0259)	.98
World demand Grindings	$ln\ D_T = 7.3276 - 0.2298\ ln\ P_{T-1} + 3.275_T + e_{D_T}$ (.0395) (.0020)	.97
World supply Production	$ln\ S_T = 6.3850 + 0.2483\ ln\ T + e_{S_T}$ (.0382)	.71

B: Seasonal Ratios[b]

Month	Sales (supply) s_t	Purchases (demand) d_t
October	0.0601	0.0858
November	0.0510	0.0851
December	0.0414	0.0838
January	0.1044	0.0825
February	0.1153	0.0811
March	0.1048	0.0794
April	0.0760	0.0778
May	0.0589	0.0762
June	0.0441	0.0811
July	0.0882	0.0860
August	0.0610	0.0909
September	0.1948	0.0903

* Basic data from Gill and Duffus Ltd., *Cocoa Market Reports*, (various issues, 1959–68, London).

The ordinary least-squares parameter estimation procedure was used in this study. Numbers in parentheses are standard errors of the respective coefficients. See the above text concerning individual equations and the notation used. The estimation periods for the equations are as follows: for the price equation, 1959 to 1969; for the *CMBP* equation, 1962 to 1968; for the yearly supply and demand, 1947 to 1969; sales ratios, 1960 to 1968; demand ratios, 1960 (last two quarters) to 1968. The prices were deflated by the U.S. wholesale price index.

[a] The data used in estimating the Cocoa Marketing Board price equation were the monthly average New York Cocoa Exchange spot market prices as P_t, and the $CMBP_t$ prices were the sum of the monthly average sales prices for Ghana and Nigeria. The result is shown in Table 3 above. The Nigerian data were complete. The Ghana Cocoa Marketing Board at times withdrew from the market and data for these months were not available. Using the Nigerian data alone, we obtained the following equation:

$$CMBP_t = -0.7758 + 0.9581 P_t + e_{CMBP_t}\ .$$
$$(.0264)$$

For the normal price ranges of cocoa spot prices, the above equation underestimates the *CMBP* prices relative to the equation in the body of the table.

[b] See text for method of construction.

simulated series to the actual series (futures, producer prices, and revenues) and thereby comment on the worth of the ICA. To do this, the following steps are necessary: (1) simulate the model under free market conditions and validate the model, (2) simulate the model under controlled (ICA) conditions, and (3) compare the revenues and comment on gains or losses from the ICA.[10]

In simulating the past behavior of market processes, a few options are open to us with regard to the type of exogenous variables to use: we could use the observed values of exogenous variables of the same year or periods, or allow the structural equations to forecast these values. For our short-run simulation, we ran two models. In the first model run (Model I) we assumed that the generated prices have no influence on the yearly demand and supply structural equations, and hence we used the observed values. For the second model run (Model II) we recognized that, in the short run, prices affected the yearly grindings (demand) but did not affect the supply response function. Thus, in this case we allowed the demand function to generate the demand exogenous variable. We then generated the monthly demand forecasts via the demand indexes and used them to calculate the expected prices. However, at the beginning of each season we adjusted for the actual initial values.[11] The simulation run in which there are no adjustments of any kind does not interest us. The results of Model I and II will be used to calculate the worth of the ICA.[12]

SIMULATION RUN RESULTS AND ANALYSIS

By using Fortran programming, we were able to incorporate most of the important decisions which would have been made by the Cocoa Council and by the buffer stock authority: when the Cocoa Council should implement basic quotas and sales quotas, and when and how the buffer stock authority should intervene in the futures market (see Appendix 1).

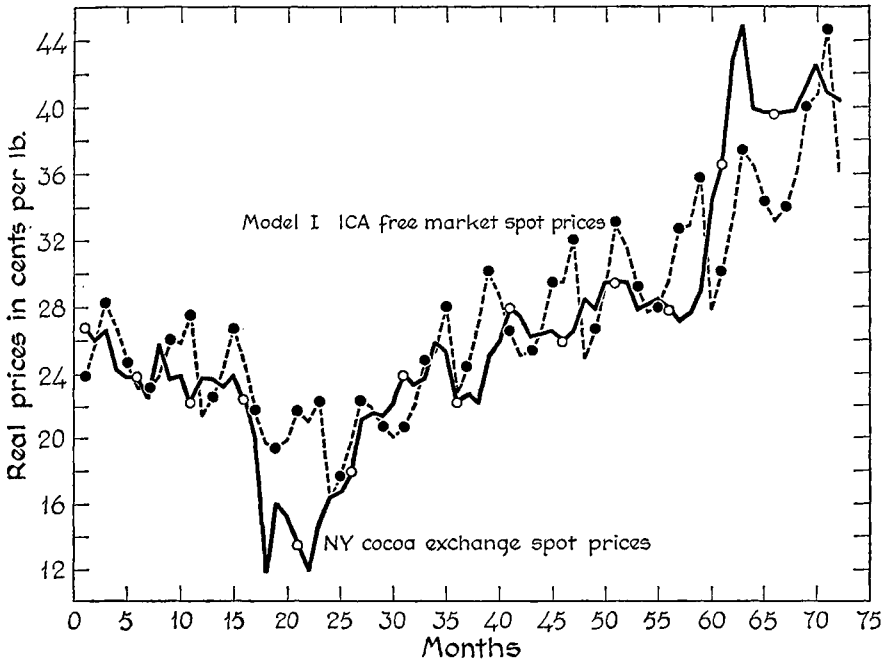
Selected historical time paths of the simulation run for the two models are shown in Charts 2, 3, and 4. The charts were constructed from information generated by the simulation run. Sample figures from Model I are shown in Table 4. The table shows simulated world prices, revenues of the six major producers and

[10] In order to use the simulation model for forecasting prices and revenues—as representing the economic processes—we must validate the model. One of the ways to approach the validation problem is to test the forecasting efficiency of the generated series by comparing it to the actual series. The time period chosen for the present study allows us to validate the simulation model, as a by-product, while presenting an analysis of our results. This is done later.

