AN ANALYSIS OF THE WORLD COCOA ECONOMY IN 1980

by

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A thesis submitted to the Graduate Faculty of
North Carolina State University at Raleigh
in partial fulfillment of the
requirements for the Degree of
Doctor of Philosophy

DEPARTMENT OF ECONOMICS

RALEIGH

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APPROVED BY:

Chairman of Advisory Committee

ABSTRACT

HOMEM DE MELO, FERNANDO BENTO. An Analysis of the World Cocoa Economy in 1980. (Under the direction of RICHARD ADAMS KING.)

This study is concerned with predicting various aspects of the world cocoa economy in 1980. Cocoa is an important commodity for many less developed countries mainly in terms of foreign exchange earnings, income, and employment.

In the 1960's some developments occurred in the world cocoa economy with possible effects for the cocoa sector. In this respect we should mention the creation of the European Economic Community, the movement in the direction of freer trade (Kennedy Round), the concession of preferential tariff treatment to products from developing countries (Generalized System of Preferences), and the interest in the arrangement known as international commodity agreements. In the context of such changes occurring in the world economy, this study attempts to increase the information available to cocoa producing countries with respect to how trade would be affected by policy changes taking place either in the production or in the consumption aspects of the cocoa economy.

The first objective of the analysis is related to obtaining estimates of prices, production, exports, consumption, revenues, expenditures, and trade flows in the cocoa economy under the assumption of free-trade conditions prevailing in 1980. The assumption of free-trade was relaxed in a second stage by introducing tariffs on cocoa as well as the European Economic Community (EEC).

The second objective of the analysis is related to the formation of an international agreement among producing countries with a view of exploiting their collective monopoly power in the cocoa market. Estimates

TO MY PARENTS

(To whom I owe the guidance and encouragement during a good part of my life.)

BIOGRAPHY

The author was born June 1, 1942, in Campinas, São Paulo, Brazil. His undergraduate program was done in the School of Agriculture of the Undersidade de São Paulo at Piracicaba, where he graduated in November of 1966. During 1967 and 1968 he worked with the Companhia de Armazens Gerais do Estado de São Paulo and with the Instituto de Economia Agricola, Secretaria da Agricultura do Estado de São Paulo, Brazil.

In 1969 he was granted a scholarship from the Ford Foundation with the purpose of pursuing a graduate program of study at North Carolina State University. In January, 1971, he received the degree of Master of Economics from that institute. His scholarship was extended by Ford Foundation in 1970 with the objective of pursuing a Ph.D. program in economics at North Carolina State University. During this time period, the author was on a leave of absence from the Instituto de Economia Agricola, São Paulo, Brazil.

The author married Miss Joyce S. Figueired in 1967, and they have a daughter, Marcia, four years old.

ACKNOWLEDGMENTS

The author wishes to express his gratitude to Dr. R. A. King, Chairman of his Advisory Committee, for the orientation provided throughout this study, and also during the most part of his graduate program of study. Gratitude is also extended to Dr. D. M. Hoover for many comments and suggestions during this study and orientation during the earlier part of his graduate program. Thanks are also due to Dr. R. L. Simmons, Dr. A. R. Gallant, and Dr. J. O. Williams, members of the Advisory Committee.

Appreciation is due to Harriet McLaughlin for the statistical and programming analyses, and to Mary Ann Justice for the efficient typing of drafts and the final version of this study. The author also thanks Ruth Good for editing this work.

Gratitude is also extended to the Ford Foundation for the financial support during the time of the author's scholarship for graduate work in the United States; also to the Instituto de Economia Agricola, Secretaria da Agricultura, São Paulo, Brazil, for the leave of absence provided.

The author will forever be grateful to his wife, Joyce, for all the encouragement, support, and patience during the time of his graduate study. To his daughter, Marcia, who will understand it in the future, our final appreciation and gratitude.

TABLE OF CONTENTS

TABLE OF CONTENTS (continued)

LIST OF TABLES

LIST OF TABLES (continued)

LIST OF FIGURES

LIST OF APPENDIX TABLES

Page

Appendix C

In addition, the existence of tariffs on cocoa would have a very minor effect on the cocoa trade, given that most of the reductions or eliminations of tariffs were already made during the 1960's.

The possibility of producing nations acting together to exploit their collective monopoly power in the cocoa market was considered under three different arrangements. It was found that producing countries can make considerable welfare gains (for the five major producers, although Ghana, Nigeria, and Ivory Coast, are the ones to gain the most) at the same time that all producing countries can increase their foreign exchange revenues (Model 6 presenting a more balanced distribution of the increase).

of the same variables mentioned above would be obtained and comparisons (in welfare and revenue terms) made with those in the first objective.

The spatial equilibrium framework in international trade is the approach used in the study, and in this context, the reactive programming procedure is the specific method applied for obtaining the equilibrium solutions in the analysis. Before such solutions could be obtained, however, two steps were required: first, to obtain estimates of unit transportation costs for cocoa beans in international trade, and second, to obtain estimates of cocoa demand and supply functions for all countries in 1980. Estimates of unit transportation costs for all pairs of centers were obtained with the use of a simple linear regression of unit costs on distance among pairs. With respect to the other requirement, two models (partial adjustment and polynomial lag) were used to obtain estimates of demand functions in ten countries. On the supply side, a polynomial lag model was used to obtain estimates of supply functions for the five major producing countries (for the remaining nations, a fixed supply was assumed for 1980). For the remaining countries on the demand side and for those on the supply side with poor statistical results, an alternative technique was used, that is, with information about 1980's production and consumption projections and values for the respective elasticities.

With the application of the reactive programming algorithm to obtain the equilibrium solutions to our spatial problem, it was found that the introduction of the EEC (old membership) caused changes in the cocoa economy, benefiting those African countries associated with it. The new EEC membership, however, would cause the pattern of trade to be reverted to a situation quite similar to the free trade pattern.

CHAPTER 1
INTRODUCTION

Cocoa is one of the most important primary commodities in terms of production and exports for several of the less developed countries today. Its importance, as a crop providing income and employment opportunities in the agricultural sector of tropical countries and foreign exchange earnings, is the justification for a closer investigation of the interrelationships in the world cocoa economy. Ghana, Nigeria, Brazil, Ivory Coast and Cameroon are the leading world producers, but the crop is also important for many other smaller countries in Central and South America, as well as in Africa.

As a first step toward defining the problem with which this study is concerned and the specific objectives of the analysis, the next section, of a descriptive nature, will present some of the relevant characteristics of the cocoa economy in the world. Economic and political factors will be considered with the objective of providing the necessary background for evaluating the present and future pattern of production, consumption, and trade of cocoa. Predictions of the cocoa market will be made for 1980 under different sets of policies, and, to accomplish this, a framework for analysis must be developed as well as the theoretical reasoning supporting it.

Description of the Cocoa Economy

Cocoa is one of a few commodities of importance in international trade where the major producing and consuming countries are clearly separated in geographical terms; the major producing countries are located in Africa and Latin America while the major consuming centers are European countries and the United States. Trade among countries is then the basic economic factor in the world cocoa economy, with the commodity moving from some of the underdeveloped countries to the developed countries of the world.

Cocoa is the basic raw material used in the production of chocolate and cocoa powder. The location of the major producing countries can be explained by the fact that cocoa is a tree crop which requires special climatic conditions found only in the tropics. Originally produced in Central and South America, cocoa production has been extended to many African countries, and today this continent is by far the largest producing region. The production data shown in Table 1 reflect this fact, since for the 1970/71 crop year, Africa was responsible for 73 percent of the world production and North, Central and South America for 25 percent.[1] In order of importance (same crop year) the major producing countries were Ghana, Nigeria, Brazil, Ivory Coast and Cameroon. Total production more than doubled from the average for the period 1946/47-1950/51 to the crop year of 1970/71. Considerable increases in cocoa production have been achieved in most African countries, the most important cases being Nigeria, Ivory Coast, Ghana, and Cameroon.

The six countries of the European Economic Community (Belgium, France, West Germany, Italy, Luxembourg, Netherlands as a group) and the United States constitute the largest import markets for cocoa beans

[1]The shift in world cocoa production can be noticed from the corresponding figures early in the century. As an average for the period 1901/02-1903/04, the Americas had 64 percent of world production as opposed to 26 percent for Africa (Schutjer and Ayo, 1967, Table 2, p. 5).

Table 1. Cocoa beans: Production by country, 5-year averages and 1970/71[a]

Continent and country	1946/47-1950/51	1951/52-1955/56	1960/61-1964/65	1965/66-1969/70	1970/71
	(thousand metric tons)				
N. and Central America	62.8	71.8	90.0	79.8	81.8
Dominican Republic	29.9	31.5	38.3	31.3	35.0
Mexico	7.4	11.6	22.7	24.7	27.0
Other	25.5	28.7	29.0	23.8	19.8
South America	182.7	203.8	202.5	271.6	286.3
Brazil	127.8	135.2	117.8	171.5	181.6
Ecuador	21.8	29.8	43.6	54.8	61.0
Venezuela	16.7	20.6	19.9	23.4	19.0
Other	16.4	18.2	21.2	21.9	24.7
Asia	3.6	5.3	7.3	9.4	9.7
Africa	465.1	492.3	929.0	931.5	1,084.7
Cameroon	46.0	59.2	81.8	94.1	112.0
Equatorial Guinea	15.6	18.5	29.7	32.7	30.0
Ghana	241.4	232.3	458.3	392.3	396.2
Ivory Coast	45.2	59.9	105.1	147.0	179.6
Nigeria	99.6	100.7	216.1	220.5	307.8
Togo	3.5	5.3	13.4	18.7	28.0
Other	13.8	16.4	24.6	26.2	31.1
Oceania	3.8	4.8	18.7	25.9	32.5
New Guinea and Papua	0.2	0.8	14.1	22.4	29.5
Other	3.6	4.0	4.6	3.5	3.0
World total	718.0	778.0	1,247.5	1,318.2	1,495.0

[a]Source: Food and Agriculture Organization of the United Nations (1958-1972).

and cocoa products. They accounted together for about 50 percent of the world consumption of cocoa beans and products (in terms of beans) in 1970. Other large consuming countries are the United Kingdom, USSR, and Japan, as can be seen from Table 2. Total world trade in cocoa beans and cocoa products was close to one billion dollars in 1970, with the value of exports by region and most important countries presented in Table 3; 80 percent of all exports, expressed in dollars, were from African countries in 1970. Trade occurs not only for cocoa in the form of beans, but also the so-called cocoa products, basically cocoa butter, powder, paste, and chocolate. For a better understanding of these product forms, the following description of the stages in the industry may be useful (Hale, 1967):

1. The cocoa beans are first cleaned and graded.

2. In the next step, the beans are roasted, which is of help for developing flavor and color as well as to remove the shell.

3. The beans are then 'kibbled', meaning, cracked.

4. Winnowing is the next step, which removes the shell and germ, leaving behind the cocoa nib.

5. By grinding, the broken pieces of nib are converted into a liquid, known as chocolate liquor or mass, which can be used for making chocolate or cocoa powder.

6. The butter content in this liquor is about 55 percent, which is too high a proportion for cocoa powder; as a result, cake is first obtained by pressing and powder is obtained after the cake is pulverized and sieved.

7. If the purpose is the production of chocolate, cocoa butter is not removed from the liquor; it may even be added for the manufacture of lighter varieties of chocolate.

Exports of cocoa from producing countries are, to a large extent, exports of cocoa beans; cocoa products constitute only a small part of total exports in value. As an average for the years 1968-70, exports

Table 2. Average consumption of cocoa beans and cocoa products, in terms of beans, major countries of the world, 1957-59 and 1967-69 averages[a]

Region and country	1957-59	1967-69
	(metric tons)	
Western Europe	381,767	563,733
Belgium	17,084	23,752
France	51,712	79,157
West Germany	102,076	161,218
Italy	16,857	29,818
Netherlands	23,770	18,996
Spain	20,044	34,316
Switzerland	15,265	21,073
United Kingdom	94,654	124,551
Other Western Europe	40,305	70,852
Eastern Europe	58,185	185,982
Czechoslovakia	10,082	16,560
East Germany	11,920	17,351
Poland	7,863	20,711
USSR	23,454	105,610
Other Eastern Europe	4,866	25,750
North and Central America	303,698	433,754
Canada	27,450	40,920
United States	274,772	370,483
Other	1,476	22,351
South America	56,201	85,744
Brazil	13,545	22,012
Colombia	20,194	27,963
Other	22,462	35,769
Asia	19,686	75,711
Japan	9,046	49,112
Other	10,640	26,599
Africa	8,756	14,524
Oceania	15,691	25,184
Australia	12,328	20,044
Other	3,363	5,140
World total	843,984	1,384,631

[a] Source: Food and Agriculture Organization of the United Nations, (1958-1972).

Table 3. Value of exports of cocoa beans and cocoa products, averages and 1970[a]

Continent and country	1955-59	1960-64	1965-69	1970
	(million U. S. dollars)			
North and Central America	42.13	33.34	29.21	36.17
South America	127.98	86.91	116.04	410.93
Brazil	100.21	60.07	82.35	109.96
Ecuador	19.39	17.80	26.11	24.62
Other	8.38	9.04	7.58	6.35
Asia	2.30	1.82	2.04	3.10
Africa	361.79	407.63	503.83	761.51
Cameroon	41.66	35.43	53.06	83.84
Ghana	168.50	197.98	192.65	294.39a
Ivory Coast	43.83	44.47	78.47	115.25
Nigeria	79.05	98.74	137.06	208.06
Togo	5.85	5.40	9.66	24.56
Other	22.90	25.61	32.93	35.41
Oceania	4.62	8.18	14.16	17.40
World total	538.82	537.88	665.28	959.11

[a]Source: Food and Agriculture Organization of the United Nations, (1958-1972).

of cocoa beans represented 85 percent of total value of cocoa exports (Food and Agriculture Organization of the United Nations, 1973a). However, exports of cocoa products, although still a small proportion of the total, have been increasing in the recent past years -- these exports almost doubled in value from 1967 to 1970. Exports of cocoa beans and cocoa products have a great importance to many of the producing countries as a source of foreign exchange. For Ghana, for instance, cocoa exports accounted for 60 percent of the value of all exports, as shown in Table 4. One of the reasons cited in the literature (Hale, 1967, p. 140) for the concentration of cocoa processing industries and chocolate manufacturing in the larger consuming countries is the special care required by cocoa and chocolate during processing and storage; heat and humidity, characteristics of the producing countries of the tropics, would be much more difficult to control, unless a different pattern of capital expenditures was adopted there. These cost conditions, then, have led to the location of a large part of the processing and manufacturing of chocolate in the temperate regions of the world.

As another characteristic of the international trade in cocoa, it cannot be said that the movement of cocoa beans and products follows a pattern dictated by free market conditions. Tariffs exist in many of the consuming countries, and their rates with respect to each product form (higher rates for products than for beans) might affect the final pattern of location for the processing industries. In addition, trade blocs exist in the world today; the two most important for the cocoa industry being the European Economic Community (EEC) and the one formed by countries members of the Commonwealth. We have already emphasized

Table 4. Leading cocoa producing countries: Importance of cocoa as an exporting commodity and major cocoa producers, averages

Country	Cocoa exports as percent of total exports[a] 1968-1970	Cocoa production as percent of world production[b] 1968/69-1970/71
Ghana	60.5	27.4
Nigeria	17.5	17.4
Brazil	3.3	13.2
Ivory Coast	20.3	12.2
Cameroon	25.0	7.8
Ecuador	13.8	4.1
Dominican Republic	9.5	2.5
Venezuela	0.3	1.6

[a]Source: Value of exports FOB from United Nations (1973); value of exports of cocoa beans and cocoa products from Food and Agriculture Organization of the United Nations (1973a).

[b]Source: Food and Agriculture Organization of the United Nations (1958-1972).

the importance of the six countries of the EEC, as a group, in terms of cocoa consumption. The United Kingdom is also a large market for cocoa, representing as Table 2 shows, about 9 percent of the average consumption of the world in the period 1967-1969; the corresponding share of the EEC in the same period was 23 percent.

With respect to the EEC, the provisions of the Rome Treaty dealing with the common agricultural policy are not relevant for the case of cocoa, but the tariff provisions might be of considerable significance (Food and Agriculture Organization of the United Nations, 1962). With the creation of a customs union including not only the six countries referred to above, but also their overseas territories (independent countries now), the tariff provisions might affect the world cocoa economy in a considerable way. The reason is that cocoa is produced in many African countries which were under French and Belgian administrations, and they have already expressed their willingness to remain associated with the EEC;[2] with importance among the cocoa producing nations we have the case of Ivory Coast, Cameroon and Togo, and with a lesser importance, Congo ex-Belgian, Congo ex-French, Surinan, and Malagasy (Schutjer and Ayo, 1967, p. 14).

In general terms, the tariff provisions in the treaty of Rome specify that internal tariffs of the six members would be eliminated in three stages ending in 1970, with the tariff reductions applying as well to the overseas territories (countries). Also, the common level of

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[2]A formal agreement was signed by the EEC and 18 African countries at Yaounde, Cameroon (Yaounde Convention) in 1963 dealing with such association.

the external tariffs on imports from other countries would also be achieved in three stages (Food and Agriculture Organization of the United Nations, 1962). Imports of cocoa from the overseas territories (countries) would be free from tariffs, while a common tariff for the six members would be imposed on imports from other producing countries for cocoa beans and products. This preferential treatment would be expected to cause a changed pattern of production and trade, which might explain, at least in part, the great production increases obtained in Cameroon, Ivory Coast and Togo (Table 1). In addition, the situation today is one where the EEC is an enlarged community with the inclusion, as of January 1, 1973, of three other countries: United Kingdom, Ireland and Denmark, which together represent 10 percent of the world consumption of cocoa beans and products. This enlargement of the EEC, and the consequent inclusion of Ghana, Nigeria and other Commonwealth cocoa producing nations among the Associated Overseas Countries,[3] would be expected to have considerable effect on the structure of the world cocoa economy.

In addition to the development of trading blocs, the cocoa sector in world trade has been characterized by the attention given by international organizations (mainly, Food and Agriculture Organization of the United Nations) to the possibility of producing and consuming countries reaching an agreement with respect to the cocoa trade. The argument essentially runs in terms of stabilizing and/or increasing prices of the product over time. In the past, there was an attempt by the five

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[3]Countries which are signatories to the Yaounde Convention.

largest producing countries (in 1964) to form the Cocoa Producers' Alliance (the members being Ghana, Brazil, Nigeria, Cameroon and Ivory Coast), with the objective of withholding cocoa from the market to achieve a higher price level for the product. The attempt was a failure and Berhman (1968) indicates that the reasons were related to the fact that some countries did not withhold their entire supplies, and the skepticism of purchasers about the eventual success of the agreement, combined with the large stocks that were kept by consuming nations.[4] The basic economic argument, on which the proposal for an international agreement is based (from the producers' point of view), is related to the price inelasticity of demand for cocoa. The problem will be discussed in greater detail later on, but here it is stressed that one objective of producing countries would be to limit their supplies, raise the level of cocoa prices and keep prices at a higher level, the goal being one of increasing their foreign exchange earnings or, alternatively, of increasing their real incomes.[5]

The Problem

The previous section emphasized the importance of international trade in cocoa to the economies of several of today's less developed countries of the world, especially as a source of foreign exchange earnings. In such a context good decision making in the economic sector

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[4]Practically the same reasons are presented by Schutjer and Ayo (1967, p. 38) to explain the failure of the Alliance. In addition, they also present a clear description of all developments related to the Alliance (pp. 27-30).