[11] In the cocoa industry, at the beginning of a season, the past year's actual grindings (demand) is known fairly accurately. The buffer stock authority, or any user of such a model, may adjust his demand estimate of the past year accordingly, before the start of the new season. In the Draft International Cocoa Agreement of 1968, the Cocoa Council is supposed to set the sales quota for the season based on an estimate of world grindings. Thus, SQ_T is fixed. If sales quotas are implemented, the buffer stock authority may use Model II—the demand-price simulation technique—to predict the probable quantities of cocoa beans to buy from or sell to the market, at the agreed price levels, in order to make adequate preparation for storage space and procurement fund. The buffer stock authority may also use the model to aid it in controlling the prices within the agreed limits. Producers, consumers, middlemen, and speculators may use such a model to aid them in decision making.

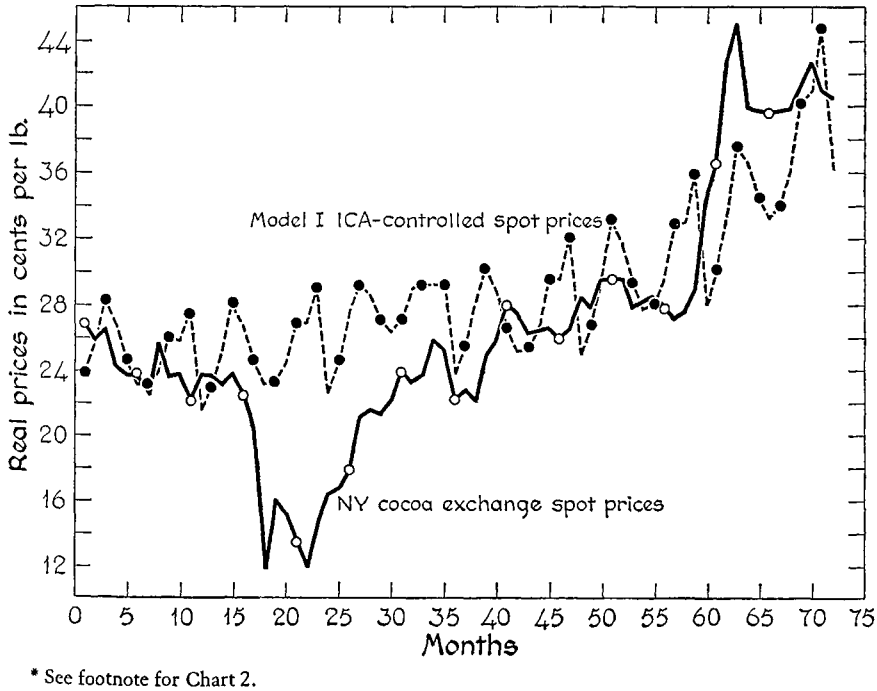
[12] In such an "ex-post" simulation of a market process, we may use Model I to calculate the worth of the ICA, by computing the difference between the controlled market and free-market runs. Alternatively, we may use both models to calculate the gains from the agreement. In this case we recognize that when the market is under the control of the buffer stock authority, the actual amount consumed will be controlled or influenced by the buffer stock authority's forecast of market conditions. Thus, the demand-price model (Model II) will be called into play; otherwise Model I will be the relevant market situation. This computation is shown in Table 5B.

CHART 2.—ACTUAL FREE MARKET PRICES COMPARED WITH (MODEL I) ICA FREE MARKET PRICES, 1963/64 TO 1968/69 SEASONS*



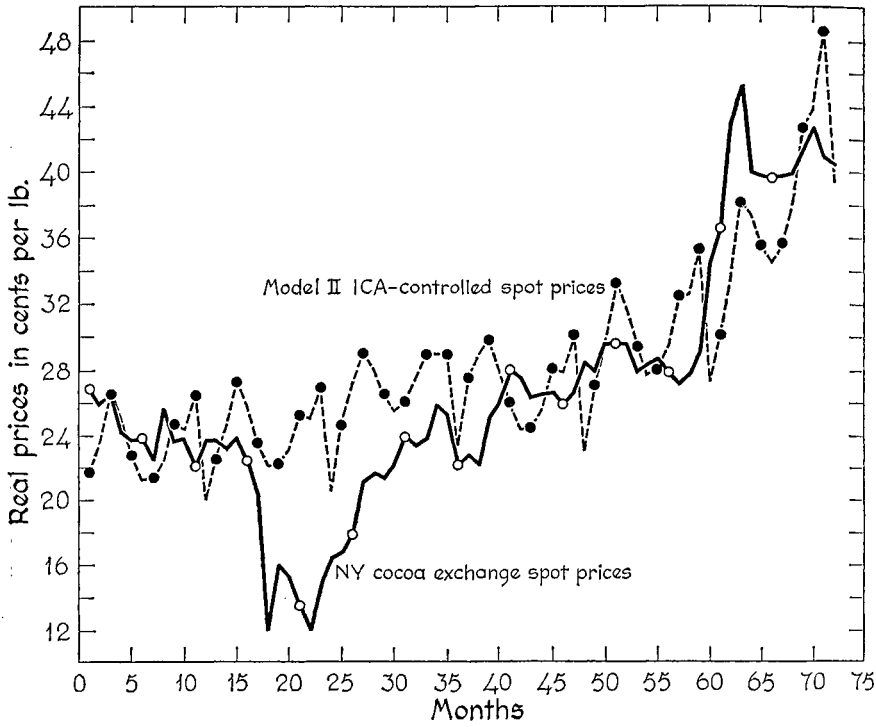
* Ghana spot price on the New York Cocoa Exchange from Gill and Duffus Ltd., *Cocoa Market Reports* (various issues, London), deflated by the U.S. Bureau of Labor Statistics wholesale price index for all commodities 1963 = 100; compared with simulated ICA prices as described in text.