[5]Chapter 3 will discuss and distinguish between these two cases.

of these countries requires the existence of information about how the pattern of trade would be affected by changes in their policies or by policy changes in the consuming countries. Since cocoa is an internationally traded commodity, prices received by producers and paid by consumers are not determined solely by economic forces inside one country's border. On the contrary, interdependence must be allowed if a complete understanding of market forces is desired. Supply and demand relations in all producing and consuming nations must be considered, as well as the fact that the relevant nations are geographically separated.

In the last decade some changes occurred in the world economy affecting directly the cocoa sector, consuming and producing countries at the same time. The European Economic Community is a case where, with respect to cocoa trade, some producers might be benefited and others may be economically hurt from the restrictions imposed on the free movement of goods internationally. Consumers are not different, with some of them probably paying higher prices for cocoa products; the expanded EEC is another change to take place in 1973 and affecting the world cocoa economy. Producing countries want to maximize their gains from trade, and they consider a form of an international cocoa agreement a possible means to achieve their goal. The situation is, to some extent, considerably more important when all the major cocoa producing countries are included in the category of underdeveloped nations attempting to increase income levels of their populations at a fast rate.

This study will be limited to one commodity in international trade, that is, attempting to predict various aspects of the world cocoa economy in 1980. To accomplish this purpose, knowledge about future supply and demand conditions for cocoa in several countries of the world is required. With the use of one specific model for obtaining the solution to spatial equilibrium problems, it will be possible to make predictions about trade flows, consumption, production, and prices of cocoa for each country or region involved, under different policies. Emphasis will be given to the situation of individual countries in each of the alternative policies to be considered, with considerably more attention given to each of the major producing nations, hoping in so proceeding to provide them with the economic information necessary for the process of decision making relevant to development.[6]

Objectives of the Analysis

In the context of the problem as described in the previous section, the broad objective of the analysis can be stated in terms of developing a model for the world cocoa economy in 1980 with the purpose of making predictions for different types of market arrangements. Along these lines, the specific objectives are:

1. To estimate prices for consumers and producers (revenues) in all countries (or regions), and the trade flows (imports and exports)

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[6] In the particular case of Ghana, Grayson (1973, p. 480) considers cocoa exports as more indicative when judging export projection; since the latter should be considered when determining the amount of external borrowing, the former becomes an important variable to be estimated. As indicated by the author, cocoa exports were overestimated for the period of the Seven-Year Development Plan (1963/64 to 1969/70), and may have been a factor explaining the worsened external debt position of Ghana. Chenery and Carter (1973, p. 465), in addition, point out that the failure to anticipate and adjust for the slow growth of cocoa earnings was the major reason for the retardation of growth in Ghana in the last decade.

of cocoa beans for 1980, by the use of the spatial equilibrium framework in international trade. Initially, the existence of tariffs and trading blocs (EEC, specifically) will be entirely ignored, and as a result, a free-trade solution will be obtained. They will be introduced, however, in a second stage, with a view to obtaining new equilibrium solutions under the presence of the above market imperfections.

2. To determine the effects upon world trade in cocoa for 1980, resulting from a possible agreement between the major producing countries (or all of them) with respect to limiting their exports of cocoa; within the framework of the spatial equilibrium problem, new solutions will be obtained for prices (producers and consumers) in all countries (or regions) as well as for trade flows. A comparison will then be made with the previous solutions (objective 1) for the variables involved, emphasis being given to this type of monopolistic cocoa pricing, in welfare terms as well as of foreign exchange revenue for the producing countries.

To accomplish these objectives some intermediate steps will be required. The first one will be to obtain estimates of unit transportation costs for cocoa beans in international trade; the second one will be to estimate cocoa demand and supply functions for the most important countries and project these relationships to 1980. The most important cocoa products are chocolate and powder, although a large part of the cocoa trade (from producing to consuming countries) is in the form of raw cocoa beans. In terms of estimating demand functions in several countries, we will be interested in the demand for cocoa beans as a derived demand. With this fact in mind, consumption will be measured in terms of beans-equivalent by using conversion factors to express the consumption of cocoa products (including the intermediate products, butter and paste) uniformly in terms of beans consumption.

CHAPTER 2
THE DEVELOPMENT OF INTERNATIONAL TRADE SPATIAL EQUILIBRIUM MODELS

The objectives of this analysis, as described in the previous chapter, emphasized the application of the spatial equilibrium framework for obtaining the solutions being looked for; however, no details about spatial equilibrium models were presented at that point. This will be the purpose of this chapter. Initially, the development of some of the models will be briefly discussed and then greater attention will be given to the specific spatial equilibrium model to be used later in the analysis.

The Development of Spatial Models

The transportation problem, accepted as a special case of linear programming, has, since its formulation and solution by Hitchcock (1941), had a great many applications in economic and business situations. The reason for this is its computational simplicity resulting from the special characteristics of the model; a systematic method of solution was first presented by Dantzig (1951).

In an interregional or international trade context, the problem can be formulated as involving a homogeneous product which is to be shipped in given amounts from each of a number of origins and received in a number of destinations also in given amounts. The transportation cost for a unit of the commodity is known for all possible pairs of origins and destinations and the problem is to determine the flows over all routes in such a way as to minimize the total cost of transportation.

Applications of the transportation problem are found for a large class of trade problems. In the context of interregional trade, King and Henry (1959) presented a discussion of the usefulness of the model in the single space dimension as well as for multiple-dimension models, i.e., space-form, space-time and space-form-time models. Also, Stemberger (1959) applied the transportation model to evaluate the competitive position of North Carolina eggs in the national market. In an international trade context, Brandt (1967) used the model to study the Brazilian competitive position in the world coffee market and to determine the effects of tariffs on the pattern of trade.

The transportation model, as mentioned, was recognized as being of great help for certain types of economic problems. However, the limitations were also clear, the basic one being the fact that regional consumption and production are exogenous to the analysis. There was then a need to develop new procedures which would allow production and consumption in all markets to be endogenous to the analysis.

A general formulation for the problem of equilibrium among spatially separated markets was given by Enke (1951): given the supply and demand functions for one product, at each of several localities, as a function of the product price there, and constant transfer costs among all possible pairs of localities, the objective was to find the final competitive equilibrium of prices in all localities, the quantities supplied and demanded in each market, and the product flows. The solution presented by Enke required the use of an electric circuit.

Samuelson (1952) was able to show that the descriptive nature of the problem as formulated by Enke could be turned into a maximization problem, which would also include the transportation problem, as above described, as a special case. This was achieved through the use of the concept of a "net social pay-off" (NSP), which is defined for any region as the algebraic area under the region's excess demand curve (equivalent but opposite in sign to the area under the excess supply curve). In the context of spatially separated markets the maximization of NSP is one of maximizing the sum of consumer and producer surplus, after discounting for transfer costs.

The procedure to obtain the maximization of NSP in a situation with several spatially separated markets with Samuelson's framework is not a direct one; in other words, as pointed out in his 1952 paper, a trial and error procedure would be used to determine the final market equilibrium, i.e., prices, production, and consumption in all regions. After this, the problem of obtaining the minimum transport cost flow solution would be solved by using the Hitchcock-Dantzig type of transportation model.

Takayama and Judge (1964b) were able to show that by assuming linear supply and demand functions with respect to prices, it is possible to convert Samuelson's formulation into a quadratic programming problem; in addition, a solution algorithm was specified to obtain the equilibrium solution for prices, quantities and interregional flows. The model so specified is general to the extent that it includes the special cases of linear demand functions and fixed supplies, or fixed demands and linear supply functions, as well as the multiproduct case of linear demand and supply functions with linear substitution and/or complementary terms included. Takayama and Judge (1964a) and Takayama (1967) formulated the mathematical (quadratic) programming model as applied to international trade and incorporated import tariffs, export subsidies and import quotas as modifications of the basic model. The basic model, which might in an international trade context be called the free trade model, was also modified by Bawden (1966) to include other types of barriers to the unrestricted movement of goods, such as ad valorem import duty, variable import levy, percentage import quota, domestic support price and domestic acreage allotment.

The quadratic programming approach to the solution of spatial equilibrium problems was applied by Hsiao and Kottke (1968) to the dairy industry in the northeast region of the United States; in an international trade context Bjarnason (1967) and Schmitz (1968) used the approach to predict the pattern of trade in 1980 for feed grains and wheat, respectively. Their study incorporated many of the government policies related to trade cited above, and also included the possibility of bilateral trade agreements.

Reactive Programming

The reactive programming procedure for obtaining the solution to spatial equilibrium problems was introduced by Tramel and Seale (1959), and at the same time applied to a problem with fresh vegetables in the United States. The procedure was defined as "a means of obtaining the equilibrium flows of a commodity between areas with given transportation cost functions, given demand schedules in each of the several areas of consumption and given supply schedules in each of the several areas of production" (Tramel and Seale, 1959, p. 1012). At the same time, it is noted that the development of reactive programming preceded the quadratic programming formulation of Takayama and Judge as discussed in the previous section; however, somewhat less attention and use of the reactive programming procedure, as compared with the latter, can be observed in the literature. Some of the controversies concerning the procedure will be noted below; at this point it should be said that reactive programming was expanded to include other types of problems besides the above type of application for fresh vegetables (fixed supply areas and demand schedules in the consuming regions). In such a context, the procedure can handle problems where demand and supply functions are defined for consuming and producing regions (with and without limits on supply), the inclusion of competing products, consideration of the time dimension, as well as the monopoly case. The power of the procedure, as exemplified by the above areas of application, is the main factor indicating reactive programming as a very general procedure for solving spatial equilibrium problems.

Contrary to the transportation model and the quadratic programming formulation, as discussed previously, no objective function is specified in the reactive programming procedure; the method consists of specifying a set of rules for obtaining the competitive equilibrium solution for the spatial equilibrium problem (Tramel and Seale, 1959, and Tramel, 1965). As a result, the procedure will provide at the same time the equilibrium quantities in each region and the flows among regions (which provides us with the least cost routes). These rules are presented in the above two publications and were extended to other types of problems by Seale and Tramel (1963). Here, it suffices to say that supply and demand functions may be defined either in linear or logarithmic form, with the price of the commodity being the dependent variable. The procedure is an iterative one, as a simulation of the competitive market mechanism, in such a way that net revenue to each shipper is maximized at the supply areas. The final equilibrium solution then is identified when no shipper can make any change in their shipping patterns in a way that would increase their returns.

Takayama and Judge (1963) reviewed the alternative methods that may be used for obtaining a solution to a quadratic spatial equilibrium model, by considering the one commodity and n region case. Their basic criticism of the reactive programming procedure primarily refers to two points: (a) the possibility that the procedure may not converge and, (b) because of the approximate nature of the solutions obtained, exact solutions could possibly be obtained only after an infinite number of iterations. In answering the above points, Tramel (1965) showed that for the type of problem specified above, the reactive programming procedure will always converge, but the convergence is an asymptotic one; with respect to the computer time necessary for obtaining the solutions, reactive programming should be emphasized as a procedure to obtain approximate solutions, where the level of accuracy is predetermined by the researcher. In such context the second criticism may have some weight, but only when absolutely exact solutions are desired. In addition, as pointed out by Tramel (1965) short cuts in computations can be used with the objective of saving computer time. King and Ho (1972) modified the Tramel program with respect to calculating the initial solution (which does not include transfer costs), and provided examples of applications of the procedure where computer time used was in the range from 3 to 14 seconds.

Only recently has reactive programming been used more frequently as the solution procedure for spatial equilibrium probelms. Pendse (1967) used the method to investigate the interregional and inter-seasonal competition in the U. S. beef industry. Zusman et al. (1969) also used the procedure to determine trade and welfare effects of EEC's tariff and reference price policy on the oranges market; this study is of a somewhat greater complexity in view of the combination of import duties and the EEC's reference price mechanism, as well as the fact that two varietal groups of oranges were considered. Finally, Jellema (1972) used reactive programming to analyze the world market for groundnuts and groundnut products in a free market context and also in the presence of import duties imposed by the major importing countries.

The Model and Data Requirements

Reactive programming will be used for obtaining the solutions to our spatial equilibrium problems. According to our objectives, as described in Chapter 1, we want to determine for 1980, and under three sets of policies in the world cocoa economy, equilibrium values for producer's and consumer's prices, imports, exports, and trade flows for cocoa (in bean-equivalents) for all countries involved. General presentation of spatial problems, in the context of obtaining solution by reactive programming can be found in Seale and Tramel (1963) and Tramel (1965); the following discussion relies heavily on their presentation, and at the same time emphasizes the data requirements for our analysis. The first step will be the definition of the variables involved in the problem; with this objective, consider the existence of m cocoa producing regions ($i = 1, 2, \ldots, m$) and n cocoa consuming regions ($j = 1, 2, \ldots, n$). Then, we define for 1980:

P_j = price of cocoa beans at consumption point in market (country) j.

P^i = price of cocoa beans at production point in country i.

Q_{ij} = the trade flows of cocoa beans, i.e., exports from country i which are imports of country j.

T_{ij} = unit cost of transportation from country i to country j.

R_{ij} = net price of cocoa beans from country i in country j.

$\bar{R}_i$ = weighted average of all R_{ij}'s for country i.

D_{ij} = deviation of R_{ij} from $\bar{R}_i$ for producing country i and consuming country j.

Q^i = total fixed cocoa production in country i for the fixed supply situation, or the total production in country i for the case of supply functions.

Q_j = total quantity of cocoa beans consumed in country j.

Z_i = the limit on the quantity of the product which may be produced in region i for the case where supply is determined as part of the solution.

As part of the requirements for obtaining the equilibrium solutions to our spatial problem of the world cocoa economy, we must have demand and supply functions projected to 1980.[7] Using the demand side as the example, we need to estimate the following functions (in general terms):

$$Q_j = f\,(P_j \mid \ldots) \quad \text{for } j = 1, 2, \ldots, n.$$

The above functions can be estimated (for purpose of the reactive programming procedure) in linear or in logarithmic form. By taking into

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[7] For some countries of less importance as cocoa producers, we will be using point estimates of production for 1980.

account values of the other explanatory variables (demand shifters) in a future year, we are able to obtain estimates of the demand functions in 1980. Since under the reactive programming procedure the above functions must be defined with price as the dependent variable, we may write the following relations for 1980:

$$P_j = g\ (Q_j), \quad j = 1, 2, \ldots, n. \tag{1}$$

which denotes the price relation in each market. Since supply functions will be estimated for the most important producing countries, we can also write:

$$P^i = h\ (Q^i), \quad i = 1, 2, \ldots, m. \tag{2}$$

If we assume that unit transportation costs are independent of volume, we have:

$$T_{ij} = \text{constants, for } i = 1, 2, \ldots, m \text{ and } j = 1, 2, \ldots, n. \tag{3}$$

As a result, R_{ij}, which was previously defined as net prices, can be expressed as:

$$R_{ij} = P_j - P^i - T_{ij} \text{ for } i = 1, 2, \ldots, m \text{ and } j - 1, 2, \ldots, n. \tag{4}$$

The weighted average of the above net prices is then:

$$\bar{R}_i = \frac{\sum_j R_{ij}\ Q_{ij}}{\sum_j Q_{ij}}, \text{ for } i = 1, 2, \ldots, m \text{ and } j = 1, 2, \ldots, n. \tag{5}$$

By using Relations 4 and 5, the deviations of net prices from the average are expressed as:

$$D_{ij} = R_{ij} - \bar{R}_i, \text{ for } i = 1, 2, \ldots, m \text{ and } j = 1, 2, \ldots, n. \quad (6)$$

The restriction which must hold in the final solution can be formulated in terms of the above defined variables; these restrictions are derived from the principle that an equilibrium will be achieved for a group of countries when each producing country is in equilibrium with all possible consuming areas. The restrictions are:

$$Q_{ij} \geq 0 \text{ for } i = 1, 2, \ldots, m \text{ and } j = 1, 2, \ldots, n. \quad (7)$$

$$Q^i \leq Z_i \text{ for } i = 1, 2, \ldots, m. \quad (8)$$

This last restriction means that total production cannot be greater than the imposed limit. If the equality prevails in 8, the following restriction will apply:

$$\text{If } Q_{ij} \neq 0, \text{ then } R_{ij} = \bar{R}_i \geq 0 \quad (9)$$

$$\text{If } Q_{ij} = 0, \text{ then } R_{ij} \leq \bar{R}_i$$

for $i = 1, 2, \ldots, m$ and $j = 1, 2, \ldots, n$. If the inequality in 8 holds, the greater or equal symbol in 9 is replaced by the quality symbol. The meaning of the restriction is that all net prices corresponding to active routes must be nonnegative and also equal for all active routes. In addition, the net prices that would be obtained if using nonactive routes must be equal to or lower than the net prices obtained by actually using the active routes. From Relation 3 we observe that in equilibrium net prices in each of the producing areas (positive trade flows) will differ from prices at the consumer centers exactly by the unit transportation cost. The following restriction 10 is implied by 9 above:

$$D_{ij} \leq 0 \text{ for } i = 1, 2, \ldots, m \text{ and } j = 1, 2, \ldots, n. \tag{10}$$

Any solution satisfying the above restrictions is an optimum solution, although it is possible that alternate optima exist.

In addition, for the case where supply is not to be determined as part of the solution (that is, a fixed supply situation that we may have when dealing with the problem of an international cocoa agreement), the following restrictions must hold:

$$\text{If } \bar{R}_i > 0 \text{ then } \sum_j Q_{ij} = Q^i \tag{11}$$

$$\text{If } \bar{R}_i = 0 \text{ then } \sum_j Q_{ij} \leq Q^i, \; i = 1, 2, \ldots, m$$

which insures that all available supply is allocated when net prices are positive but not necessarily so if net prices are zero.

The assumptions necessary for obtaining the equilibrium solution for all variables in our problem of the world cocoa economy can be summarized as: (a) perfect competition in the trading activity, (b) a fixed point representing production and consumption in each market, points which are connected by transport cost independent of volume, (c) the product (cocoa beans) must be a homogeneous one; this assumption will mean that buyers of cocoa in international trade do not discriminate on the basis of origin or possible brand names.

CHAPTER 3
ANALYSIS OF TRADE POLICIES

As emphasized in Chapter 1, the objective of this study is to determine the spatial equilibrium in the world cocoa economy in 1980 under three policy alternatives, *i.e.*, free trade, trade under the existence of tariffs and trading blocs, and trade after the introduction of an international cocoa agreement. The variables whose equilibrium values will be determined include exports and imports by country (or region), commodity flows among countries (regions), and prices at consumption and production points. This chapter will present a theoretical analysis of the world cocoa economy in the presence of trade policies by the governments involved, *i.e.*, the imposition of import tariffs, existence of trading blocs, and the introduction of an international cocoa agreement. To facilitate the analysis, transport costs will not be specifically considered in this chapter; this will be done at a later stage in the analysis.

Import Tariffs

In this section we will investigate the effects of a tariff imposed on an imported good (cocoa beans) in a partial equilibrium framework. Basically, two types of tariffs can be distinguished: a specific and an ad valorem tariff. The former is a fixed amount per unit of the good being imported, and the latter is a fixed percentage of the unit value of the imported good. Several reasons for the imposition of tariffs as well as the resulting effects are presented in the literature of commercial policy in international trade (Freeman, 1971, Chapter 9, and Walter, 1968, Chapter 7). However, the cocoa case is a very peculiar one because cocoa beans are not produced in the important consuming nations of the world; as a result, most of the domestic arguments for protection lose significance and they will not be taken up here. Two of the reasons for the imposition of tariffs and their respective effects domestically and internationally will be examined: they are, the revenue and terms of trade reasons. To achieve this objective, a distinction will be made with respect to importing nations concerned. The first type of importing country will be the one with such a small importance in the world cocoa trade that the supply curve of imports is perfectly elastic; expressing the same point in different words, the country in question can import as much cocoa beans as wanted without affecting the unit price prevailing in the international market. The second type of importing country will be one with greater importance in cocoa trade such that the supply curve of imports (cocoa beans) is upward sloping.

The first case is presented in Figure 1 where D_c is identified as the domestic demand for cocoa beans (a derived demand), S_c is the perfectly elastic supply of imports (no domestic production exists); quantity imported is Q_1 at price P_1 prevailing in the world market. Now, the imposition of a tariff on imports causes the supply of imports to be shifted upwards, as represented by $S_c + t$, where t is the level of the tariff;[8] the price consumers pay domestically is given by P_2 and

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[8] In this case, since world price is unaffected, it does not matter whether the tariff is a specific or an ad valorem one. For simplicity, it is identified as a specific tariff in the amount given by t. Alternatively, the effect of the tariff can be observed by referring to a downward shift of the demand curve in Figure 1 (average revenue to exporters), the new curve passing through point A and parallel to D_c in the case of an excise tariff.

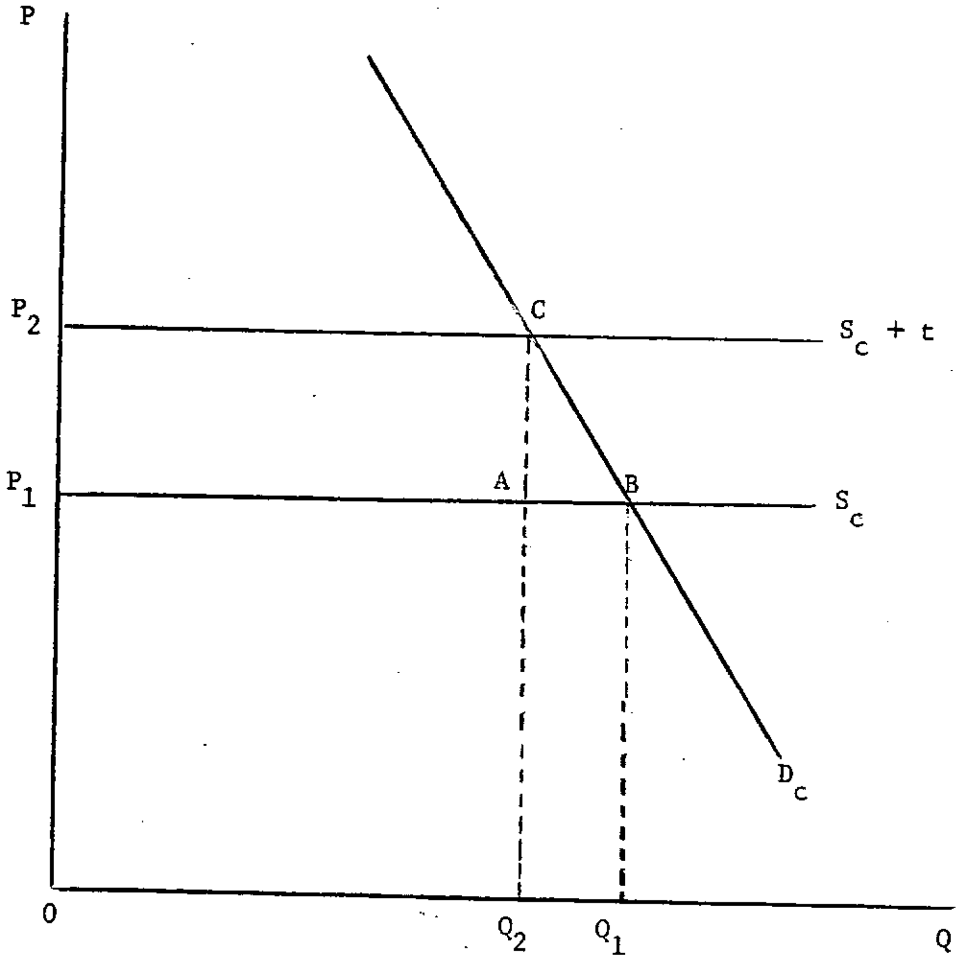

Figure 1. The effects of a tariff on cocoa imports -- the small country case

quantity imported is reduced to Q_2, but world price of cocoa beans remains unchanged at P_1. The price difference $(P_2 - P_1)$ times the amount imported represents the tariff revenue raised by the government of the importing nation (equal to the area P_2 CAP_1 in the figure), and this is identified as the revenue effect of the tariff. Consumers, as expected, are worse off with the tariff, since they pay a higher unit price and consume a lower amount (quantity Q_2 at price P_2). Consumers' surplus, measured as the area under the domestic demand curve and above the price line,[9] is lower after the tariff and its decrease is given by the area P_2 CBP_1. Since the area P_2 CAP_1 is transferred to the government as tariff revenues, the real loss to society is given by the area of the triangle ABC.[10] The exporting countries are affected only to the extent that the amount of cocoa beans imported is reduced from Q_1 to Q_2, but world price remains the same.

The results obtained above can now be contrasted with the type of country facing an upward sloping supply curve of imports; large consuming countries such as the United States, or groups of countries like the European Economic Community (which have a common external tariff), might be included in this category. Figure 2 presents this case. All curves have the same meaning as before (Figure 1); the initial equilibrium at price P_1 and quantity Q_1 is affected by the

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[9] For an evaluation of the use of consumers' surplus as indicators of welfare change, see Berry (1972, pp. 79-81), and Currie et al. (1971, pp. 742-753).

[10] Although not of direct concern to our analysis, a complete analysis of the effects of the tariff must take into account how the tariff revenue is spent, including possible effects on the demand curve for the commodity.

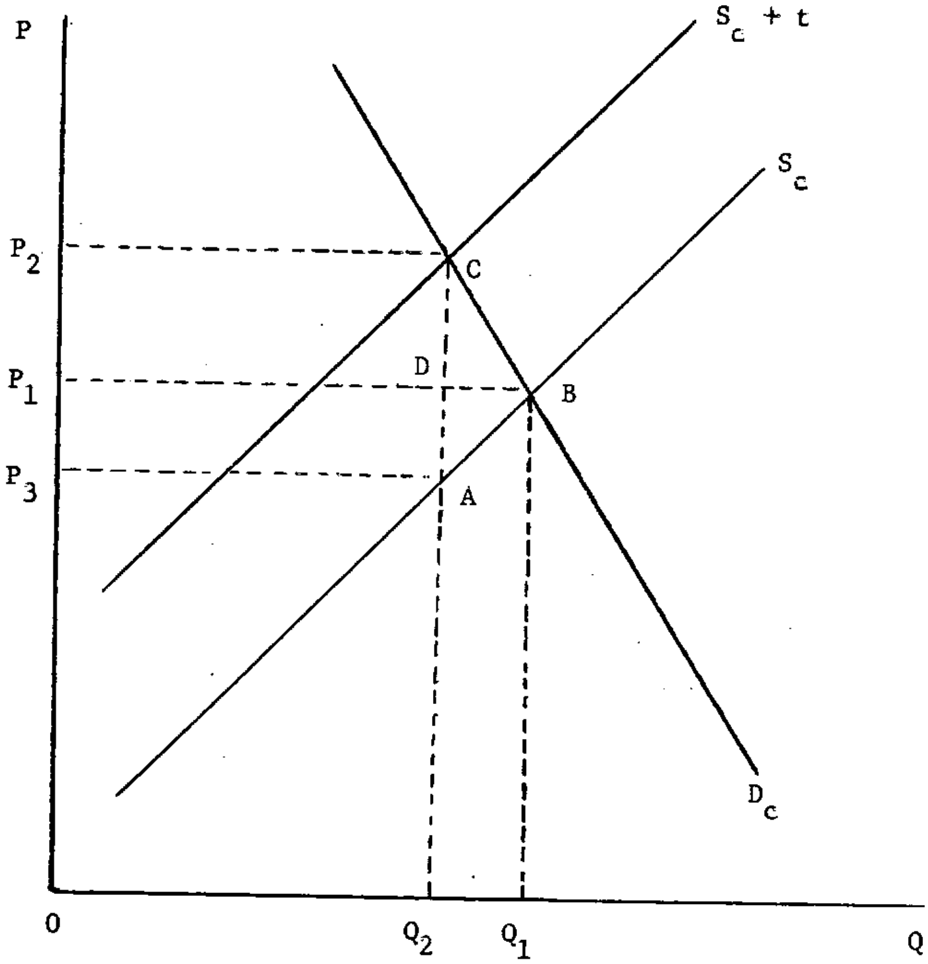

Figure 2. The effects of a tariff on cocoa imports -- the large country case

importing country's imposition of a specific tariff at level t.[11] The imposition of the tariff by the country in question raises the domestic price to P_2, which reduces the quantity demanded domestically by Q_1Q_2; the consequence for a lower domestic demand for the commodity is to cause a decline in world price from P_1 to P_3. As a result, we have that the tariff is levied partially on producers in the exporting country since part of the revenue effect of the tariff (area P_2CAP_3) is borne by the foreign exporter (area P_1DAP_3, because of the reduced world price P_3), and only part by the domestic consumer (area P_2CDP_1).

In terms of welfare change, the country in question may even gain from the action of imposing a tariff on imports of cocoa beans. To examine this point, we have to indicate that consumers suffer a loss of consumer's surplus given by the area P_2CBP_1, but the government obtains revenues measured by P_2CAP_3. The final indication of loss or gain to the country will depend on the comparisons of areas CBD and P_1DAP_3; the former is the net loss in consumer's surplus and the latter is the portion of tariff revenues which is borne by the foreign exporter. This result makes the difference with respect to the previous analysis of the small country case. Since world price is decreased as a result of the tariff, the importing country in question enjoys an improvement in its terms of trade,[12] and consequently the exporting country experiences a deterioration in its terms of trade, all other things constant.

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[11] Figure 2 shows the case of a specific tariff t. With an ad valorem tariff, the supply curve with the tariff would diverge from S_c by increasing absolute amounts as we move up in the price axis.

[12] Reference is made to the commodity terms of trade, defined as the ratio of an export price index and an import price index with quantity as weights (Freeman, 1971, pp. 86-87). It is assumed that the disposition

It is worth emphasizing at this point that, in the absence of retaliation by the exporting country, it is possible to find a level for the tariff which would maximize the importing country's gain from the tariff. Proceeding with the supply-demand partial equilibrium framework, the importing country could act as a monopsonist and select that level of imports where the marginal cost of the imported good equals the domestic demand price (Freeman, 1971, pp. 143-146). At a later point in the analysis we will consider the symmetric case of monopoly power for the exporting country.

As mentioned above, the other side of the tariff refers to the deterioration of the terms of trade of producing countries, which combined with lower quantity of exports would have the effect of decreasing their foreign exchange earnings from exports of cocoa. In the small country case, as discussed above, it is much more likely that the reason behind the imposition of the tariff is to be found in administrative simplification of obtaining revenues from imports, since no gains in the terms of trade are involved. Since no protection of domestic industry is involved, and since these countries are usually developed ones, it should not be very difficult in administrative terms to move to alternative forms of taxing the domestic sector to achieve the same level of government revenues. After a possible elimination of tariffs on cocoa beans and other raw materials, welfare might be

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of the tariff revenues do not in turn affect the position of the country's offer curve after the tariff, and that the domestic demand curve for the commodity is a "total" one (Berry, 1972). Ideally, markets for other goods should also be considered in the welfare change when an improvement occurs in the country's terms of trade.

increased with this change since consumers' surplus would be increased.[13] As a result, exports of cocoa beans would increase, as well as the level of exchange earnings of producing countries. In the large country case, the situation is more difficult, since they have their terms of trade improved as a result of the tariff, but nevertheless suggestions for the elimination of tariffs on imports of raw materials from less developed countries as a means of expanding trade and thus contributing to solving the problem of their export proceeds can be found in the literature (Pincus, 1965, Staley, 1965, and Committee for Economic Development, 1967).

In addition to the existence of tariffs on cocoa beans, the creation of the European Economic Community (EEC) in the early 1960's may also have affected the world cocoa economy. This type of economic integration, known as a Customs Union, has as its basic characteristics the free movement of factors of production as well as goods and services among member countries, but a common external tariff is imposed on imports from nonmember countries. In the particular case of cocoa, former French and Belgian territories (most of them independent countries now) remained associated with the EEC (Yaounde Convention), and as a result have preferential treatment for their exports of cocoa as compared with third countries. This means that Latin American and other cocoa producers (including some African ones) are discriminated against as a result of the trade arrangements of the EEC, since the free

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[13] A complete comparison would include possible welfare losses from increasing taxation elsewhere in the economy, as well as the administrative costs in both situations.

trade pattern created by the common market is a limited one in terms of participating countries.

As compared with the situation before creation of the EEC, where imports of cocoa were free of tariffs, or at least a situation with tariffs but without discrimination with respect to sources, it is possible that the existence of the EEC has contributed to trade diversion in the cocoa economy. Taking Latin American cocoa producing nations as a basis for comparison with the benefited African producers, before the imposition of a common external tariff to the imports from the former countries, they were able to compete for a share of the EEC market with the latter nations. Considerations of transport and production costs would determine the shares of each country or region in the markets of nations now belonging to the EEC. After the imposition of a common external tariff on cocoa from nonmember countries, it is possible that the pattern of trade might be changed in such a way that African countries associated with the Common Market would be able to increase their market share, although lower cost imports (without the external tariff) might be available from Latin America (or other sources). This negative production effect would also be combined with negative consumption effect (Walter, 1968, Chapter 23), i.e., higher prices to consumers. If existing, these effects would tend to change the free trade pattern with nonmember countries as prior to the integration by diverting trade in cocoa to African countries associated with the EEC.

The situation described above would not take place if the African countries benefiting from the EEC policy enjoyed, to start with, great advantages with respect to production costs and location which would allow them to supply (under no discrimination) the imports of cocoa for the EEC. The imposition of a common external tariff to nonmember countries in such a context would not result in trade diversion in the short run; however, in the long run (allowing for technical changes in cocoa production) some degree of trade diversion might result from the discrimination imposed on Latin American and other producers. This situation might even become more serious to some of these countries when we take into account the enlarged nature of the EEC market (with the additon of United Kingdom, Ireland, and Denmark) as of January 1, 1973, and the possible inclusion of Ghana and Nigeria, the two largest producing countries, among those nations receiving preferential treatment.

International Commodity Agreements

Historical Development

Since the 1920's there has been a great deal of discussion concerning international trade in primary products, and international commodity agreements to control the price and quantities produced and sold (Law, 1970). This discussion has given emphasis basically to two issues: price instability and the terms of trade for primary commodity producers; in this context, the shifting of position of the United Nations is a relevant point to be noted.[14] During the interwar period and with the proposed International Trade Organization (Havana Charter), and even through the 1950's, the discussion centered mainly around the issue of price instability; the Havana Charter even attempted to limit

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[14] The historical development relating to international commodity agreements can be found in Johnson (1967) and Law (1970). Most of the information in the text is obtained from them.

the use of techniques of trade restriction which aimed at increasing commodity prices.

A more direct interest of the United Nations for the terms of trade issue started in the 1950's and culminated in 1964 at UNCTAD I (United Nations Conference on Trade and Development), a time when the shifting of emphasis was completed. The issue of price stability for primary commodities was not entirely abandoned, but a much greater emphasis was put on international commodity agreements as a means of improving the terms of trade of less developed countries and increasing their foreign exchange earnings. The position of the United Nations in 1964 and after could be summarized as seeking price stability and greater exchange earnings for primary products, with more weight attached to the latter than to the former point.

In the period following World War II until the present, five commodities have experienced some form of international agreement:[15] wheat, sugar, coffee, tin and olive oil (Johnson, 1967). However, only the type of agreement in the coffee case is relevant for the present analysis. The restriction procedure (export quotas) in the international trade of coffee originated as an agreement in 1957 between seven Latin American countries, the coverage being increased to 90 percent of the world exportable production in 1961, and with the inclusion of major importers in 1962 (Kravis, 1968). The official International Coffee Agreement was signed by the major producing and consuming countries in 1963 for a period of five years and it was renewed in 1968.

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[15] Gwyer (1972) also mentions the recent introduction of an informal sisal agreement.

The relevancy of the coffee agreement for our analysis refers to the fact that, similar to cocoa, coffee is produced in less developed countries, has no close substitutes, and all major consumers are developed countries. The coffee situation is, however, somewhat complicated by the existence of at least three major types of product (Milds, Brazils, and Robustas). The restriction scheme in existence in the coffee agreement is based on export quotas for each participating nation (actual quotas are determined annually for each crop year), and a quota adjustment mechanism (upward and downward) introduced in 1967 in accordance with an indicator price for each of the different categories of coffee (Kravis, 1968).

Collective Monopoly Power

The question of international commodity agreements will be approached in this analysis in such a way as to take into consideration the possibility of the producing countries having, collectively, some degree of monopoly power in the cocoa market. In such a context, an international commodity agreement will be viewed as the means through which a group of producers (or all of them) could act collectively in such a way that by restricting their exports of the product they would increase their incomes and/or foreign exchange earnings from the product in question. To the extent that their action is successful, a transfer of resources takes place from the developed countries to them via the commodity market. The problem of price instability (for cocoa beans in our case) is not necessarily solved by monopolist pricing, but a stabilization scheme might be devised to achieve this objective, mainly with respect to a rigid control of domestic production and some stock maintenance to account for fluctuation in supply caused by climatic conditions. The indications in the case of cocoa are, however, that producing nations are disposed to live with some degree of price instability, to the extent that the price variations are around a higher price level for the product.[16] This reasoning is to some extent confirmed theoretically because not all causes of price disturbances are detrimental to producing nations, from a total foreign exchange earnings or welfare point of view (Grubel, 1964, and Hueth and Schmitz, 1972).