CHART 3A.—ACTUAL FREE MARKET PRICES COMPARED WITH (MODEL I) ICA-CONTROLLED PRICES, 1963/64 TO 1968/69 SEASONS*



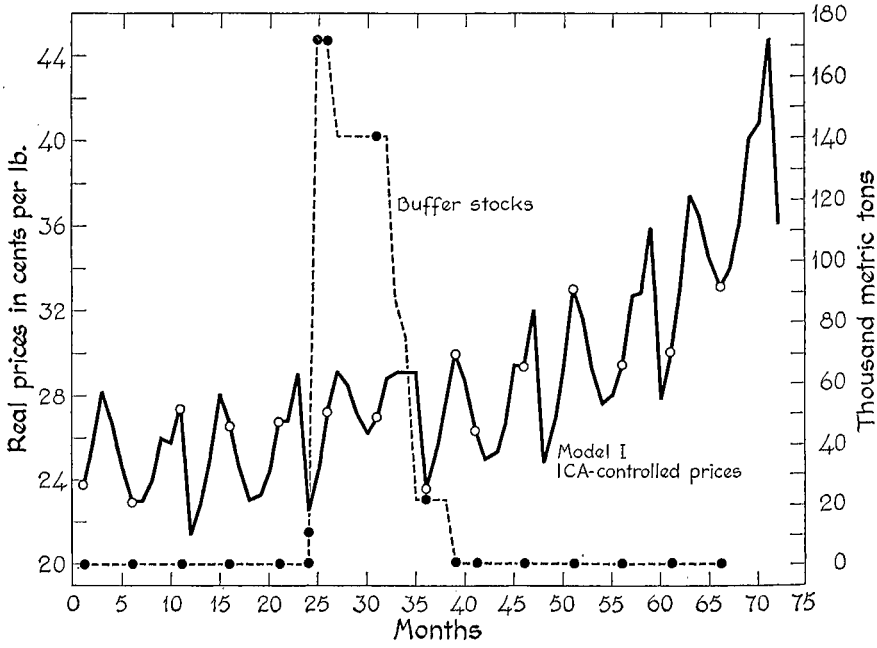
* See footnote for Chart 2.

CHART 3B.—ACTUAL FREE MARKET PRICES COMPARED WITH (MODEL II) ICA-CONTROLLED PRICES, 1963/64 TO 1968/69 SEASONS*



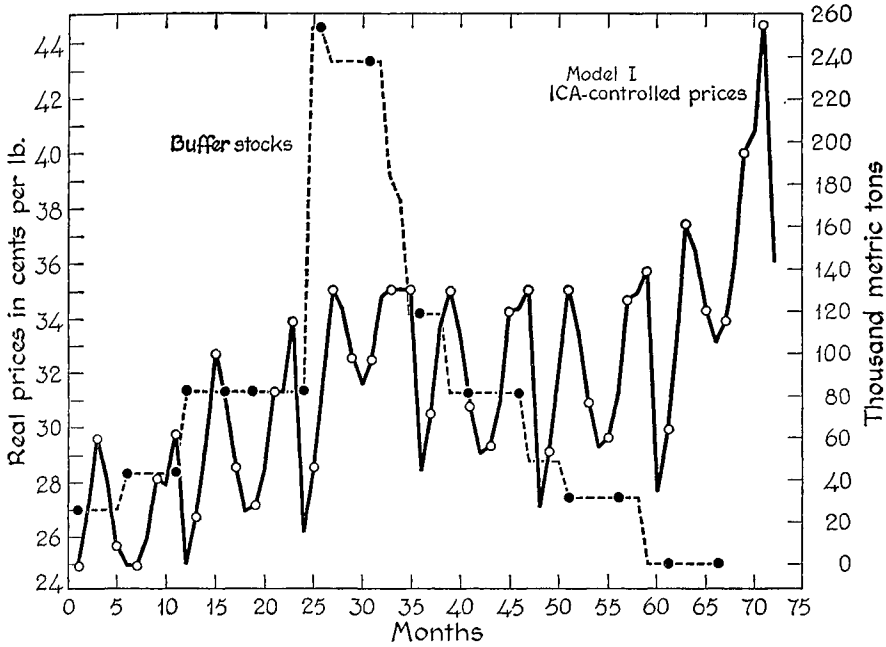
* See footnote for Chart 2.

CHART 4A.—MODEL I, ICA-CONTROLLED PRICES COMPARED WITH BUFFER STOCKS, 1963/64 TO 1968/69 SEASONS: PRICE RANGE OF 20–29 CENTS A POUND*



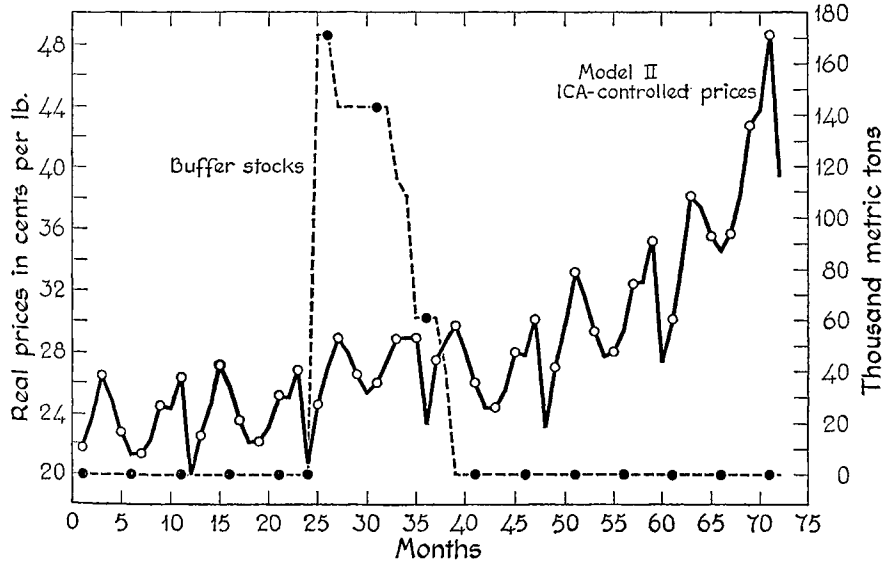
* Simulated data.