In addition, the objectives, under the approach of exploiting collective monopoly power, may be much more precisely defined by the participating countries (in terms of increased income and/or foreign exchange earnings) than under the lines of counteracting a possible deterioration of the terms of trade or, alternatively, preserving some purchasing power parity relationship of primary and industrial products.[17] This approach also makes clear that the less developed countries may achieve their chosen goal by their initiative, i.e., by acting collectively, although as recognized below the participation of consuming nations might enhance the chances of success for the agreement.

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[16]Killick (1967, p. 20) mentions that during the 1963 negotiations for an international cocoa agreement, producing countries emphasized the improvement in terms of trade as the primary goal by accepting a price range that would allow fluctuations of 33 percent upward and 25 percent in the downward direction. Price instability, may, however, in the long run be a factor reducing the world demand for the commodity if the uncertainty created (with respect to input costs and stock maintainance) provides the incentive to use substitute products or invest in research and development (Helleiner, 1972, p. 52).

[17]The last objective is attributed by Johnson (1967, p. 154) to Raul Prebisch, former secretary of UNCTAD.

The approach of exploiting the collective monopoly power through an international agreement among producing nations is based on the optimum tariff argument in the theory of commercial policy (Kreinin, 1971, pp. 249-250, and Freeman, 1971, pp. 143-146). In a partial equilibrium framework, the problem reduces to finding that level of exports of the commodity for which marginal revenue equals marginal opportunity cost of production. Figure 3 illustrates the case of monopoly power in international trade. D_w is the world demand for the commodity in question, S_o is the supply curve from other sources rather than the country whose policy is being examined (supply curve given by S_A; constant costs are assumed only for simplicity of exposition). Without monopoly pricing by A, equilibrium occurs at quantity Q_1 and price P_1, with country A selling $Q_1 - Q_1^0$ and the other sources exporting Q_1^0. Now, with country A deciding to exploit its monopoly power, the relevant demand curve facing it becomes D_A (actually an excess demand, found by subtracting S_0 from D_w horizontally), and corresponding marginal revenue curve given by MR_A. By equating marginal revenue with the constant marginal opportunity cost of production (Point B), price P_2 is determined; as a result, other sources will export Q_2^0 and country A will be the residual supplier with quantity Q_2^A. By so acting, country A will have its exports decreased, but at the same time monopoly profits given by the area P_2 CBP_1 are obtained, as well as resources previously used in this activity are released for alternative uses.[18]

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[18] The valuation of the released resources is obtained by multiplying the quantity $(Q_1 - Q_1^0 - Q_2^A)$ by the price P_1.

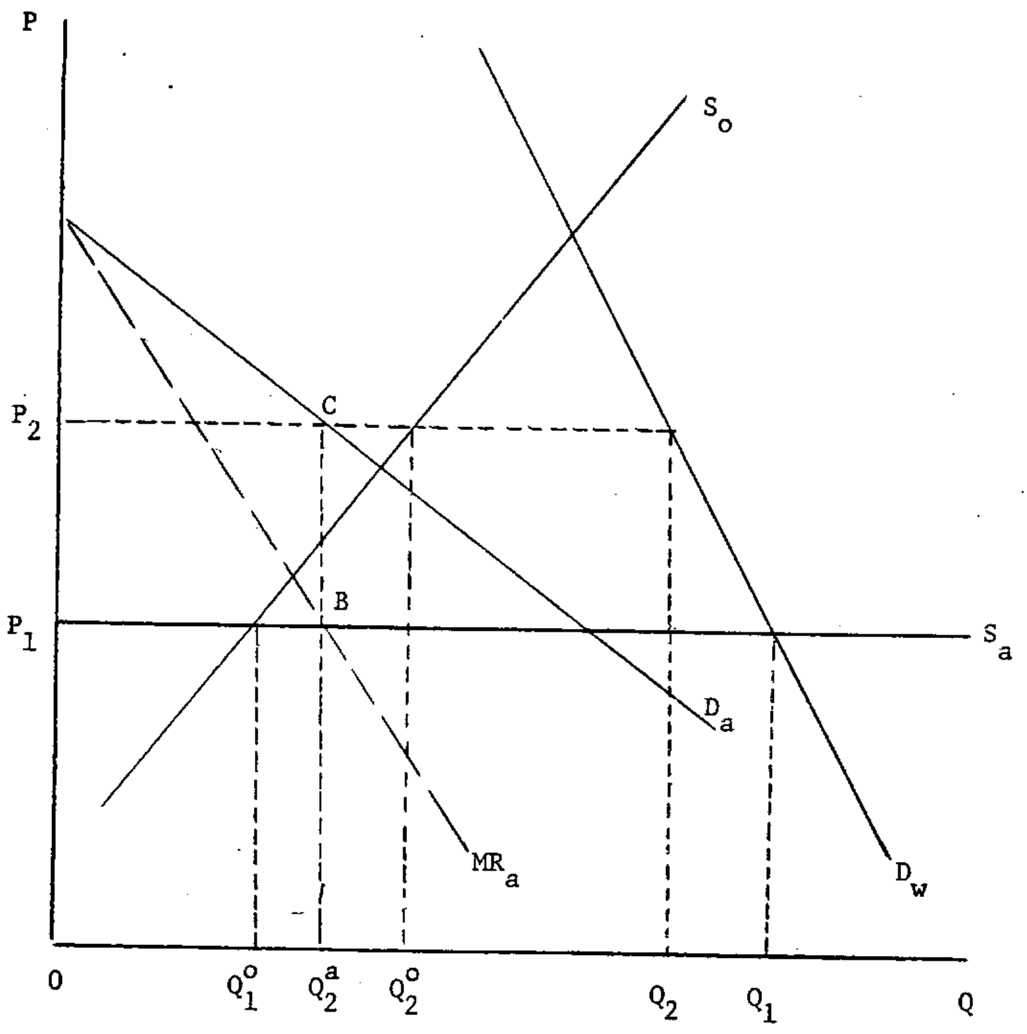

Figure 3. The effects of monopoly power in international trade: The leading country

With the objective of investigating the existence of monopoly power in the cocoa market by a group of producing nations, we will now briefly consider the case of the unsuccessful Cocoa Producers' Alliance of 1964. As mentioned in Chapter 1, the Alliance was to include Ghana, Nigeria, Brazil, Cameroon and Ivory Coast, the five leading cocoa producers representing over 80 percent of cocoa exports in value terms (average 1960-64, Table 3, Chapter 1). To determine to what extent this group of countries, collectively, has monopoly power in the cocoa market, we need an estimate of the price elasticity of the demand curve facing them (corresponding to the excess demand curve D_A in Figure 3). An estimate of this elasticity can be obtained by the use of the following relationship (derived in Appendix A):

$$\eta_A = \eta \left(\frac{1}{s_A}\right) - \varepsilon_0 \left(\frac{1 - s_A}{s_A}\right) \qquad (12)$$

where η_A is the elasticity of excess demand for cocoa beans facing the above countries, s_A is their share in total exports, η is the demand elasticity for cocoa in the world, and ε_0 is the supply elasticity of cocoa beans from sources besides the five countries listed above. Killick (1967) provides an estimate of η in industrial countries as -0.28, obtained by the Food and Agriculture Organization of the United Nations in 1963. Estimates of ε_0 are more difficult to come by, but Behrman (1968) provides us with this elasticity for two countries not included among the above five: they are very close to zero in the short run (0.03 and 0.12) and somewhat more elastic in the long run (0.15 and 0.38), being obtained from supply regressions in the period

1946-47 through 1963-64.[19] If we use a value of 0.30 for ε_0 in the above expression, and since we know that $s_A = 0.80$, we obtain -.425 as the estimate of η_A.[20] This is a relevant result for the present analysis, because it would indicate that at the price level of cocoa beans used to obtain the above estimates of the necessary elasticities, the countries included in the Cocoa Alliance were operating in a situation of negative marginal revenues. Total profits from cocoa exports could be increased simply by reducing exports, since by so doing, total revenue would increase and total cost would decrease.

The result obtained above is very relevant to the export policy of the countries included. With the objective of clarifying the question of monopoly power, a very brief review of monopoly theory will now be made since there is some confusion in the literature dealing with international commodity agreements and monopoly. Figure 4 will illustrate the points to be emphasized. In the context of international trade, implying a multi-country framework (but disregarding, as before, the space dimension), D can be interpreted as the aggregate demand curve for cocoa beans and MC as the horizontal summation of individual countries' marginal cost curves; in a free trade situation, equilibrium would take place at quantity Q_1 and price P_1. If all the producing countries decide to act collectively to exploit their monopoly power in

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[19] Short run is defined to include a period of time too short for new plantings to come into bearing, and long run as the time period allowing for the above and other adjustments to take place.

[20] The above estimate for η refers to a short-run elasticity; if we use $\eta = -0.56$, that is, the double of the original value, as an attempt to come closer to the long-run elasticity, the final result for η_A is -0.775.

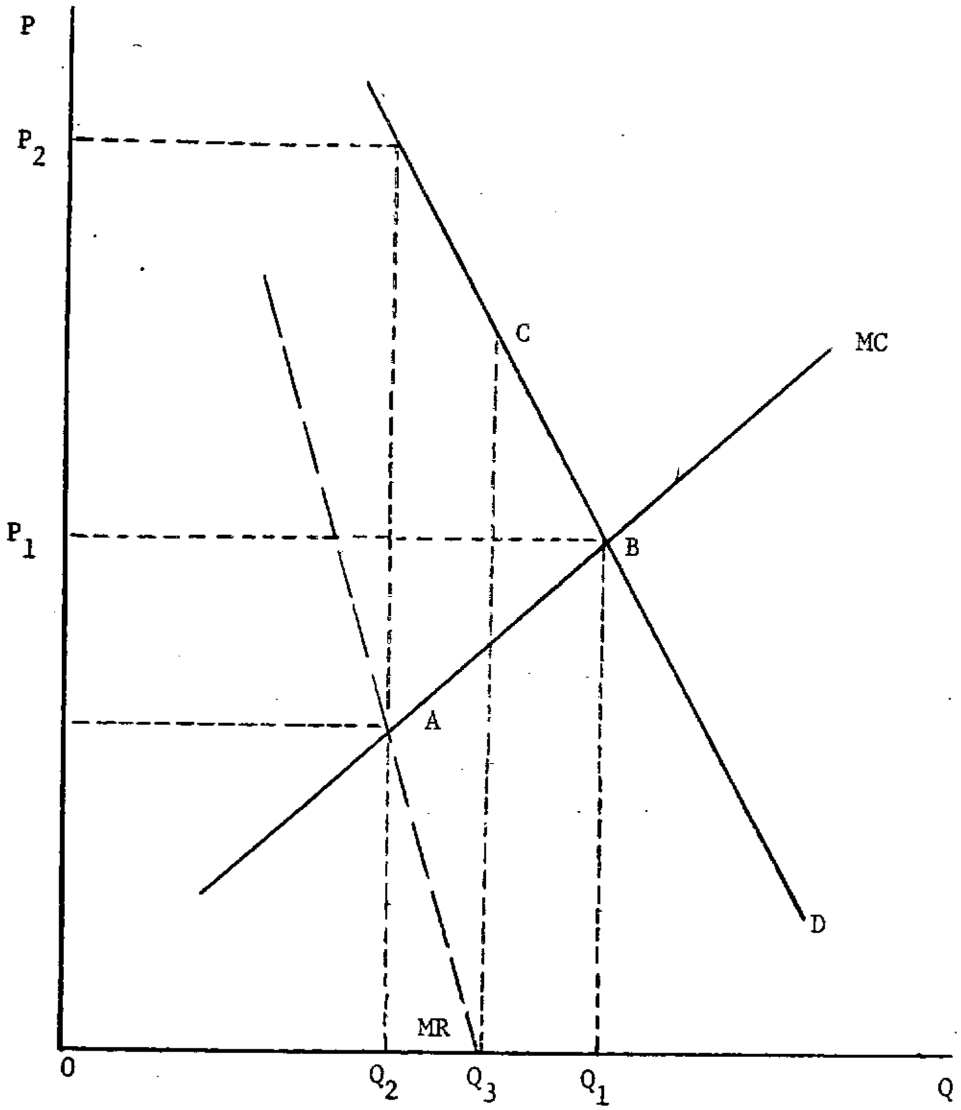

Figure 4. Monopoly power and demand elasticities

the market, equilibrium quantity will be obtained by equating marginal revenue (MR) to marginal cost; by so doing, the new equilibrium occurs at quantity Q_2 and price P_2. Since we are in a multi-country context the allocation of production would occur by equating individual countries' marginal cost to the equilibrium one (point A in the figure). Profits are then maximized for the group as a whole,[21] and as compared to the competitive solution, resources valued by the area Q_2Q_1BA are released for alternative uses.

The relevant point to be noted with respect to the competitive solution as shown in Figure 4 is that the equilibrium is occuring at a quantity where marginal revenue is negative. From the relationship between marginal revenue and the price elasticity of demand, we know that when marginal revenue is negative, the demand elasticity is below one in absolute value.[22] It follows then that all countries acting together in the cocoa market cannot maximize profits if the demand elasticity is less than one in absolute value because marginal revenue is negative and marginal cost is positive. They should then, to maximize profits, reduce output because in so doing, total revenue will be increased and total cost decreased.

At this point it is worth mentioning the misconception existent at least in part of the literature on commodity agreements with respect to

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[21] We disregard at this point problems related to possible retaliation, which is assumed away in the text, although the group of countries may still gain even after retaliation (Johnson, 1961).

[22] $MR = P\ (1 - \frac{1}{\eta})$, where η is the price elasticity of demand in absolute value; see Henderson and Quandt (1958, Chapter 6).

the feasibility of an export-restricting type of policy by the producing countries. The argument is that a price-raising commodity agreement would be successful only to the extent that the demand for the commodity has less than unitary elasticity in absolute value (Law, 1970, Pincus, 1965, and Killick, 1967). Following this reasoning, it can be seen that total revenue (foreign exchange earnings) from exports will be maximized at the quantity where marginal revenue is zero (quantity Q_3 in Figure 4), implying a unitary elasticity of demand (point C on the demand curve of Figure 4). However, this level of exports is the adequate one only if the policy objective is one of maximizing foreign exchange earnings rather than of income (profits). If the producing countries have as their policy objective the maximization of income, exports should be decreased in such a way that the new equilibrium will be on the elastic portion of the demand curve (to the left of point C in Figure 4).[23] The point to be emphasized, as put by Johnson (1967, Chapter 5, and Helleiner, Chapter 3), is that even if the elasticity of demand is greater than one in absolute value, there exists an optimum degree of export restriction, which decreases as the above elasticity increases, and, as put by Johnson, the confusion arises by looking at the problem of development from a balance of payments rather than from a real resources point of view.

[23] As mentioned by Johnson (1967, p. 156) and also shown by Kindleberger (1968, p. 210), this is not an optimum policy from the point of view of world efficiency and welfare of the developed countries. A combination of lower than optimum export tax and subsidies by the developed countries could keep the producing nations at the same welfare level and increase the welfare of developed countries.

The information presented above indicates that the price elasticity of demand for cocoa beans is below one in absolute value, and as a result, the case for introducing export restriction policies is a strong one since the demand elasticity in industrial countries, as cited above, is -.28 and the excess demand elasticity for cocoa beans from the five members of the Cocoa Producer's Alliance is -0.425 (or -0.775 as in Footnote 20), in either case (all countries acting collectively, or only the Alliance's five). The policy to be followed should involve a decrease of exports. In such a situation (less than unitary demand elasticity), the simple reduction of exports would increase both total revenue and profits, until a point on the demand curve is reached where the elasticity becomes unitary. Beyond this point, profits from exports could still be increased, but total revenue (foreign exchange earnings) would decrease.

A more comprehensive approach to the question of monopoly power in commodity markets in international trade should, however, take into account possible differences in the values of price elasticity of demand when introducing the time dimension (see Footnote 18). Among the factors determining the price-elasticity of demand for a product, we have to consider the availability of substitutes (Wu and Pontney, 1967, p. 199); if producers (in the case of a raw material or intermediate goods) and consumers are able to find a greater number of substitutes for the commodity in question over a longer period of time, then the long-run price elasticity of demand would be more elastic.[24] The price

[24] When referring to a group of countries (Cocoa Alliance, for instance) having monopoly power, another factor affecting the long-run elasticity (more elastic), as in relation 1 above, is the development of alternative sources of supply (changing s_A).

rise, resulting from the monopolist action in the cocoa case, could provide an important incentive for greater expenditures in research and development since no direct substitutes are available at present for making chocolate (International Federation of Agricultural Producers, 1972).[25] The problem of optimal export taxes by a country with monopoly power in international trade in the short and long run was investigated by Repetto (1972) and his conclusion was that the optimum tax depends on the long-run and short-run price elasticities, the relationship between them, and the social time discount rate. The obtained relationship can be expressed as:

$$T^* = \frac{1}{\eta_L} \left(1 + \frac{r}{b}\right) = \frac{r + b}{\eta_s} = (r + b)\, T^s \qquad (13)$$

where T^* is the optimal tax (as a percentage of the export price) when allowing for the time dimension, η_s is the short-run price elasticity of demand, b is the ratio between the short-run and long-run demand elasticities ($0 \leq b \leq 1$), r is the social discount rate, T^s ($= \frac{1}{\eta_s}$) is the optimum tax using only the short-run demand elasticity, and η_L is the long-run elasticity of demand. It then can be seen that the optimum tax T^* is higher, the higher the discount rate, the lower the long-run elasticity and the slower the demand response as given by b.[26] By considering these factors it is then possible that the optimum export

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[25] A more detailed discussion about substitutability and complementarity is presented on the section about demand estimation in Chapter 4.

[26] The parameter b, as defined by Repetto, measures the demand adjustment over time in terms of convergence to the long-run equilibrium. The closer b is to one, the faster is the adjustment.

tax T^* should be lower than the short-run tax T^s; in terms of exports, it would mean that the optimum (restricted) level of quantity reported of cocoa beans might be at a greater amount than the one obtained by only considering the short-run elasticity of demand.

The social discount rate r would, according to expression 13, be positively related to the optimum tax T^*. Since it could be assumed that the less developed countries are willing to increase rapidly the degree of industrialization of their economies (assumption based on their past policies), with a view of increasing the flexibility of their economic structures (Johnson, 1967, p. 155), we would expect this type of strategy to contribute to the existence of a higher social discount rate than otherwise, which would constitute a factor expected to increase the optimum tax (decrease the amount expected), other things constant.