CHART 4B.—MODEL I, ICA-CONTROLLED PRICES COMPARED WITH BUFFER STOCKS, 1963/64 TO 1968/69 SEASONS: PRICE RANGE OF 25–35 CENTS A POUND*



* Simulated data. With the price range 25–35 cents a pound, the buffer stock authority would have controlled the market most of the time.

CHART 4C.—MODEL II, ICA-CONTROLLED PRICES COMPARED WITH BUFFER STOCKS, 1963/64 TO 1968/69 SEASONS: PRICE RANGE OF 20–29 CENTS A POUND*



* Simulated data.

the rest of the producers as a group, and other relevant information about them.

Charts 2 and 3 show the time paths of the actual New York Cocoa Exchange Accra spot prices charted against the simulated free market and the controlled market spot prices. The computer program had a memory section that recorded additions to or depletions from the buffer stock inventory. The time paths of these changes are shown in Chart 4. The operations of the buffer stock mechanism are more pronounced in the model run where the price range is between 25 and 35 cents per pound.

The 1964/65 season was a bumper crop year, and the computer program designated it "a quota year." The excess supplies were sold to the buffer stock authority at the end of the season.[13] Chart 4A shows that the authority made a purchase of 171,000 tons of cocoa at the end of that season. Under Chart 4A rules, most of the stocks were sold by the first quarter of the 1966/67 season. Thus, if the 1963 Cocoa Conference had ratified the cocoa draft agreement, the unusually low prices which prevailed in the 1964/65 season could have been avoided (see Charts 2 and 3). The time paths of the various prices have shown that the price levels are raised and the amplitude of fluctuations are shortened whenever the buffer stock mechanism operates. The simulation affords us the opportunity to make objective analysis of income and gains or losses from the stabilization scheme.

Analysis of Revenues and Gains from the Buffer Stock Stabilization Scheme

The revenue results obtained from our free market simulation study were almost identical with the actual revenues that were reported by some of the producing countries from the sales of cocoa. These results attest to the validity of our simulation model.[14] The Ghana Cocoa Marketing Board reported sales for the 1963/64 season of $211,497,000 (*8*). Our free market simulation result for the

[13] The actual conditions on the market in 1965 showed that these excess supplies resulted in exceptionally low prices for cocoa for about eight months. This would not have been the case under an ICA (see Chart 3). Observed values on the market showed that the tonnage harvested in 1964/65 was 21.6 percent above the previous season's harvest, which was the largest up to that date and 22.7 percent above the following year's crop. Before the 1964/65 season the Cocoa Producers Alliance had agreed to withhold supplies in case prices fell below the agreed level. There were very few sales from October 1964 to January 1965. However, in February 1965 the Cocoa Producers Alliance collusive agreement broke down, in light of the bumper crop, and the producer countries started selling frantically. As a result of this "non-orderly" marketing, the futures prices did not reflect the supply and demand conditions on the market. We may say that the functions of the futures market—guidance of inventory and establishment of forward prices—was impaired during this period. These unusual conditions resulted in exceptionally low prices for cocoa (see Chart 2).

[14] One of the ways to approach the validation problem is to regress the generated series as a function of the actual series and test whether the resulting regression has an intercept which is not significantly different from *zero* and slopes which are not significantly different from *unity* (*5*, pp. 120–21). As commented earlier, a bumper crop was harvested during the 1964/65 season. This is shown on Chart 2, between the 16th and 24th months. Visually, the generated series overestimatd the actual spot market prices between the 16th and 25th months. Since the additional income due to the agreement was accumulated in these months, it may be pointed out that we underestimated the worth of the agreement. The validation test was performed on the entire generated prices (72 observations) and also for 64 observations, i.e., excluding the eight months of "non-orderly" marketing of cocoa (see fn. 13). We obtained the following results for the 72 and 64 observations, respectively:

$$P_S = -4.49 + 1.14\,P_E,\ R^2 = .76 \qquad P_S = 1.15 + 1.04\,P_E,\ R^2 = .73$$
$$(2.21)\ \ (.08) \qquad\qquad (2.28)\ \ (.08)$$

where P_S is the generated monthly average spot market prices and P_E is the actual New York Cocoa Exchange spot prices. The numbers in parentheses are the standard errors.