Alternative Commodity Agreements

The most common approach found in the literature of commodity agreements, with respect to dealing with the goal of price increase, refers to the use of export quota restrictions; this is in fact one of the main features of the International Coffee Agreement. In the present analysis, dealing with the cocoa market, export quota restrictions will be viewed as the operational scheme applied by the producing countries aiming at raising prices of the product and exploiting their collective monopoly power in the world market. This approach is in line with the reactive programming method of obtaining the solution to a special equilibrium problem, as discussed in Chapter 2.[27]

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[27] In fact, the reactive programming procedure provides the optimum export quantities as one of the results of the solution; the procedure will actually start working with production restrictions (more about this in Chapter 6).

The use of an export restriction policy as the scheme to exploit collective monopoly power in international trade must, however, meet certain conditions to be effective over time. A very important one is that the agreement must include the major producing countries in terms of a large share in total exports. The reason for this is that the price raising nature of the agreement provides an incentive for individual nations to stay out of the scheme and, to some extent, enjoy a situation where prices are higher for their exports with no quota limitations. In other words, the outside country would be getting the full benefit of the resultant higher price, without incurring any of the cost through reduced output (see also Footnote 22); this is the free rider problem (Stigler, 1966, p. 233). If several countries decide to remain outside the agreement, the effectiveness of the remaining group to raise prices and thus exploit their monopoly power may be considerably diminished over time. A new country coming into the cocoa production activity, because of the price incentive, would also add to the above problem. In such a context, the participation of the major consuming countries and their discrimination against non-members (with respect to origin of their imports) become important elements for the agreement's effectiveness.[28]

In addition to restricting the level of output and exports, it must be recognized that the restriction scheme working through the use

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[28]The International Coffee Agreement includes such a feature, in addition to an export quota control mechanism (a certificate of origin accompanies coffee exports, with a copy to the International Coffee Organization); imports from nonmembers are limited by quotas imposed by consuming nations.

of export quotas may cause an inefficient allocation of resources in the cocoa industry. Emphasizing the similarity (disregarding location and resultant transportation costs) between the agreement in question and the multiplant monopoly problem, we recall that the correct output would be at the quantity where aggregate marginal cost equals aggregate marginal revenue. The optimal allocation of production among the individual countries would be achieved at the quantity where each country's marginal cost is equal to the common value of aggregate marginal cost and revenue at the monopoly equilibrium output. Under the assumption of different cost conditions among countries, if export quotas are distributed by other criteria than the above efficient allocation (for instance, based on previous production or export performance), there is no guarantee that resources will be properly (efficiently) allocated in the industry. In addition, profits from the agreement would not be maximized if misallocation occurs (Ferguson, 1969, pp. 270-272 and Stigler, 1966, p. 233). Furthermore, unless enough flexibility in the distribution of quotas over time is included at the beginning, the scheme will not be responsive to changed cost conditions among countries and possible existence of new countries, coming into the industry, with low-cost conditions.[29]

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[29] As a possibility for moving in the direction of greater efficiency, Helleiner (1972, p. 57) suggests that the annual right to export, however determined, be made transferable at a price between countries. In addition, mention is also made (Kravis, 1968) of an international tax (administered by a control organization). Various alternatives are possible for the distribution of the proceeds, including one where part would be returned to producing countries directly for use in development programs. Similar possibilities are the imposition of import duties by the developed consuming nations with return of the proceeds to producing countries (Helleiner, 1972, p. 62), and the imposition of an export tax by producing nations concerned (the gains would accrue to them directly).

As an additional requirement for an export restricting type of agreement for cocoa to be successful, measures must be introduced by the individual participating nations to separate prices paid to individual cocoa producers from the export price.[30] Unless such measures are taken, the efforts of reducing supplies in the world market to obtain an increase in price may be in jeopardy, since domestic production would be increased as a result of the price incentive, stocks would tend to increase, and pressures from individual countries for special treatment with respect to quota increases might unfavorably affect the basis for the initial collective action (and so contributing to the failure of the agreement).[31] Diversification measures, providing incentives for producers to move away from cocoa production, would be in order here, and although each individual country should, in principle, be responsible for the programs, a greater participation from the agreement's central organization might be advisable.[32] As a result of of the separation of the domestic and export price of cocoa, the gains to be made by participating in the agreement (monopoly profits) would accrue to each country as a whole and not to individual cocoa producers.

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[30] For some strategies to control domestic production (e.g., exchange control), see Rogers (1973, p. 42).

[31] This type of problem was encountered in the International Coffee Agreement mainly with respect to Central American and African countries, which were able to obtain quota increases; the conditions for this have become more stringent recently (Kravis, 1968).

[32] Brazil developed a diversification program for coffee on its own initiative during the 1960's and more recently a proposal was made for the creation of a coffee diversification fund in the International Coffee Organization with compulsory contribution from exporting member countries (Kravis, 1968).

In addition, by encouraging diversification in production, output of other crops might be increased with the use of the resources released by the cocoa restriction scheme.[33]

The problem of keeping stocks of the commodity in storage is not completely avoided by the monopolist pricing scheme; even with the use of export quotas and rigid control of domestic production, individual countries must consider possible quota increases resulting from expansion of consumption over time and the more random fluctuation in production caused by climatic conditions. These elements making necessary the maintenance of stocks will be in operation even under conditions of price stability in the world market, more so when consideration is given to the fact that cocoa is a tree crop, requiring several years before new plantings are reflected in the market in the form of increased production.[34]

A word about participation of consuming nations in an export-restricting type of arrangement as described above is in order. Along the lines of the second objective of this analysis, as described in Chapter 1, the explicit inclusion of consuming countries in a cocoa agreement is not necessary. This is so because our objective was to determine the effects of the commodity agreement upon cocoa trade

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[33] Special attention might be given to those farmers directly affected by the reduction in cocoa output, that is, the adjustment problem for owners and hired labor in moving to alternative activities.

[34] It is likely that, with the functioning of the agreement, most of the cocoa stocks kept in storage will be directly controlled by the respective governments rather than by private firms; the uncertainty created by the bargaining process in the yearly allocation of quotas and the political considerations involved would tend to favor state control.

(consumers and producers' price and trade flows), as well as the gains (income or total revenue) to be had by producing countries as compared with alternative market arrangements. The application of the reactive programming method for obtaining the equilibrium solution of the spatial problem will not require the specific inclusion of consuming countries in the restriction scheme. In such a context, the objective is one of evaluating the potential gains to the producing nations from exploiting their collective monopoly power. The inclusion of consuming nations might become an important element for the success of an actual agreement (in terms of effective policing), when, as mentioned above, some countries decide to remain outside the scheme, and also as a way to obtain the enforcement of each country's export quota (Johnson, 1967, p. 146, Helleiner, 1972, p. 58). Since consuming countries would then be performing a useful role with respect to the effectiveness of the agreement, and since producing and consuming nations would have divergent interests with respect to prices and quotas, it is likely that their participation may be obtained only at the cost of producing member countries accepting a level of profits lower than the optimum (that is, larger export quotas and lower prices as compared with the monopoly's optimum).[35]

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[35]Consideration might also be given by consuming countries to decreasing the amount of aid provided directly or through multilateral institutions, since with the agreement, transfers would be made via the commodity market. Since this interdependence can be considered only as a possibility and since we are interested in the magnitude of the potential gains to producing countries as an indicator for policy action, this question will not be taken directly into account in the analysis to follow.

An International Cocoa Agreement

The information presented above indicates that cocoa producing countries might obtain considerable gains by collectively exploiting their monopoly power in the market. This was true not only in an agreement including all producing nations, but also in the specific example given of the five members of the once existing Cocoa Producers' Alliance. The only empirical investigation of the consequences of a monopolistic cocoa pricing scheme was the one by Behrman (1968). With respect to total revenue of producing countries, his findings indicated a maximum level to be reached in the price range of 75-80 cents per pound, the absolute increase being in the order of 360 million dollars. By assuming the same production shares which prevailed in the period 1960-61 through 1964-65, the change in revenue (at various prices) was distributed among eight leading producers; Ghana was the largest beneficiary, in terms of value of total exports (a 45 percent increase in the range of 75-80 cents per pound), followed by Cameroon, Ivory Coast, and Nigeria with much lower increases. The smaller countries, Ecuador, Dominican Republic and Venezuela, had very small increases (8.7, 4.6, and 2.4 percent, respectively).

In what follows, the basic approach to be adopted will be one where all countries producing cocoa would participate in the agreement, but the downward adjustments in production necessary to the establishment of reduced exports will occur only for the five leading producing nations (Ghana, Nigeria, Ivory Coast, Cameroon, and Brazil).[36] In such

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[36] Fewer difficulties in the actual negotiation of an agreement are an advantage of such procedure; reduction also for other producing countries can and will, however, be introduced as variations of this basic approach.

a case, Figure 5 should be useful in terms of clarifying the issue of gains accruing to any one of the above five countries as a result of a possible international cocoa agreement. The usefulness of Figure 5 relates to the fact that such gains can be presented not only in terms of foreign exchange revenues, but also that a welfare analysis of the agreement (as compared to a free trade situation) can be made.

In Figure 5 the situation of a representative country (either one among Ghana, Nigeria, Brazil, Ivory Coast, and Cameroon) is presented for the case of free trade and trade under a cocoa agreement; in that figure SS is the long-run cocoa supply curve and DD is the long-run domestic demand curve for the product. OQ_1 represents the competitive output for such country, at a world price given by OA; total revenue is given by the area OQ_1BA, of which Q_2Q_1BC represents foreign exchange earnings. Now, with the agreement, an output restriction (or quota) is set at OQ_3 (and similarly for all other participating countries).[37] After supply and demand functions in all countries (as well as transfer costs) are allowed to interact in the world cocoa market, price for this country's product is determined at OH. As a result, total revenue is given by the area OQ_3IH and foreign exchange revenue by the area Q_4Q_3IG.

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[38]Disregarding the space dimension, total output would be determined, as previously discussed, by the condition of equality between aggregate marginal cost and marginal revenue; after the quota sizes are agreed, each country would face a demand curve equal to s_i times D^t where s_i is country's i share of the total cartel output, and D^t is the world demand for cocoa. In our context, we do not need to draw a demand curve in Figure 5, but the above described one is implied, going through points I and B (see also Stigler, 1966, pp. 231-234).

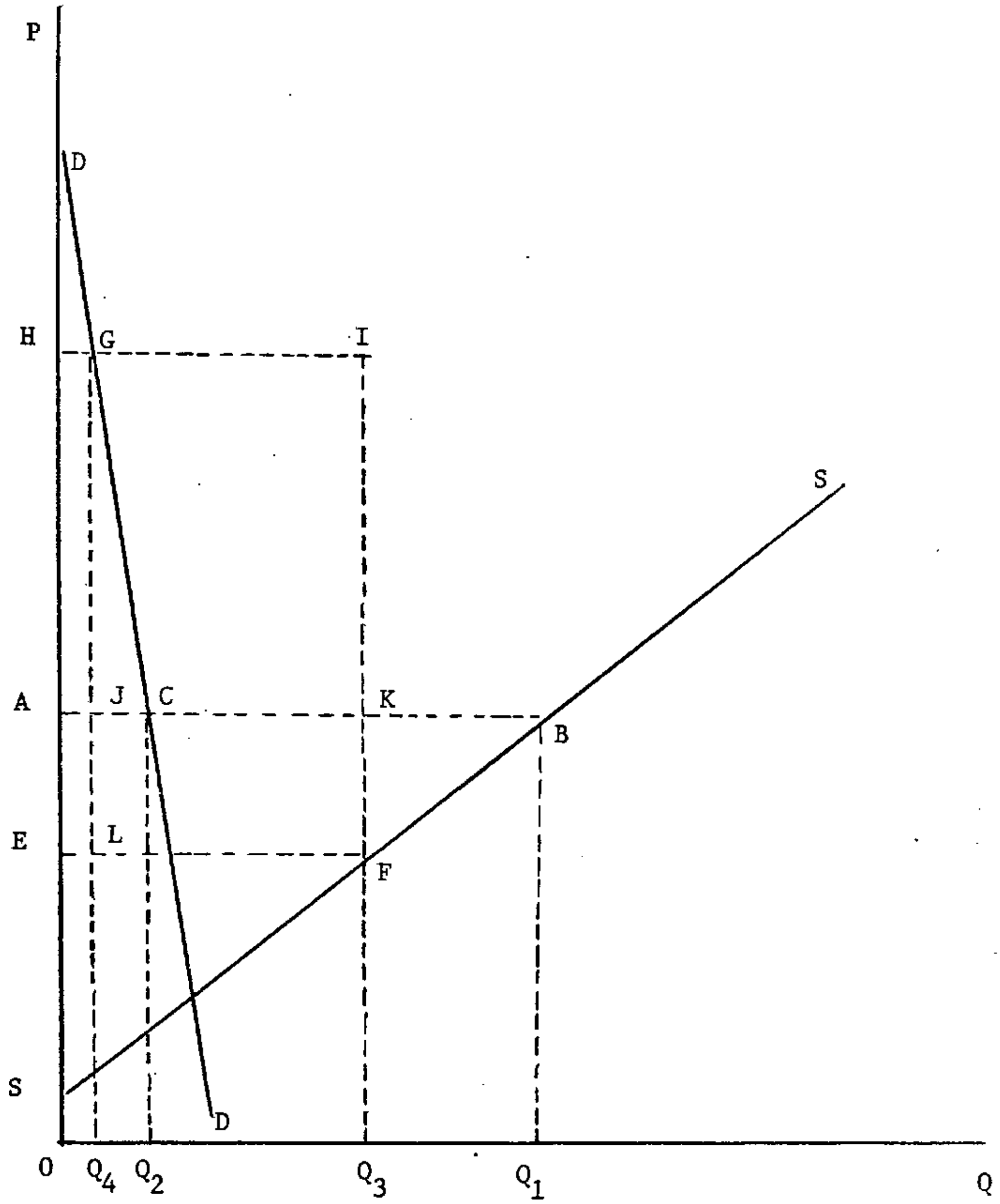

Figure 5. Possible gains to a representative country from an international cocoa agreement

Our welfare analysis of a possible cocoa agreement, on the other hand, will be restricted to a partial equilibrium framework and the use of consumers' and producers' surplus for measuring the welfare changes taking place.[38] In the context of a Marshallian partial equilibrium analysis the following two points will be necessary for the identification of welfare change: (a) the area under the demand curve is a measure of the total utility derived from the commodity being consumed, (b) the area under the supply curve is a measure of the opportunity costs of the resources used in production. Thus, consumers' surplus will be represented by the area under the demand curve above the equilibrium price, while producers' surplus will be given by the area above the supply curve below the same price line. Berry (1972, pp. 80-85) argues that the above conditions are satisfied if the following prevails: perfect competition (for the existence of the supply curve), no externalities, constant returns to scale, the demand and supply curves are "total" ones,[39] and the marginal utility of income is the same for everyone.

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[38] Currie _et al_. (1971) present a comprehensive review of the concept of economic surplus as well as its application in economic analysis; specific application to international trade questions is also presented (pp. 775-783). The authors justify the widespread use of partial welfare analysis by saying that "this is virtually inevitable for the economist's limited knowledge of the complex interrelationships characterizing any economic system precludes any possibility of allowing for all the ramifications generally associated with a change in one particular industry" (Currie _et al_. 1971, pp. 787-788).

[39] The concept of a "total" curve instead of a partial curve is one where indirect effect (substitution and complementarity) are accounted for (_i.e_. all other markets are in equilibrium). The concept on demand was presented by Buse (1958); Hushak (1971) used the concepts to formulate a three-sector model to analyze the voluntary corn diversion program. It is possible that for some of the countries involved the assumption of a "total" curve, mainly on the supply side, is not a

Within this framework, we now consider the case of an international cocoa agreement (as in Figure 5, a representative country). It is clear that such an agreement will involve a departure from the competitive situation, with a lower quantity being produced and sold at a higher price. In such a context, there will be a net loss in consumers' and producers' surplus resulting from the production restriction and consequent price increase brought about by the agreement. In addition, we have to account, for the individual country in question, for the gain represented by the monopoly rent accruing as the result of cocoa exports at a higher price.[40]

In terms of our graphical presentation (Figure 5) and the two market arrangements being considered, that is, free trade and an international cocoa agreement, the following results in terms of the economic surplus (ES) involved hold:

(a). Free trade:

$$(ES)_1 = (ABS) + (DCA)$$

where areas ABS and DCA refer respectively to producers' and consumers' surplus.

(b). International Cocoa Agreement:

$$(ES)_2 = (EFS) + (DGH) + (HIFE)$$

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realistic one, because of the industry's importance, the magnitude of the resources released, and the size of the price reduction involved (for producers).

[40]A type of welfare analysis that is very similar to the type of problem we are investigating here is the one by Johnson (1965) about the social cost of the tobacco program in the United States, which also included monopoly rents from the export sector.

where EFS and DGH are producers' and consumers' surplus with this agreement and HIFE is the gross monopoly rent accruing to the country.[41] With the objective of obtaining a measure of welfare change, the economic surplus under free trade must be subtracted from the surplus under a cocoa agreement; a net measure is thus obtained, and represented by the net monopoly rent (GIKC) less the net loss in producer's surplus (KBF). This is so because we must consider that the areas HGCA and AKFE are not real gains to the country but only a transfer from cocoa consumers and producers respectively to the country as a whole (i.e., those who are the beneficiaries from the final distribution of the gains). These two areas can then be used (at a later point of our analysis) to actually compute the gains to accrue to the five countries listed above from a possible introduction of an international cocoa agreement.

Several characteristics of a commodity appropriate for this type of market arrangement are listed by Pincus (1965, Chapter 6, and Helleiner 1972, Chapter 3); most of them were already referred to previously, but it will be useful to put them together at this point. Cocoa is an important commodity in the export trade of the producing countries, a few leading producers have a large market share, and the product is mainly consumed in the developed countries of the world[42]

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[41] The monopoly rent accruing to the country (in a system of fixed exchange-rate) can be thought in terms of buying imports valued at Q_4Q_3IG while exporting resources in exchange, valued at Q_4Q_3FL (we disregarded the domestic consumption sector in these areas).

[42] This factor becomes important to prevent transfers of income from less developed to other less developed countries.

but is not produced by them. The requirement of homogeneity of the commodity is met by cocoa, which is considered as one of the more homogeneous of agricultural commodities (International Federation of Agricultural Producers, 1972). The demand elasticity considerations relevant for the feasibility of an agreement were presented previously and considered to be very encouraging in terms of potential gains to producing countries. Related to demand considerations, no direct substitute for cocoa in the chocolate industry is known at the present (International Federation of Agricultural Producers, 1972), although attention must be given to the possible substitution of other fats for cocoa butter (Pincus, 1965, Behrman, 1968).[43] In addition, the gains to be had from such an agreement will be evaluated by comparison with the prospects of a free market situation in 1980, attention being also given to the difficulties in the operation of the scheme (as listed in the next paragraph).