TABLE 4.—SIMULATION RESULTS: SELECTED SERIES FOR 1965/66, MODEL I*

	Year	Month 1	2	3	4	5	6	7	8	9	10	11	12
U.S. cents per pound													
Ghana spot price, New York Cocoa Exchange		24.4	27.2	29.0	28.4	26.9	26.1	26.9	28.8	29.0	29.0	29.0	23.5
Cocoa Marketing Board price		22.7	25.6	27.6	26.9	25.4	24.5	25.4	27.3	27.6	27.6	27.6	21.7
Thousand long tons													
Actual value													
Demand[a]	1,375	118.0	117.0	115.2	113.4	111.5	109.2	107.0	104.8	111.5	118.2	125.0	124.2
Supply[b]	1,198	72.0	61.1	49.6	125.1	138.1	125.6	91.0	70.6	52.8	105.7	73.1	233.4
Predicted value													
Demand		122.7	121.7	119.8	118.0	116.0	113.5	111.2	109.0	116.0	123.0	130.0	129.1
Supply		82.5	70.0	56.8	143.3	158.3	143.9	104.4	80.9	60.6	121.1	83.8	267.5
Buffer stock													
Total		171.0	171.0	139.4	139.4	139.4	139.4	139.4	139.4	85.2	72.6	20.7	20.7
Change		.0	.0	−31.6	.0	.0	.0	.0	.0	−54.2	−12.6	−51.9	.0
Month end inventory		382.0	326.1	292.1	303.7	330.4	346.7	330.8	296.6	292.1	292.1	292.1	401.3
Thousand U.S. dollars													
Buffer stock fund[c]	56,157	56,156.8	56,156.8	56,156.8	56,156.8	56,156.8	56,156.8	56,156.8	56,156.8	56,156.8	56,156.8	56,156.8	56,156.8
Producer net revenue[d]													
World	676,391	36,553.7	35,057.2	30,631.0	75,328.0	78,527.6	68,873.5	51,711.0	43,159.3	32,628.6	65,257.3	45,132.6	113,531.5
Brazil	79,070	4,273.1	4,098.2	3,580.8	8,805.8	9,179.9	8,051.3	6,045.0	5,045.3	3,814.3	7,628.6	5,276.0	13,271.8
Cameroons	45,048	2,434.5	2,334.8	2,040.0	5,016.8	5,229.9	4,587.0	3,444.0	2,874.4	2,173.1	4,346.1	3,005.8	7,561.2
Ghana	227,220	12,279.5	11,776.8	10,289.9	25,304.9	26,379.8	23,136.7	17,371.3	14,498.5	10,960.9	21,921.9	15,161.4	38,138.6
Ivory Coast	62,160	3,359.3	3,221.8	2,815.0	6,922.6	7,216.7	6,329.5	4,752.2	3,966.3	2,998.6	5,997.1	4,147.7	10,433.5
Nigeria	116,021	6,270.1	6,013.4	5,254.1	12,921.0	13,469.8	11,813.9	8,870.0	7,403.1	5,596.8	11,193.6	7,741.6	19,474.1
Others	146,872	7,937.3	7,612.3	6,651.2	16,356.7	17,051.5	14,955.2	11,228.5	9,371.6	7,085.0	14,170.0	9,800.1	24,652.2
Buffer stock sales[e]													
World	92,836	.0	.0	19,533.5	.0	.0	.0	.0	.0	33,470.3	7,773.4	32,059.0	.0
Brazil	10,853	.0	.0	2,283.5	.0	.0	.0	.0	.0	3,912.7	908.7	3,747.7	.0
Cameroons	6,183	.0	.0	1,300.9	.0	.0	.0	.0	.0	2,229.1	517.7	2,135.1	.0
Ghana	31,186	.0	.0	6,561.9	.0	.0	.0	.0	.0	11,243.7	2,611.3	10,769.6	.0
Ivory Coast	8,532	.0	.0	1,795.1	.0	.0	.0	.0	.0	3,075.9	714.4	2,946.2	.0
Nigeria	15,924	.0	.0	3,350.6	.0	.0	.0	.0	.0	5,741.2	1,333.4	5,499.1	.0
Others	20,158	.0	.0	4,241.5	.0	.0	.0	.0	.0	7,267.7	1,687.9	6,961.3	.0

* See text for description of the model, and Table 3 for the equations.

[a] Grindings: quarterly and annual from Gill and Duffus Ltd., *Cocoa Market Reports* (London), monthly data calculated using ratios shown in Table 3.

[b] Production: annual data from source cited in note *a*, monthly data calculated using ratios shown in Table 3.

[c] Accumulated by levy, see Table 5A.

[d] Excluding buffer stock sales: world total net revenue distributed among producing countries according to their respective average market shares as shown in Table 2.

[e] Total buffer stock sales: distributed among producing countries as described for net revenues.

TABLE 5A.—YEARLY WORLD AGGREGATE REVENUES (MODEL I): ICA-CONTROLLED COMPARED WITH ICA FREE MARKET*
(*Thousand U.S. dollars*)

Season	Free market (A)	Controlled market (B)	Buffer stock fund[a] (C)	Buffer stock and administrative expenses
1963/64	610,863	583,805	27,059	141
1964/65	616,122	637,794	29,097	141
1965/66	539,035	676,391		6,311
1966/67	747,959	751,579		326
1967/68	842,377	842,377		141
1968/69	936,826	936,826		141
Total	4,293,182	4,428,772	56,156	7,201
Gross for controlled market B + C		4,484,928		
Net	4,293,182	4,477,727[b]		
Net Gains from stabilization net B minus net A		184,545		

* Simulated by the author; see text.

[a] For the first two years producers paid one cent on a pound weight of cocoa sold to the buffer fund.

[b] Gross controlled market value less buffer stock operations costs of $7,201,000, of which $846,000 is administrative costs.

same period is $205,207,490 and controlled market simulation is $196,117,490.[15] (The statutory marketing boards no longer publish sales figures.) We may compute the gains from the buffer stock stabilization scheme by subtracting the free market run revenue from that of the controlled market, after having made allowance for costs associated with the buffer stock operations. Discussions with members of the New York Cocoa Exchange led to the estimate that it costs one-fifth of a cent per month to store one pound of cocoa in a Philadelphia-licensed cocoa warehouse. This cost includes rent, insurance, interest, and other services (22, p. 75). The computer generated monthly tonnages of cocoa stored by the buffer stock authority from which we could calculate the monthly storage costs. The buffer stock expenses over the period 1963/64 to 1968/69 came to $7,201,000. This included $846,000 of administrative expenses for a staff of six people in a New York office. The calculation of the additional income or worth of the ICA for Model I run amounted to $184,545,000, most of which accumulated in the 1965/66 and 1966/67 seasons. Tables 5A and 5B present revenue analyses for both models. The alternative calculation of the gains from the agreement using the results of both models is analyzed in Table 5B.[16]

[15] The controlled simulation is lower because $27 million was collected to finance the buffer stock operations.