In the process of evaluating the potential relative gains to be obtained by an international cocoa agreement, producing member countries should consider certain principles that might be followed by the scheme after the initial decision on export quotas and price level is reached (Pincus, 1965, Chapter 6). The use of an indicator price range, along the lines of the coffee agreement, together with quota adjustments, is a useful procedure. Attention must also be given to a greater flexibility in changing quotas in response to changed demand and supply

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[43] A more accurate statement would be that no substitutes exist for one of the key roles performed by cocoa butter, that is, of melting just below body temperature (Amoa, 1965, p. 124). The other two roles performed by butter, reduction of viscosity and control of rancidity, may be adequately performed by other oils. More about this in Chapter 4.

conditions, participation of consuming nations, separation of individual producer's price from export price, diversification measures and maintenance of stocks.

In recent years the discussions about an international cocoa agreement have increased considerably (International Federation of Agricultural Producers, 1972), including formal talks between the major consuming and producing nations in 1971 and early 1972, in addition to the meetings taking place at UNCTAD III (United Nations Conference on Trade and Development at Santiago, Chile). These efforts culminated in October 1972 with the adoption, at the United Nations Cocoa Conference, of an International Cocoa Agreement (Food and Agriculture Organization of the United Nations, 1973b, p. 3). The Agreement incorporated some of the features discussed, including export quotas, a quota adjustment mechanism based on a price range of 23-32 US cents per pound, and a butter stock. The United States has not signed as a member so far, the reason apparently being related to the price range adopted.

In such a context, the present analysis may contribute in terms of increasing the information available concerning the world trade in cocoa in 1980 under the free trade alternative and the one of exploiting the collective monopoly power of producing nations.

CHAPTER 4
DATA REQUIREMENTS AND ESTIMATION PROCEDURES

According to the objectives of the analysis as described in Chapter 1, we want to determine for 1980 (under three types of policies in the world cocoa economy), equilibrium values for prices at production and consumption points, total imports and exports as well as trade flows for cocoa beans for all countries and regions included. With such information, estimates of foreign exchange earnings obtained by producing countries, with different policies prevailing, can be obtained and compared. In addition, an alternative measure of gains to producing nations (based on the concept of economic surplus) can be computed for meaningful comparisons after the introduction of an International Cocoa Agreement.

Chapter 2 also presented reactive programming as the solution procedure to be used for the spatial equilibrium problem in the cocoa economy. In that context, we briefly discussed the data requirements of the model, mainly with respect to demand functions for cocoa beans in 1980, supply functions (or point projections), and transportation costs from production to consumption points. The present chapter will present a more detailed discussion of the above requirements as well as the estimation procedure to be used. First, production and consumption points will be selected for the reactive programming procedure; a review of previous studies concerning estimation of supply and demand functions for cocoa beans will follow, and finally the model to be used in estimating the required relationships will be discussed.

Consumption and Production Points

Table 1 presented the breakdown of world cocoa production by countries (the most important ones), groups of countries and regions (based on a geographical division). From that table, it is apparent the concentration of world production is in a few African and Latin American nations. The five countries that formed the Cocoa Producers' Alliance in 1964, Ghana, Nigeria, Brazil, Ivory Coast and Cameroon, were responsible for more than 75 percent of total world production in 1970/71. The basic consideration determining which countries to include individually in the spatial equilibrium model was related to the importance of each one with respect to production and trade, as well as available data.

Information about consumption of cocoa beans and cocoa products (in terms of beans) was presented in Table 2. It is clear that the major consuming countries are the United States and nations of Western Europe (mainly West Germany and United Kingdom). Based on the same criteria of importance in cocoa trade, additional countries and regions were selected as net importers; all production and consumption points are listed in Table 5 with their representative centers (for purposes of calculating transfer costs). It is then seen that the world was divided into 32 regions; each country or region included is considered as an individual producing and/or consuming point, since we have net exporters and net importers of cocoa beans. In the first case, each country (region) produces cocoa beans for its own consumption and will export the surplus; in the latter case, those countries or regions that produce an insufficient amount to satisfy their consumption or, alternatively, have no cocoa beans production, must import the

Table 5. World cocoa regions and representative centers[a]

Country (region)	Representative center
1. Ghana	Accra
2. Nigeria	Lagos
3. Ivory Coast	Abidjan
4. Cameroon	Douala
5. Other Africa Production	Bata
6. Other Africa No Production	Algiers
7. Brazil	Salvador
8. Ecuador	Guayaquil
9. Venezuela	La Guaira
10. Mexico	Progreso, Acapulco
11. Dominican Republic	Santo Domingo
12. United States	New York, San Francisco
13. Canada	Montreal, Vancouver
14. Other America	Valparaiso, Buenos Aires, Kingston
15. Japan	Tokyo
16. Other Asia	Singapore
17. Australia	Sydney
18. Other Oceania	Torres Strait
19. Belgium	Antwerp
20. West Germany	Hamburg
21. France	LeHavre
22. Denmark	Copenhagen
23. Italy	Naples
24. Netherlands	Rotterdam
25. United Kingdom	London
26. Ireland	Dublin
27. NSFI	Oslo
28. Spain and Portugal	Lisbon, Barcelona
29. Austria and Switzerland	Genoa
30. Eastern Europe 1	Rijeka
31. Eastern Europe 2	Gdynia
32. Soviet Union	Riga

[a]The complete list of countries included in Regions 5, 6, 14, 16, 27, 30, and 31 is presented in Appendix B.

difference, or the entire consumption. The assumption that the country or region is represented by a point will, in our analysis, mean that production and consumption take place at that particular location, no allowance being made to possible costs occurring in the space and form dimension of the marketing process, in addition to the transfer costs between two respective points. For some of the regions, two or three points representing the ports of entry are considered; however, in the actual calculation of transfer costs between two regions, only the point having the lower cost figure was taken into account, being the one used in the reactive programming solution procedure.

Review of Previous Research

Supply Analysis

A common problem faced by many researchers in the area of supply response for cocoa is the lack of adequate data in most of the major producing countries. This fact, as recognized by Bateman (1969), has affected the number of attempts to estimate supply relations for cocoa and other perennial crops. The same author presented a discussion of four models applicable to the planting decision for perennial crops; these models are concerned with the factors influencing the farmer's decision about planting, and in such context the variable to be explained is either acreage planted or stock of trees. In a very brief summary, the models can be presented as:

Model I - Gross Investment as a Function of Prices.

$$X_t = a_o + a_1\bar{P}_t + a_2\bar{S}_t + \mu_t \qquad (14)$$

where $\bar{P}_t = \frac{\sum_{i=o}^{n} (P^*_{t+i})}{n+1}$ and $\bar{S}_t = \frac{\sum_{i=o}^{n} (S^*_{t+i})}{n+1}$

X_t being the number of acres planted in year t, P^*_{t+i} being the expected real producer price in year t+i, S^*_{t+i} being the expected real producer price in year t+i of an alternative crop, and n representing the last productive year for the tree. In addition, Nerlove's price expectation model is assumed:

$$\bar{P}_t - \bar{P}_{t-1} = \beta (P_t - \bar{P}_{t-1}) \quad (15a)$$

$$\bar{S}_t - \bar{S}_{t-1} = \beta (S_t - \bar{S}_{t-1}) \quad (15b)$$

The equation to be estimated is obtained by combining relations (14) and (15) above, such that:

$$X_t = a_o B + a_1 \beta P_t + a_2 \beta S_t + (1 - \beta) X_{t-1} + u_t' \quad (16)$$

where

$$u_t' = u_t - (1 - \beta) u_{t-1}$$

<u>Model 2</u> - Stock of Trees as a Function of Expected Prices.

$$T_t = b_o + b_1 \bar{P}_t + b_2 \bar{S}_t + Z_t \quad (17)$$

where T_t is the total stock of trees in year t, and the other variables are as previously defined. By assuming the same price expectation model given by (15) above, the equation to be estimated is obtained as

$$X_t = b_o B + b_1 \beta P_t + b_2 \beta S_t - \beta T_{t-1} + Z_t' \quad (18)$$

where

$$Z_t' = Z_t - (1 - \beta)\ Z_{t-1}$$

Model 3 - Desired Stock of Trees as a Function of Expected Prices.

$$T_t^* = c_o + c_1\bar{P}_t + c_2\bar{S}_t + e_t \qquad (19)$$

T_t^* being the desired stock of trees in year t. Further, Nerlove's partial adjustment model is introduced by assuming that the adjustment of actual to desired stock is not an instantaneous one:

$$T_t - T_{t-1} = \gamma\ (T_t^* - T_{t-1}) \qquad 0 \leq \gamma < 1 \qquad (20)$$

By combining Relations 15, 19, and 20, the estimating equation is obtained as:

$$X_t = c_o\beta\gamma + c_1\beta\gamma P_t + c_2\beta\gamma S_t + (1 - \beta - \gamma)\ X_{t-1} - \beta\gamma T_{t-2} + e_t' \qquad (21)$$

where

$$e_t' = \gamma\ [e_t - (1-\beta)\ e_{t-1}]$$

Model 4 - The Liquidity Model.

It is recognized in this model that, given the existence of imperfect capital markets, a liquidity variable could affect planting decisions; thus all three models previously discussed could be altered to take this into account, and Bateman chose farmers' income in the preceding year as a proxy for liquidity.

If adequate data were available for the variables acreage and stock of trees, one of the models discussed above could be used, depending, of course, on the circumstances of the particular product. Short-run and long-run acreage elasticities would then be obtained, information which would be of great importance in our analysis.[44] However, data for these variables are not generally available, except for quantity produced of cocoa beans. To proceed with his analysis of supply response of perennial crops in less developed areas, Bateman postulated a planting-output relationship of the following form:

$$Q_t^* = \sum_{i=k}^{\infty} (b_1 X_{t-i}) \qquad (22)$$

where, Q_t^* is the potential yield of the crop in year t, b_i is the potential yield per acre in year t of the acres planted in year t-i, and k is the age at which trees first begin production. To go from potential output to actual output, other factors should be introduced in Equation 22, such as climatic and economic variables.

For the specific case of Ghana's cocoa, and based on previous information about the crop, Bateman (1965) was able to specify the following planting-output relation:

$$Q_t = b_1 \left(\sum_{i=k}^{s-1} X_{t-i} \right) + b_2 \left(\sum_{i=s}^{\infty} X_{t-i} \right) + cR_{t-1} + dH_{t-1} + eP_t \qquad (23)$$

where Q_t is the amount of cocoa harvested in year t, R and H are, respectively, rainfall and humidity variables, and P_t is the real cocoa price in t. By transforming Equation 23 into a first-order

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[44] Acreage elasticities would constitute a lower bound for the supply elasticities.

difference equation, and then combining with Equation 16 (Model 1) above, the estimating equation is arrived at. However, when estimating, the author obtained a value of zero for the lagged dependent variable, which implies that $\beta = 1$ in Nerlove's adaptive expectation hypothesis, and resulting in the relation $\bar{P}_t = P_t$. In addition, the coefficient for the current price variable was insignificant; as a result of these preliminary results, the model which was finally estimated by ordinary least squares was:[45]

$$\Delta Q_t = b_2 a_o + b_1 a_1 P_{t-k} + (b_2 - b_1)\ a_1 P_{t-s} + b_1 a_2 S_{t-k}$$

$$+ (b_2 - b_1)\ a_2 S_{t-s} + c\Delta R_{t-1} + d\Delta H_{t-1} + \tilde{u}_t$$

where $\tilde{u}_t = u_{t-k} + u_{t-s}$

This model was applied to seven different geographical regions in Ghana, and the results obtained were good in general, with respect to the significance of coefficients and coefficients of determination. When attempting to obtain aggregate supply functions however, the results were satisfactory only for two combinations of regions (which included 3 and 2 separate regions in each of the cases).[46]

Behrman (1968) used a formulation similar to Model 3 above, which was combined with a planting-output relationship along the same approach

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[45] Although not clear from the author's discussion, presumably the values for k and s were selected by maximizing the value of the coefficient of determination in the ordinary least squares procedure.

[46] Aggregate elasticities were not reported.

as given by Equation 23, but excluding the climatic variables for lack of data. Behrman performed the supply analysis for eight of the leading producing countries, but the results obtained were not as good as those of Bateman for single regions in Ghana. Many of the coefficients from the ordinary least squares regression were not significant and the values of the coefficient of determination were not as large as Bateman's. The values obtained for the supply elasticities are presented in Table 6. Since it might be expected[47] that rainfall and humidity play an important role in explaining cocoa production, and Behrman's supply analysis was made for entire countries (as opposed to regions of Ghana in Bateman's study), these factors might account for the lesser success of Behrman's attempt.

Table 6. Price elasticity of cocoa supply in eight countries[a]

Country	Short-run	Long-run
Ghana	-	0.71
Nigeria	0.04	0.45
Brazil	0.53	0.95
Ivory Coast	-	0.80
Cameroon	0.68	1.81
Ecuador	-	0.28
Dominican Republic	0.03	0.15
Venezuela	0.12	0.38

[a]Source: Behrman (1968); Nigeria's short-run, from Olayide (1972).

[47]Coefficients for rainfall and humidity were significant at 5 percent level in 6 and 4 of the 7 regions of Ghana (Bateman, 1965), respectively.

Demand Analysis

The fact that cocoa consumption is concentrated in countries with high per capita income in Europe and North America has directed the few studies of demand for cocoa in such a way as to obtain estimates of price and income elasticities only for those most important consuming nations. Behrman (1965) attempted to obtain estimates of income, price, and cross-price elasticity with respect to sugar, for France, West Germany, Netherlands, United Kingdom, and United States in the period 1950-1961. A system of equations was specified and the method of instrumental variables was applied for estimation with the purpose of allowing for simultaneity. However, in a later study (Behrman, 1968), the author modified the estimation procedure by applying ordinary least squares in the demand analysis. The objective of the author's study was, to some extent, similar to one of the objectives of our analysis, that is, the evaluation of possible gains to producing countries from a monopolistic cocoa pricing, but without the spatial equilibrium approach taken here.[48]

The period covered by Behrman's second study was 1948-1964, including the following countries: West Germany, United States, United Kingdom, France, Canada, Netherlands, Spain and Italy.[49] The demand function which was used is the following:

$$Q_t = a_o + a_1 P^c_{t-1/2} + a_2 P^s_{t-1/2} + a_3 P^v_{t-1/2} + a_4 Y_t + u_t \qquad (25)$$

[48] A brief discussion of Behrman's results was presented in Chapter 3.

[49] Least squares estimates for the rest of world (as an aggregate) were also obtained, but with considerably less success.

where Q_t is the annual per capita grindings of cocoa beans, P^c, P^s, and P^v are, respectively, the wholesale price of cocoa beans, sugar, and vegetable oil (soybean oil was the one specifically used). As can be noted from the above function, all prices were lagged one-half year, the reason given by the author being that "response in chocolate formulas to changes in cocoa bean prices reputedly require a lag of that length" (Behrman, 1968, p. 716). The results obtained, when considering the coefficient of determination, were quite good (exception being Netherlands), although for most of the countries included, the coefficients of the variables P^c and P^s were not significantly different from zero.

The results of Behrman's analysis (shown in Table 7) indicate that demand for cocoa beans is quite inelastic in the short-run[50] (long-run elasticities were not obtained). In addition, income elasticities are below unity for all countries, and soybean oil is a substitute for cocoa beans (the coefficients in the regression appear to be significantly different from zero for most countries).

In addition, Viton (1970) reported values for the price elasticity, of -0.23 for Western Europe and -0.15 for the United States.

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[50] The range for the elasticities' values in a FAO study in 1961 was from -0.27 to -0.50. Weymar (1968), reports the countries and figures from this FAO study as:

United States	-0.35	United Kingdom	-0.27
Belgium	-0.26	Austria	-0.35
France	-0.35	Denmark	-0.49
Netherlands	-0.41	West Germany	-0.49
		Sweden	-0.35

Table 7. Elasticities of demand for bean-equivalents, several countries[a]

Country	Elasticity of demand with respect to: Price of cocoa	Income	Price of sugar	Price of soybean oil
United States	-0.25	-	0.08	0.19
West Germany	-0.18	0.93	-	0.32
United Kingdom	-0.16	0.71	-	0.40
France	-0.38	0.68	0.15	0.05
Canada	-0.19	0.72	-0.12	0.43
Netherlands	-0.89	0.62	-	0.77
Spain	-0.24	0.85	-	-
Italy	-0.21	0.93	-	0.05

[a]Source: Behrman (1968, p. 706, Table 2).

Estimating Supply and Demand for 1980

The availability of estimates of supply and demand functions for 1980, as well as transportation costs of the commodity, constitute the basic data requirements for our analysis of the cocoa economy at that future year. If the results to be obtained from the present study are to provide useful information for the decision-making process of the countries involved, it is important that supply and demand functions be obtained with accuracy. In estimating supply and demand functions, the first necessary step to be taken is the construction of an economic model process where economic theory plays a very important role; by combining the economic model with the other necessary requirements, that is, adequate data and statistical techniques, estimates of the relevant parameters in the relationships can be obtained.

The difficulties involved in estimating supply and demand functions, however, are not the same. In our case, the objective is to obtain estimates of these functions for a future period, namely 1980, from an estiming technique that will involve the use of time series data covering, say, the period 1950-1970. It is seen then that, in addition to the usual problems normally faced in the estimation process, we have to deal with question of prediction, that is, outside the period of observation; in other words, we must be able to predict how the functions will change over time. This point is clearly emphasized by Schultz (1956) who pointed out that the demand for a commodity is relatively more stable than supply. The reason for this is to be found in the fact that tastes, one factor affecting the demand for the commodity, remain fairly constant over a certain period of time, while technology, one factor underlying the supply of the commodity, does not. It becomes then very important to predict changes in technology if accurate estimates of supply are to be obtained. According to Schultz, this is the reason why the knowledge about demand functions is much greater than that of supply.

The situation, as described above in general terms, is relevant for the particular case of cocoa where technology (varieties, chemical products for control of diseases, spraying techniques, farmer's skills) appears to play an important role in explaining production changes in most countries (Food and Agriculture Organization of the United Nations, 1966). In addition, climatic factors (humidity and rainfall) as indicated by the study of Ghana's cocoa by Bateman (reviewed earlier in the chapter) appear to be an important determinant of output. This was cited as a possible reason for the relative lack of success in Behrman's study of supply response in eight countries, where climatic factors were not considered because of lack of data. The age distribution of the stock of trees, for which no data are available, should be another important element in supply analysis (Food and Agriculture Organization of the United Nations, 1966). French and Matthews (1971) developed a detailed model of supply response for perennial crops, where account is taken not only of the planting process and existence of lags in response, but also the removal and replacement of plants and the effects of populations of bearing plants on production. However, even with the simplifications introduced and deletion of some variables because of data problems in their estimation of supply response for asparagus in the United States, the model is not feasible for cocoa because of lack of data for one of the variables to be explained, namely, acreage harvested, in most countries. In what follows, an attempt will be made to start the alternatives available with respect to estimating supply and demand relationships for 1980.