[16] The revenue results of the Model I run may be interpreted under the assumption that the buffer stock authority predicted the aggregate world demand accurately while controlling the prices within the agreed limits. Alternatively, we may assume that the buffer stock authority used the demand-price model (Model II) to aid it in making decisions on quantities to sell to or buy from the market during the 1965/66 and 1966/67 seasons when it influenced the market. In the 1965/66 season the buffer stock authority would have controlled the market for the entire season and only for the first three months in the 1966/67 season. Thus, we may replace the revenues of the 1965/66

TABLE 5B.—CALCULATION OF WORTH OF AGREEMENT USING MODEL I AND MODEL II*
(Thousand U.S. dollars, except as otherwise indicated)

Season	ICA revenues Model I (A)	ICA revenues Model II yearly adjustment[a] (B)	Year end buffer stock for (A) *(long tons)*	Year end buffer stock for (B) *(long tons)*	Buffer stock and administrative expenses for (B)
1963/64	583,805	551,065	—	—	141
1964/65	637,794	582,931	171,000	171,000	141
1965/66	676,391	667,326	20,680	63,550	11,842
1966/67	751,579	718,062	—	—	549
1967/68	842,377	849,196	—	—	141
1968/69	936,826	1,008,598	—	—	141

Calculation of worth of ICA

Sum of Model I revenues excluding 1965/66 and 1966/67 seasons	= 3,000,802	(1)
Revenue 1 + 1965/66 revenue of Model II[b]	= 3,668,128	(2)
Revenue 2 + adjusted 1966/67 revenue of Model I[c]	= 4,447,555	(3)
Gross ICA [Revenue 3 + Buffer Fund Levy of $56,156]	= 4,503,711	(4)
Buffer stock and administrative costs	= 12,955	(5)
Net gains from stabilization [(4 − 5) − free market revenues, from Table 5A]	= 197,574	(6)

* Simulated by author; see above text.

[a] The demand quantities used in simulating Model II were generated by the regression equation in Table 3. At the beginning of each season we adjusted for actual initial conditions. As we have pointed out, the simulation run in which there are no adjustments of some kind does not interest us.

[b] Model II revenues were used because under an ICA the actual demand for the year would be equal to the value forecast by the buffer stock authority and regulated by it.

[c] Note that for the 1966/67 season the buffer stock authority will have (63,550–20,680) 42,870 long tons on hand. In both Model I and Model II the buffer stock authority sold all its stocks by the third month of the 1966/67 season. Hence, the buffer stock authority would have sold the 42,870 tons at 29 cents a pound by this time. This amounted to close to $28 million. Since 42,870 was only 3 percent of the supply for the 1966/67 season, we assumed that this additional supply injected by the buffer stock authority did not affect the overall price levels for the year. Thus, the revenue for the 1966/67 season was adjusted from 751,579 to 779,427.

CONCLUSIONS AND INFERENCES FROM THE STUDY

The simulation study showed that had producers and consumers ratified the 1963 Draft Agreement for three years or more, producing countries would have been better off in terms of earnings by about $185 million, net of costs of running the stabilization scheme.[17]

The records show that, as a result of the excess supplies of the 1964/65 season,

season in Model I by that of Model II and also adjust the value of the 1966/67 revenue in Model I and recompute the worth of the ICA. Such a computation resulted in a gain of about $198 million.

[17] This did not take into account the costs involved in establishing an ICA. We pointed out earlier that the United Nations and its agencies have been trying since 1956 to design, negotiate, and implement an ICA on cocoa without success. However, we may argue, intuitively, that these costs so far are much less than $185 million. Most of these costs are fixed costs that will be incurred anyway, without an agreement.

There is room for improving the present model. For example, the seasonal indexes could be updated continuously. Perhaps a more sophisticated model would have predicted much higher earnings. As we pointed out earlier (fn. 15), we underestimated the worth of the ICA because our model overestimated actual New York Cocoa Exchange spot prices in the 1964/65 and 1965/66 seasons. However, improved models will have to await improved data collection in the cocoa market.

the cocoa industry experienced low prices which could have been alleviated by an ICA. Cocoa was sold by some major producers at nine cents a pound, equalling the undeflated prices for cocoa in the war years and at early stages of the great depression. We may conclude, according to our simulation study, that producers would have benefited from the stabilization scheme.[18] As it was, most of the major producing countries faced economic hardships in 1965 and 1966. Low prices and subsequent low incomes continued beyond the 1964/65 season and contributed to political instability in Ghana, which helped to cause a military take-over of the government.

In summary, we may conclude that an ICA, such as the proposed Draft International Cocoa Agreement, based on buffer stocks and sales quotas control mechanism, if implemented under the decision rules taken for the simulation run and also under a condition of excess supplies, would be beneficial to producers. We may also conclude that a buffer stock is a desirable policy measure.

Further inferences may be drawn from this study concerning the design and the technical administrative operations of an ICA. For example, with the aid of a computer, we can set up such a model and run a series of historical time paths under different economic behavioral and structural assumptions to simulate ex post or ex ante forecasts to help us design an optimal type of an ICA for the commodity involved.

Secondly, buffer stock authorities may employ such a simulation technique as an aid in short-term decision making. As pointed out in our study, the structural parameters and the supply and demand indexes comprising the econometric model can be updated monthly. Hence the buffer stock manager could predict the monthly supply and demand adequately and therefore make optimal decisions concerning quantities of cocoa to buy from the market or sell to the market, and also make adequate preparation for storage space and procurement funds.

In the next decade we can expect revolutionary changes in agricultural production, at least in world cereal production, and to a lesser extent in the cocoa industry, due to rapid advances in agricultural technology and productivity—the green revolution. There will be a general tendency for world output of various products to be in excess of world demand at current prices. Some developing country importers will become potential exporters. In the short run, domestic and international commodity prices will fluctuate excessively due to uncertainties in the shifts of the supply schedules and in all probability there will be a long-run downward trend in commodity prices and earnings. Developing countries will face difficulties in entering new markets and will need to adjust to marketing policies of the importer countries and build export services and internal buffer funds. These changes will demand adjustments in internal as well as in international trade that will involve government intervention in pricing, in shaping marketing policies, and in negotiating international agreements. Elsewhere in this issue, E. M. Ojala, Assistant Director-General of the Economic and Social Policy Department of FAO, foresees the need for an international framework to solve the adjustment problem, but does not suggest a model: "A much more

[18] The bumper crop of the 1964/65 season was followed by light crops in the 1965/66 and 1966/67 seasons, making it possible for the buffer stock authority to sell all the stocks accumulated in the 1964/65 season at 29 cents a pound in the next two seasons.

broadly acceptable international framework for such adjustments, of which there is no sign at present, will have to be formulated and negotiated, if the benefits of agricultural science and technology are to be widely and equitably shared among the peoples of the world" (*17*, p. 127). It seems that international agencies and governments will have to design models similar to the one developed above to solve the adjustment problem. Herein lies the usefulness in using the simulation approach as an aid in decision-making to solve the "commodity problem."

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APPENDIX 1

MEMORANDUM OF AGREEMENT*

The following is the text of a *Memorandum of Agreement* adopted today at the conclusion of the cocoa consultations. The Memorandum will be submitted to the resumed UN Cocoa Conference which is expected to be held later this year.

"At the UNCTAD Cocoa Consultations held in Geneva from 25 September to 4 October 1967, the following matters were unanimously agreed to by the delegations represented at the Consultations for inclusion in the agreement to be concluded at a resumed United Nations Cocoa Conference.

1. If, at the time the Council fixes annual sales quotas under Article 29, the indicator price is between 24½ and 28 cents, quotas do not become immediately operative, unless the Council by special vote decides to put them in operation.

2. Where quotas are not in operation, producing countries may not sell more than [75 percent] of their annual quota in the first two quarters or [95 percent] in the first three quarters.

3. If the indicator price falls to 24½ cents, the quotas set at the beginning of the year automatically come into operation.

(a) *When indicator price moves downwards from 24½ cents*

At 22 cents: The Council would meet to review the market situation and to decide, by special vote, on possible action to defend the minimum price (20 cents).[1]

At 21 cents: *(lower intervention price)* Automatic sales quota cut of 3½ percent unless the Council decides on a different figure under Article 33.

At 20 cents: Further automatic sales quota cut of 3½ percent.

(b) *When indicator price moves upwards from 20 cents*

At 22 cents: Restoration of the sales quota cut made at 20 cents.

At 23 cents: Restoration of the sales quota cut made at 21 cents.

At 24½ cents: If quotas are in operation and if the indicator price rises to 24½ cents, the Council shall be convened and shall meet within 10 days. If the Council is not able, within 5 working days, to come to an agreement by special vote on whether to retain or increase or suspend quotas, then quotas shall be suspended automatically unless in the meantime the indicator price has declined below 24½ cents.

(c) *When indicator price moves upwards from 24½ cents to 29 cents*

At 27 cents: Council meets to review market situation and to decide, by special vote, on possible action to defend the maximum price (29 cents).[2]

At 28 cents: *(upper intervention price)* Automatic suspension of sales quotas if any are in force, and commencement of mandatory sales from the buffer stock."

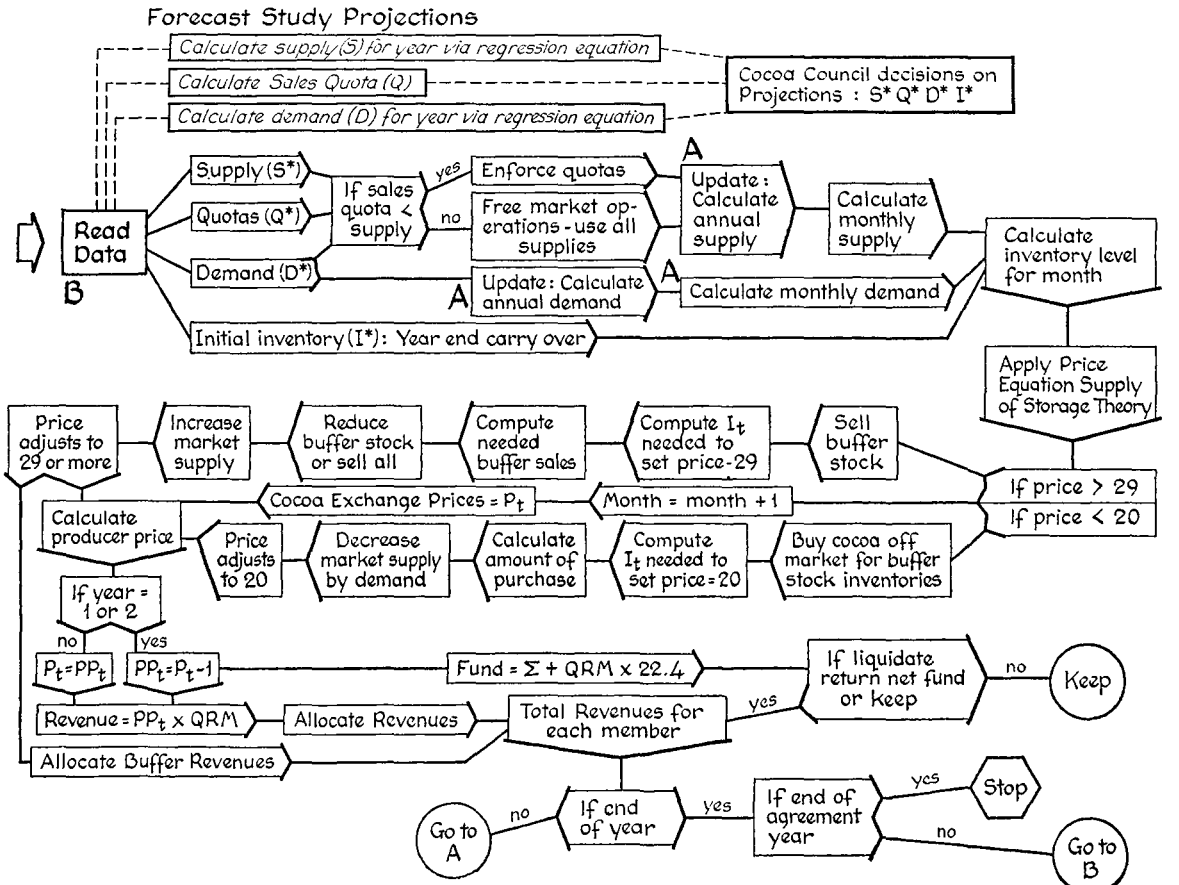
The fourteen countries attending the cocoa consultations were Brazil, Cameroon, Ecuador, Federal Republic of Germany, France, Ghana, Ivory Coast, Mexico, Netherlands, Nigeria, Switzerland, USSR, UK, and United States.