Supply Estimation

The difficulties in estimating supply functions for cocoa and making predictions for 1980 are to a large extent concentrated on the lack of adequate data for some of the relevant variables described when discussing some of the models above, and problems associated with predicting changes in technology. These factors constitute a limiting element for the investigation of supply functions of cocoa in 1980 for the leading producing countries included in the analysis. However, in line with the requirements of the programming procedure, the following alternative can be presented:

(A) Point Projection of Output:

Projections of cocoa output (including the most important countries, individually) for 1980 were recently made by the Food and Agriculture Organization of the United Nations (1971). These projections were based on assumptions about real producer prices and production assistance policies of individual countries. As a result, two sets of projected output were obtained: a "basic" production projection which takes 1970's conditions (prices and assistance policies) as fixed, and a "supplementary" projection, which allows for some improvements in such variables. With the "basic" projection as reference, we would then have for 1980 a quantity and a price which would define a point on the supply curves of individual countries. With the information provided by Berhman's (1968) study with respect to supply elasticities for the five countries which were members of the Cocoa Producers' Alliance of 1964, we would be able to derive estimates of the intercept term in the supply relations, and consequently, obtain estimates of the supply functions for these five countries.[51] For the other countries included in the analysis, the point projections of cocoa output, referred to above, would be used (that is, a perfectly inelastic supply function).

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[51]Our approach will involve an attempt of estimating supply functions only for the five countries once members of the Cocoa Producers' Alliance. They are the most important producing countries (78 percent of world production as the average for the period 1965-66 through 1969-70).

(B) Estimating Supply Functions:

The lack of data for some of the variables normally included in supply studies is one difficulty with this alternative, probably accounting for the relative lack of success in the comprehensive study by Behrman (1968). Departing somewhat from the three models for perennial crops discussed above and also the one by French and Matthews (1971), emphasis might be given only to the output variable (instead of acreage) and the existence of lags in adjustment. Let us thus start by specifying the following relationship between cocoa output and cocoa prices (a simple distributed lag model):

$$Q_t = a + \sum_{i=0}^{k} \beta_i P_{t-i} \qquad (26)$$

where Q_t is cocoa output in t, P is cocoa price, k is the number of periods covered by the lag function, and β is the lag weight.[52] With the objective of obtaining a more flexible specification of the lag pattern (in relation to a Nerlove's partial adjustment model, where the lag weights decline geometrically), the Almon Type of procedure where the coefficients of the distributed lag are restricted to a polynomial of low order will be used (Johnson;[53] et al. 1972).

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[52] The simple lag model given by Equation 13 might, in principle, be estimated directly by applying ordinary least squares (if k+2 is less than the number of observations). However, a complete specification would include other variables (including lagged ones), which might limit estimation given the available time series; multicollinearity also might be a problem. A restricted specification (such as Almon's procedure) would then become the alternative.

[53] T. Johnson, A Note on Distributed Lags in Polynomial Form, unpublished economics workshop paper, Department of Economics, N. C. State University, Raleigh, N. C., 1969.

In such a context, we now consider the case where the lag weights (β_i) are represented by a quadratic polynomial with only three parameters, such that Relation 26 above might be rewritten as:

$$Q_t = \sum_{i=0}^{k} (\alpha_o + \alpha_1 i + \alpha_2 i^2) P_{t-i} \tag{27}$$

where

$$\beta_i = \alpha_o + \alpha_1 i + \alpha_2 i^2 \tag{28}$$

A restriction that might be imposed on the lag formulation is that $\beta_i = 0$ when $i = k$ (Chen et al. 1972), that is,

$$\alpha_o + \alpha_1 k + \alpha_2 k^2 = 0 \tag{29}$$

Solving Equation 29 for α_o and substituting the result into Equation 28, we obtain the following final relation:

$$\beta_i = \alpha_1 (i - k) + \alpha_2 (i^2 - k^2) \tag{30}$$

With this expression for β_i, Equation 26 can be rewritten as:

$$Q_t = a + \alpha_1 \sum_{i=0}^{k} (i - k) P_{t-i} + \alpha_2 \sum_{i=0}^{k} (i^2 - k^2) P_{t-i} \tag{31}$$

Equation 31 is appropriate for estimation purposes. In our case of cocoa supply response, however, the general distributed lag model should include other variables besides the product price as above; as a modification of Equation 26 we would have the following relation for the cocoa case:

$$Q_t = a_o + \sum_{i=0}^{k} \beta_i P_{t-i} + \sum_{i=0}^{k} \theta_i P^c_{t-i} + dt + u_t \tag{32}$$

where, in addition to the variables already defined, P^c, represents price of coffee, t is time in years (as a possible 'proxy' for technology in cocoa production), and u is a random disturbance. After representing the lag weights β_i and θ_i by polynomials of second order and proceeding in the same manner as above, an expression of the form to be estimated would be obtained:

$$Q_t = a_o + \alpha_1 \sum_{i=0}^{k} (i-k) P_{t-i} + \alpha_2 \sum_{i=0}^{k} (i^2 - k^2) P_{t-i} \tag{33}$$

$$+ \delta_1 \sum_{i=0}^{k} (i-k) P^c_{t-i} + \delta_2 \sum_{i=0}^{k} (i^2 - k^2) P^c_{t-i} + dt + u_t$$

For purposes of notation simplicity, we may rewrite Equation 33 as:

$$Q_t = a_o + \alpha_1 W_1 + \alpha_2 W_2 + \delta_1 V_1 + \delta_2 V_2 + dt + u_t \tag{34}$$

where:

$$W_1 = \sum_{i=0}^{k} (i-k) P_{t-i}$$

$$W_2 = \sum_{i=0}^{k} (i^2 - k^2) P_{t-i}$$

$$V_i = \sum_{i=0}^{k} (k-k) P^c_{t-i}$$

$$V_2 = \sum_{i=0}^{k} (i^2 - k^2) P^c_{t-i}$$

At this point we note that the problem raised in Footnote 52 is a real one in the case of cocoa supply; from Equation 32 we can see that if ordinary least squares is to be used, the number of parameters to be estimated would be 2(k+1)+2. If we think of a value for k in the range of 8 to 12, the number of observations available in a post world war time series (20 - 25) would preclude such a direct estimation. In such a context, the polynomial lag formulation described above might become a meaningful alternative. With respect to the number of parameters to be estimated, we observe that by imposing the restrictions that the lag weights lie on a polynomial of degree two (Relation 28), and that $\beta_i = 0$ when $i = k$, that number is reduced from 2(k+1)+2 in Equation 32 to only six in Equation 33 (or 34).[54]

Demand Estimation

Since knowledge of demand functions is one of the basic requirements of the reactive programming procedure for obtaining equilibrium solutions to our spatial problem, estimates must be obtained for, at least, the most important consuming nations. In such respect, the same alternatives described in the supply analysis (point projection and statistical estimation) are available for estimating demand functions.

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[54]Among the problems mentioned by Schmidt and Waud (1973) in their review directed to the application of the Almon lag technique, an important one is the specification error committed when such technique is used, although the weights do not follow the pattern imposed. The existence of a lag in cocoa supply is clear in terms of the delayed response of cocoa production (cocoa, a tree crop) to a change in cocoa price; in addition, the pattern for the weights indicated by our restrictions (first increasing and then declining) appears to be a good description of the cocoa case. This is confirmed by the information provided by Berhman (1968), when mentioning that the yield per tree is practically zero until 5-8 years after planting, but that two substantial increases in yield occur in the period of 6-14 years after planting, with the decline occurring slowly over time.

As the first alternative, we should point to the existence of demand projections by individual countries in the same study of the United Nations cited earlier (Food and Agriculture Organization of the United Nations, 1971). As a result, the same procedure (using the available estimates of price elasticities of demand) described for supply estimation could be used to obtain estimates of the demand functions in 1980 (short-run, since long-run elasticities are not available).

The second alternative, as before, involves the actual estimation of demand functions for cocoa beans in 1980 for some countries. As a general statement, the same model (polynomial lag formulation) is also relevant for demand estimation, because of the common phenomenon of existence of lags in response. The indication that a distributed lag model is the appropriate one for the cocoa demand is provided by Weymar (1968) and Behrman (1968) when considering the possible change in chocolate formulas as a result of price changes of cocoa beans or substitutes. As an alternative to the polynomial lag formulation, Nerlove's partial adjustment model also takes this delayed response question into account; the rationale for the existence of lags refers to the existence of adjustment costs that would justify the slow response of economic agents to economic stimuli (Griliches, 1967, and Behrman, 1968, p. 716 for the cocoa case). We now consider the following specification of the long-run demand function for cocoa beans, a derived demand:

$$Q_t^* = a_o + a_1 P_t + a_2 P_t^s + a_3 P_t^v + a_4 Y_t + w_t \qquad (35)$$

where, Q_t^*, a long-run equilibrium quantity, represents the per capita grindings of cocoa beans (actual grindings adjusted for net imports of cocoa products), P, P^s, P^v, are, respectively, the real wholesale price of cocoa beans, sugar, and a vegetable oil (possibly soybean oil), Y is real per capita income, and w is a random disturbance. Equation 35 would then represent the long-run derived demand function by manufacturers for the raw material cocoa beans. If we postulate a dynamic adjustment equation (Nerlove, 1958), given by:

$$Q_t - Q_{t-1} = \beta \ (Q_t^* - Q_{t-1}) \qquad 0 \leq \beta < 1 \tag{36}$$

as a result of substituting 35 for Q_t^* in 36, the following final expression is obtained:

$$Q_t = a_o\beta + a_1\beta P_t + a_2\beta P_t^s + a_3\beta P_t^v + a_4\beta Y_t \tag{37}$$

$$+ (1 - \beta) \ Q_{t-1} + \beta w_t$$

A word is in order about the variables included in this demand function; besides the price of the product, two other prices, sugar and a vegetable oil, are included. Sugar is a complement to cocoa beans because of the high proportion in final product by weight, although an opposite force may exist because of the substitutability of sugar confectionary for final products of cocoa (Behrman, 1968). The evidence presented by Behrman (1968) and Weymar (1968) suggests that sugar prices are not an important determinant of cocoa beans consumption. One is then tempted to use such prior information of Equation 37, such that this variable would be dropped from the equation (its coefficient would be restricted to assume the value of zero).[55] Mixed forces also exist in the case of vegetable oils because they can be substitutes for cocoa butter but complements to cocoa powder (Amoa, 1965, and Behrman, 1968). No substitutes exist presently for one of the key roles performed by cocoa butter, that is, of melting just below body temperature (Amoa, 1965, p. 124). The other two roles, reduction of viscosity and control of rancidity, may adequately be performed by other oils. Then, for those products where the melting property is not of great importance, vegetable oils will be substitutes for butter; usually for these same products, the chocolate flavor is very important and this can be provided by the powder, which explain the complementarity cited.

Since the demand for cocoa beans is a derived demand, the starting point to consider is the production function of the firm and industry; in such a situation, a relevant variable in the derived demand would be the output level. However, in the case of the cocoa industry, this information is possibly non-existent; the same difficulty applies to information about final products' prices. The income per capita variable is then introduced in the derived demand as a factor representing the demand for the final products. As pointed out by Amoa (1965, p. 32), however, the income elasticities in the two functions (derived

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[55] One advantage to be obtained from this would be the increase in degrees of freedom. We also know, that the existence of multicollinearity (the price variables, in this case) would result in the inaccurate estimation of the coefficients and difficulty in their interpretation (Huang, 1970, p. 149). Multicollinearity may have been a factor in Behrman's (1968) results, but the dropping of the sugar price may also lead to specification bias for the coefficients of the remaining variables if, actually, sugar price is a variable belonging to the equation.

demand and final products' demand) do not necessarily coincide (they will only with one imput, or more than one imput but under fixed factor proportions).

Alternatively, the polynomial lag formulation (developed above in supply analysis) could also be applied for estimating demand for cocoa. Without repeating the arguments and developments, the Almon type of procedure to handle the lagged adjustment may be introduced; the equation to be estimated would then be:

$$Q_t = a_o' + \gamma_1 \sum_{i=0}^{k} (i-k)\, P_{t-i} + \gamma_2 \sum_{i=0}^{k} (i^2 - k^2)\, P_{t-i} \tag{38}$$

$$+ \lambda_1 \sum_{i=0}^{k} (i-k)\, P^v_{t-i} + \lambda_2 \sum_{i=0}^{k} (i^2 - k^2)\, P^v_{t-i} + a_4' Y_t + \varepsilon_t$$

which might be rewritten as:

$$Q_t = a_o' + \gamma_1 Z_1 + \gamma_2 Z_2 + \lambda_1 U_1 + \lambda_2 U_2 + a_4' Y_t + \varepsilon_t \tag{39}$$

where:

$$Z_1 = \sum_{i=0}^{k} (i-k)\, P_{t-i}$$

$$Z_2 = \sum_{i=0}^{k} (i^2 - k^2)\, P_{t-i}$$

$$U_1 = \sum_{i=0}^{k} (i-k)\, P^v_{t-i}$$

$$U_2 = \sum_{i=0}^{k} (i^2 - k^2)\, P^v_{t-i}$$

ε_t is a random disturbance and k, is the number of periods covered by the lag function (not known beforehand). Chen et al. (1972) estimated their milk response equation for several values of k and Gardner (1972) selected a k value of five in a study of the agricultural labor market. This procedure seems to be more appealing because of the large number of regressions that would otherwise have to be fitted for all countries involved in our analysis. In addition, a value in the neighborhood of k=4 or k≐5 would be reasonable in terms of number of observations lost in the time series (because of lagged prices in the variables Z and U, Equation 38).

Discussion of Models for Estimation

The models described above for estimating supply and demand functions of cocoa were presented with the implicit assumption of estimation by ordinary least-squares (OLS). However, this may not be the best technique to use because of the problem of simultaneous equation bias. The fact is that, in both supply and demand estimating equations derived above, two endogenous variables are present, that is quantity demanded (or supplied) and price of the product.[56] The fact that price is listed as one of the independent variables in the regression would contradict the assumptions required for the application of ordinary least-squares. These assumptions can now be presented; first we write a general regression model as:

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[56] It should be noted that we are considering the variables, price of vegetable oils (or sugar, if present) in the demand equations and price of coffee in the supply equations, as exogenous. A more complete model, however, would allow for interdependencies among all of these sectors.

$$y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \ldots\ldots + \beta_k X_k + u \tag{40}$$

or, in matrix notation,

$$Y = \bar{X}\beta + \underline{u} \tag{41}$$

The necessary assumptions are (Huang, 1970, pp. 66-69):

(a) The X_i variables are fixed or nonstochastic.

(b) Absence of perfect linear combinations among the X_i variables (linear independence), that is, rank $(\bar{X}) = k+1$.

(c) $E(\underline{u}) = 0$, that is, the model contains the relevant variables.

(d) In addition to having identical distribution with zero mean, the disturbances have variance σ^2 and zero covariances, that is: $E(\underline{u}\,\underline{u}') = \sigma^2 I$, where I is an identity matrix, $\sigma^2 I$ being the variance - covariance matrix of $\underline{u}$.

The important point in our context is that the explanatory variables must be a set of fixed numbers, which would imply that $E(\bar{X}'\,\underline{u}) = 0$, since $E(\underline{u}) = 0$; if one or more of the explanatory variables are stochastic, the optimal properties of the OLS estimators will still prevail, if these variables are independent of the disturbances (Huang, 1970, pp. 176-179). If we think of the previous relationships (supply and demand equations) as part of a system, it will be clear that one of the regressors, price of cocoa beans, will be stochastic and not independent of the disturbance. In such a case, price of the product is jointly determined with the quantities and would be influenced by random shifts in the demand or supply equations. The system of equations cited above would consist of the demand equation for each country individually included, a demand equation for the rest of the world, the supply equation for each country included, a supply equation for the rest of the world, and finally, an identity for the equilibrium condition in the market. Application of ordinary least-squares in the estimation of supply and demand equations (when simultaneity prevails) would give biased and inconsistent estimates of the coefficients (Huang, 1970, p. 179).

However, in a particular situation that is likely to include many of the consuming nations, the above problem probably would not arise. That is, in such a situation, ordinary least squares could be applied without the above problems related to simultaneous equation bias. The reason for this apparently contradictory statement is that these countries would be so small a force in the international trade of cocoa (as discussed in Chapter 3) that price would be taken as given by them, and the country in question would adjust its quantity demanded to that price (Klein, 1960, and Prais, 1962). However, countries, such as the United States, West Germany and United Kingdom, could not possibly be taken to be of such small size as to have no influence on cocoa price.[57] If the conditions for identifiability of the demand equations of

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[57] These same considerations apply on the supply side; small countries (such as Ecuador, Dominican Republic, Ivory Coast and Cameroon) could probably have their supply functions estimated by ordinary least squares without serious problems related to simultaneous equation bias. For Ghana and Nigeria (the two largest producers), however, this problem is more likely to arise.

individual countries in the system described above are met, we still might be able to obtain an estimate of these demand functions if the supply schedules can be shown to shift more randomly than the demand schedules (Huang, 1970, p. 214 and Bronfenbrenner, 1953, pp. 226-229). Since climatic and disease factors were shown to be important determinants of cocoa output, the above should be a reasonable assumption; the demand equations would, as a result, be identified. However, the estimates obtained by ordinary least-squares for these large countries would still present some bias, and the bias would be smaller the more elastic is the supply of imports facing the respective country (Bronfenbrenner, 1953).

CHAPTER 5
RESULTS FROM ESTIMATION OF SUPPLY AND DEMAND EQUATIONS

In the previous chapter, 32 representative centers were selected for inclusion in our predictive model of the world cocoa economy in 1980. However, estimation of supply and demand relationships will be made only for the most important consuming and producing nations. For the remaining centers, point projections of supply and demand for cocoa in 1980, as obtained by the Food and Agriculture Organization of the United Nations, will be used.[58]

In this chapter, results obtained from the demand and supply analysis are presented. Initially, a few topics common to all models and countries are discussed. After that, the specific results in the estimation process are presented, as well as the procedure used to predict the above relationships for 1980.

Form of Equations and Included Variables

The nature of the objectives, as previously defined, implies that the estimated demand and supply equations should be in linear form. Specifically, in the case of investigating potential gains (to producing countries) to be obtained from an International Cocoa Agreement, profit maximization under condition of monopoly is involved. In such a context (as previously discussed), operation in the inelastic portion of the demand curves would be inconsistent with the assumption of profit-maximization. As a result, the objective of obtaining the equilibrium

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[58]They will be used directly on the supply side (a perfectly inelastic supply) and, in conjunction with estimates of demand elasticities, to obtain estimates of demand functions.

solutions under the agreement's alternative will require that the estimated demand equations be in linear form, that is, the price-elasticity of demand will vary along the curves.[59]

In the previous chapter alternative models for estimation were presented, at the same time that the relevant variables to be included were specified. Here it will suffice to say that the values of the price variables for all countries (cocoa beans, sugar, soybean oil, and coffee) are those prevailing at the same location (as indicated in detail later, the New York spot price); a meaningful equilibrium solution will require that all variables be measured in the same units, in our case, the U. S. dollar. A price is paid for this simplification, however, since price differences due to the separation of countries in the space dimension, and individual government's policies affecting cocoa import prices, are then disregarded when estimating supply and demand functions. The alternative to the above procedure would be to estimate the functions with the relevant variables defined in terms of each country's currency and, only then, make the conversion to a common currency by multiplying the price coefficient by the assumed exchange rate (Elliott, 1972).[60] This approach was not pursued here because of data difficulties with respect

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[59]The reactive programming procedure allows supply and demand equations to be defined either in linear or logarithmic form, being, to this extent, more flexible than quadratic programming, where only the former is possible.