* UNCTAD Press Release, 4 October 1967 (TAD/256).

[1] The possibility of a sales quota cut is not excluded.

[2] The possibility of sales from the buffer stocks is not excluded.

APPENDIX 2
SIMULATION FLOW CHART



APPENDIX 3

The Simulation Algorithm

1. Start the system. Read in all variables and parameters.

2. Calculate the demand (GR) and supply (QR) for the year using the regression equations. (At times the observed values of these exogenous variables may be read in.)

3. Beginning with the first year, generate the monthly quantities for demand (GRM), supply (QRM) and sales quotas (WQ), if you are enforcing quotas. The monthly seasonal indices for supply and demand are RAT and BAT respectively. When these ratios are multiplied by the yearly supply and demand, the values generated are the monthly sales and purchases.

4. Decide if quotas are to be enforced:

(a) If world sales quotas (WQ)—computed by the "highest production"—are less than supply, enforce sales quotas.

(b) Otherwise use QR for the year.

5. Begin monthly calculation: Calculate the "supply of storage" for the current month

$$IRM = I_{t-1} + s_t - d_t$$

or

$$IRM(K) = IRM(K-1) + QRM(K). - GRM(K)\,.$$

6. Find the ruling market price for the month by using the price equation.

7. Recompute 5 and 6, if necessary, depending on the market price level using the following decision rules:

UPPER LIMIT RULES

(a) If price $[P(K)]$ is greater than 29, compute XRM, which is the "supply of storage" needed to restore price level to 29. Compute XRM by using the price equation and setting $P(K)$ equal to 29. Now find ASU.

$$ASU = XRM - IRM(K)\,.$$

ASU is the additional supply to be added to $IRM(K)$ to restore the price.

(b) Is there enough inventory in the buffer stock, $BS(K)$? If $ASU > BS(K)$, the buffer stock manager sells $BS(K)$; otherwise he sells only ASU. In either case the value is added to $IRM(K)$. The program records the buffer stock transactions, sales and changes in inventory.

LOWER LIMIT RULES

(c) Once again XRM is computed by using the price equation and by setting $P(K)$ equal to 20. In this case, XRM is the total amount of supply of storage to be supplied in that month to restore the price level. ASL, the amount to be taken off the market, is calculated and subtracted from $IRM(K-1)$, the initial inventory and the buffer stock transactions are recorded.[8]

$$IRM(K) = \text{Initial inventory} - ASL\,.$$

Record the buffer stock transactions:

$$\text{New buffer stock value} = BS(K) + ASL\,.$$

[8] We should have carried out a buffer stock limit test: If $BS(K)$ capacity is filled, we divert the excess to non-traditional uses. For example, cocoa may be sold to makers of soap, or margarine, or cosmetics, at cheap prices. We made the assumption, and correctly so, that the limit was never reached.

8. The prices generated by 6 are Cocoa Exchange spot prices. Now compute $PP(K)$, the producer or *CMBP* price.

9. Compute the revenues and share them among the major producers and the rest of the world, treated as one producer, and also collect the funds to finance the buffer stock operations. For the first two years collect a "fund" by a levy of 1 cent per pound weight of cocoa sold. Thus revenues for the month are given by:[4]

$$[PP(K) - 1] \times QRM.$$

If there was a sale by the buffer stock manager, the buffer stock revenue is given by *DLRS* function:

$$DLRS = BSCH(K) \times PP(K)$$

where *BSCH* is the change in buffer stock reserves. The revenues, so calculated, are shared among the producers according to historical market shares for each month. At the end of the year sales quotas outstanding are sold to the buffer stock agency.

Comments on the Computer Realization of the Cocoa Market Models

The computer program realized most of the important decisions that would be made under a controlled market. However, there were important price control decisions that we failed to realize: The rules for decisions that are to be made when the prices are approaching the limits cannot be made in our model because our time periods are in monthly units, while the decisions are made with daily information. In the draft agreement, there is an automatic 3½ percent cut in sales quotas or a 3½ percent sale of the inventories in the buffer stock when prices average 21 cents or 28 cents per pound for six consecutive market days, respectively. Given this short time period, we cannot incorporate these decision rules in our model. The effect of the above decision rules will be to stabilize price fluctuations within the month. The time period that we chose, the monthly time period, was determined by the available data. Smaller time intervals would have been better. However, time series data on weekly or daily sales are not available.

[4] If the "fund" is not being collected, the revenue is given by $PP(K) \times QRM$.