[60]The advantage of this method would be to allow the researcher to investigate the effects of different exchange rates in the final equilibrium solutions.

to the price variables in most countries (availability of the information and period of time covered.[61]

The problem of conversion from the domestic currency to a common currency (dollars) appeared, however, when estimating the demand functions, because of the variable income per capita included in the specifications (Chapter 4). With the objective of maintaining the same pattern of variation (year-to-year direction and proportion of change) for this variable (as expressed in each country's currency) in the time series, the conversion was made using only the exchange rate prevailing in 1970, rather than using the fixed rates prevailing in a year-to-year basis. In addition, the relevant variables (prices, and incomes) were deflated by indices with the same base year used for the currency conversion, that is, 1970.[62]

The Estimated Demand Equations

The demand equations to be estimated for cocoa beans were presented and discussed in Chapter 4. To facilitate the presentation of results, however, they are repeated here as:

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[61]Another reason for the use of the same series (New York price) for all price variables was the attempt made to allow for simultaneity in the relationships of the cocoa market (by the use of the instrumental variable technique). However, the statistical results obtained in the reduced form regression (price of cocoa beans as the dependent variable) were not satisfactory in terms of the coefficient of determination obtained and sign as well as significance of coefficients. Since relevant climatic and inventory variables were neglected in the specification of the models discussed in Chapter 4, because of lack of data, this exclusion might have been a factor explaining the poor results. As a consequence, we did not pursue the method of simultaneous equations any longer, and all the results to be presented refer to the ordinary least squares technique.

[62]This procedure was used by Bjarnason et al. (1969) to convert price series in international trade to a common currency.

$$Q_t = a_o\beta + a_1\beta P_t + a_2\beta P_t^s + a_3\beta P_t^v + a_4\beta Y_t + (1-\beta)\ Q_{t-1} + \beta w_t \tag{42}$$

which is a direct reproduction of Equation 37 (Chapter 4). In addition, we also have:

$$Q_t = a_o' + \gamma_1 Z_1 + \gamma_2 Z_2 + \lambda_1 U_1 + \lambda_2 U_2 + a_4' Y_t + \varepsilon_t \tag{43}$$

where:

$$Z_1 = \sum_{i=0}^{k} (i-k)\ P_{t-1}$$

$$Z_2 = \sum_{i=0}^{k} (i^2 - k^2)\ P_{t-i}$$

$$U_1 = \sum_{i=0}^{k} (i-k)\ P_{t-i}^v$$

$$U_2 = \sum_{i=0}^{k} (i^2 - k^2)\ P_{t-i}^v$$

which corresponds to Equation 39 (Chapter 4). Both equations above were estimated linearly by ordinary least squares. The variables are defined for each country as:

Q_t = Per capita grindings of cocoa beans (actual grindings adjusted for net trade of cocoa products converted into bean equivalents) at time t, in pounds.

P_t = Real spot price of cocoa beans (Ghana) in New York, cents per pound, time t.

P_t^s = Real wholesale refined cane sugar price at New York, cents per pound, time t.

P_t^v = Real price of refined soybean oil at New York, cents per pound, time t.

Y_t = Real per capita income in dollars, time t.

k = Number of time periods covered by the lag function (i=0, 1, ... , k).

w, ε = Random disturbances, with the properties assumed in Chapter 4.[63]

Price and income variables were defined above in real terms; the deflator used was the wholesale price index in the United States for all price variables, and consumer price index (wholesale price index, in its absence) for income in all countries. Equation 42 can be recognized as representing the demand formulation including Nerlove's dynamic adjustment equation[64] (β being the coefficient of adjustment), while Equation 43 is the formulation including Almon's technique to handle the lagged adjustment. It can be noticed that these two procedures for demand estimation (as given by Equations 42 and 43) differ because of the absence of the variable sugar price in Equation 43 (and its presence in 42). As indicated in Chapter 4, the available evidence suggests that sugar price is not an important determinant of cocoa beans consumption. Since each price variable would require two independent variables (similar to Z_1, Z_2 and U_1, U_2, in Equation 43) when moving to Almon's formulation, the question of degrees of freedom becomes of great

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[63]For testing the hypothesis, an additional assumption is required, that is, the disturbances having a normal distribution.

[64]In models of this type (a lagged dependent variable in the right inside) the ordinary least squares estimates will be biased even if the disturbances are independent; now, if the disturbance term follows a normal distribution, the estimates will be asymptotically efficient and consistent (Johnston, 1963, pp. 211-215).

importance; this was the reason for dropping the variable sugar price from Equation 43, but keeping it, at least initially, in Nerlove's formulation.

Table 8 presents the estimated demand equations for cocoa beans following the formulation given by Equation 42. It can then be seen that all coefficients of the variable price of cocoa beans have the expected negative sign, and all but two (United Kingdom and Australia) are significantly different from zero, at the 20 percent level at least. Also, seven of the coefficients of the income variable are positive and significantly different from zero, at the same level of significance; Netherlands is the only country with a negative coefficient for income, although not significant. The performance of the two other price variables (sugar and soybean oil) was less satisfactory however. Changes in the price of sugar did not affect cocoa beans consumption in an important way; only the coefficient for Japan was significant (sugar being a substitute for cocoa beans.[65] The coefficient of the variable price of soybean oil was significant in only two countries (as substitutes), United States and Italy. We recall that opposite forces work with respect to this variable (similarly for sugar), and we did not make any prediction (in Chapter 4) about its expected sign in the regressions (five countries have negative, although not significant, coefficients for price of soybean oil). The coefficient of the variable lagged per capita grindings had the right sign in seven countries, with the coefficients being significant in five of them.

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[65] One problem with the variable price of sugar is that the range of values observed in the time period 1951-1970 was very small, probably due to the existence of international agreements. This might well be a reason for the results obtained.

Table 8. Least squares estimates of demand for cocoa; bean equivalents, 1951-1970, partial adjustment (Nerlove) model[a]

Country	Least squares estimates (t values in parentheses)[b]						
	Constant	P	P^s	P^v	Y	Q_{t-1}	R^2
United States	1.3764 (2.1488)[a]	-0.0155 (-5.3458)[a]	-0.00004 (-0.0008)	0.0129 (1.3941)[c]	0.0002 (1.8644)[b]	0.5414 (4.9871)[a]	0.89
Belgium	3.1707 (1.9940)[b]	-0.0176 (-2.2945)[a]	-0.0636 (-0.5171)	-0.0115 (-0.4617)	0.0013 (2.4705)[a]	0.2288 (1.1137)	0.87
Denmark	2.7429 (1.8958)[b]	-0.0357 (-4.6281)[a]	0.0452 (0.3776)	-0.0182 (-0.6738)	0.0011 (3.4083)[a]	-0.0112 (-0.1076)	0.91
Netherlands	7.4012 (1.5750)[c]	-0.0919 (-4.0974)[a]	0.0891 (0.2463)	-0.0164 (-0.2068)	-0.0014 (-1.1562)	0.3348 (2.0718)[b]	0.68
Germany	1.2772 (0.9182)	-0.0248 (-3.6345)[a]	0.0468 (0.4270)	0.0130 (0.4832)	0.0006 (1.3902)[c]	0.5888 (3.9888)[a]	0.95
France	0.6548 (0.5229)	-0.0104 (-1.6207)[c]	0.0016 (0.0159)	0.0277 (1.2391)	0.0009 (2.6316)[a]	0.2641 (1.3188)	0.78
United Kingdom[c]	0.3786 (0.0941)	-0.0138 (-0.8173)	0.0387 (0.1767)	0.0485 (0.5536)	0.0003 (0.1524)	0.6765 (1.9448)[b]	0.58
Italy	-0.1527 (-0.5115)	-0.0031 (-2.0462)[b]	0.0312 (1.2524)	0.0093 (1.6023)[c]	0.0010 (4.9385)[a]	-0.2426 (-1.1370)	0.95
Japan[d]	-0.6116 (-0.9441)	-0.0055 (-1.7114)[c]	0.0995 (1.8106)[b]	-0.0066 (-0.5257)	0.0002 (0.6483)	0.6108 (3.2348)[a]	0.93
Australia	1.6924 (1.0068)	-0.0134 (-1.1694)	0.0502 (0.4175)	-0.0148 (-0.7105)	0.0011 (1.7793)[b]	-0.0526 (-0.1433)	0.72

Table 8 (continued)

[a]All variables are defined in the text. Data sources: per capita grindings and price of cocoa beans (Food and Agriculture Organization of the United Nations, 1958-1972); price of sugar and of soybean oil (Commodity Research Bureau, 1952-1971); income, population, price indices (United Nations, 1950-1972). The results for the Durbin-Watson statistic are all in the inconclusive range and thus are not reported; this is to be expected because of the number of observations in our sample and number of independent variables.

[b]For significance of the coefficients the code is:

- a statistically significant at the 5 percent level;
- b statistically significant at the 10 percent leve;
- c statistically significant at the 20 percent level.

[c]Time period 1952-1970.

[d]Time period 1953-1970.

The price and income elasticities computed from the estimated demand equations of Table 8 are presented in Table 9, the elasticities being calculated at the mean value for the price and income variable.[66] The results for the price elasticities of demand for cocoa beans indicate that all but one (Netherlands) are included in the range from -0.11 to -0.44. All values, however, show that the short-run demand for cocoa beans is an inelastic one; even in the long-run, only the price elasticity for Netherlands changes from inelastic to an elastic one. Compared with available information (presented in Chapter 4), our results are consistent in terms of the order of magnitude involved.

The computed values for the income elasticity of demand indicate that in all countries but one, cocoa is an income inelastic superior good; the only exception is Netherlands, although the income coefficient given in Table 8 is not significantly different from zero. Previous results by Behrman (1968) and reported in Chapter 4 are consistent with our findings, although his figures were somewhat greater than ours in absolute terms; Behrman's (1965) results show cocoa as an inferior good in some countries (including Netherlands).

An additional run was made with the same Nerlovian formulation, but introducing the following modifications: (a) the variable price of sugar was dropped from the model. It was felt that since the range of values taken by this variable was very small (a reason for the large standard error of the coefficient), any possible effect of sugar price

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[66] Cross price elasticities of demand are not presented since most of the coefficients were not significantly different from zero. The exceptions are for price of sugar in Japan ($\eta = 1.71$), and price of soybean oil in the United States ($\eta = 0.46$), and Italy ($\eta = 0.18$).

Table 9. Elasticities of demand for bean-equivalents: Partial adjustment (Nerlove) model[a]

Country	Elasticity of demand with respect to		
	P (short-run)	P (long-run)	Y
United States	-0.16	-0.34	0.18
Belgium	-0.14	-0.19	0.43
Denmark	-0.44	-	0.51
Netherlands	-0.83	-1.24	-0.44
Germany	-0.19	-0.47	0.21
France	-0.14	-0.19	0.47
United Kingdom	-0.11	-0.33	0.09
Italy	-0.13	-	0.99
Japan	-0.33	-0.84	0.20
Australia	-0.16	-	0.59

[a]Computed from values given in Table 8 and mean values of the variables.

would not be captured in the regressions.[67] (b) The variable lagged per capita grindings was dropped in the regression for Denmark, Italy and Australia. The reason for this was the negative sign of its coefficient, as presented in Table 8, which implies that β (the coefficient of adjustment) is greater than one, which is inconsistent with the formulation of the distributed lag model. By dropping this variable, however, we are actually leaving Nerlove's lag formulation aside, the immediate implication being that short- and long-run coefficients (elasticities) are the same.

Table 10 presents the results obtained from this alternative to the basic Nerlove formulation. The coefficients of determination are only slightly changed, indicating that the excluded variables were contributing very little to the explanation of per capita grindings. With respect to the individual coefficients, their t values are generally increased, and the number of coefficients significantly different from zero at the 20 percent level at least is also greater. The result for the United Kingdom, however, is an extreme case where no improvements were obtained from the unsatisfactory figures of Table 8. The elasticities computed from the results of this alternative formulation are reported in Table 11, where only very small changes can be noticed with respect to the elasticities presented in Table 9.

As an attempt to improve our estimation of demand equations, the alternative formulation given by Relation 43 was fitted to the data.

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[67] If price of sugar is a variable which really belongs to a model of demand for cocoa beans, by dropping it we may introduce a bias when estimating the coefficients (Theil, 1971, p. 549).

Table 10. Least squares estimates of demand for cocoa; bean-equivalents, 1951-1970, altered partial adjustment (Nerlove) model[a]

Country	Least squares estimates (t values in parentheses)[b]					
	Constant	P	P^v	Y	Q_{t-1}	R^2
United States	1.3761 (3.1035)[a]	-0.0155 (-5.5335)[a]	0.0129 (1.4536)[c]	0.0002 (1.9433)[b]	0.5414 (5.1728)[a]	0.89
Belgium	2.5725 (2.4179)[a]	-0.0176 (-2.3532)[a]	-0.0112 (-0.4626	0.0013 (2.4771)[a]	0.2276 (1.1357)	0.87
Denmark	3.2109 (4.5453)[a]	-0.0355 (-5.1219)[a]	-0.0197 (-0.8252)	0.0011 (4.5467)[a]	-	0.91
Netherlands	8.2711 (2.7562)[a]	-0.0919 (-4.2287)[a]	-0.0174 (-0.2265)	-0.0013 (-1.1670)	0.3403 (2.1954)[a]	0.68
Germany	1.7282 (1.9635)[b]	-0.0247 (-3.7261)[a]	0.0130 (0.4968)	0.0007 (1.48910)[c]	0.5917 (4.1271)[a]	0.95
France	0.6709 (0.9419)	-0.0104 (-1.6777)[c]	0.0277 (1.2826)	0.00094 (2.7670)[a]	0.2642 (1.3672)[c]	0.78
United Kingdom[c]	0.7151 (0.2090)	-0.0139 (-0.8596)	0.0474 (0.5627)	0.0004 (0.1794)	0.6858 (2.0675)[b]	0.58
Italy	0.1616 (0.9279)	-0.0030 (-1.9509)[b]	0.0071 (1.2619)	0.0009 (8.8116)[a]	-	0.94
Japan[d]	0.4320 (1.3481)[c]	-0.0054 (-1.5623)[c]	-0.0063 (-0.4632)	0.0001 (0.3434)	0.7441 (3.9471)[a]	0.91
Australia	2.0710 (2.5630)[a]	-0.0122 (-1.8337)[b]	-0.0160 (-0.8244)	0.0011 (3.1128)[a]	-	0.71

Table 10 (continued)

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[a]P^s was excluded from all countries and Q_{t-1} from regressions for Denmark, Italy and Australia. The remaining variables as well as the code for determining the significance of the coefficients are the same as in Table 8. The Durbin-Watson statistic was inconclusive for all countries but Australia.

[b]For significance of the coefficients the code is:

- a statistically significant at the 5 percent level;
- b statistically significant at the 10 percent level;
- c statistically significant at the 20 percent level.

[c]Time period 1952-1970.

[d]Time period 1953-1970.

Table 11. Elasticities of demand for bean equivalents: Altered partial adjustment model[a]

Country	Elasticity of demand with respect to P (short-run)	P (long-run)	Y
United States	-0.16	-0.34	0.18
Belgium	-0.14	-0.19	0.41
Denmark	-0.43	-	0.51
Netherlands	-0.83	-1.25	-0.42
Germany	-0.19	-0.47	0.21
France	-0.14	-0.19	0.47
United Kingdom	-0.11	-0.34	0.10
Italy	-0.12	-	0.82
Japan	-0.33	-1.25	0.11
Australia	-0.15	-	0.58

[a]Elasticities were obtained from figures in Table 10 and mean values of the variables.

As mentioned in Chapter 4, Nerlove's formulation has the characteristic that the lag weights decline geometrically; the polynomial lag model, as presented by Equation 43, is more flexible in the sense that the highest response to a price change may occur at a period of time other than the first. In other words, in our case of cocoa beans, the rate of consumption response from a price change could, possibly, first increase and then decrease (Chen et al. 1972). With respect to estimating Equation 43, a decision must be made relating to the size of k, that is, the number of time periods covered by the lag function;[68] a value of k = 4 was selected, although we have no way of knowing, a priori, the correct value for it. Chen et al. (1972) tried several values for k in their regressions for California's milk production response (k values of 5, 6, 7, 8, and 9), but this procedure in our case would require a large number of regressions since we are dealing with ten countries separately.[69]

Table 12 presents the results obtained for the ten countries of our analysis when using the polynomial lag formulation. Although additional computations will have to be made to obtain the coefficients of the two price variables (cocoa beans and soybean oil), it can be

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[68] Following Chen et al. (1972), the lagged weights were defined, for estimation purposes, as:

$$Z_1 = \sum_{i=0}^{4} (k-i)\, P_{t-i} \text{ and } Z_2 = \sum_{i=0}^{k} (k^2 - i^2)\, P_{t-i}$$

and similarly for U_1 and U_2, which correspond to the variable price of soybean oil.

[69] To try several different values of k and then use a criterion for the final selection is also the suggestion made by Schmidt and Waud (1973, p. 13).

Table 12. Least squares estimates of demand for cocoa beans, polynomial lag formulation, 1951-1970[a]

Country	Least squares estimates (t values in parentheses)[b]						
	Constant	Z_1	Z_2	U_1	U_2	Y	R^2
United States	2.0481 (3.0367)[a]	-0.0051 (-1.6002)[c]	0.0004 (0.6183)	-0.0166 (-1.1173)	0.0043 (1.4223)[c]	0.0006 (4.2095)[a]	0.85
Belgium	4.3089 (3.2898)[a]	-0.0086 (-1.3044)	0.0012 (0.8873)	0.0060 (0.1866)	-0.0019 (-0.2760)	0.0013 (2.4342)[a]	0.89
Denmark	4.6477 (5.9508)[a]	-0.0212 (-4.3456)[a]	0.0037 (3.6840)[a]	0.0394 (1.7945)[b]	-0.0094 (-2.0622)[b]	0.0006 (2.5047)[a]	0.96
Netherlands	15.2365 (4.9643)[a]	-0.0439 (-2.6519)[a]	0.0059 (1.7167)[c]	0.0045 (0.0566)	-0.0026 (-0.1580)	-0.0030 (-2.3590)[a]	0.80
Germany	1.6694 (0.8586)	-0.0109 (-1.4679)[c]	0.0013 (0.8218)	0.0335 (0.9033)	-0.0052 (-0.6523)	0.0023 (3.7776)[a]	0.93
France	0.4757 (0.5208)	-0.0045 (-0.8649)	0.0003 (0.2490)	-0.0224 (-0.9088)	0.0060 (1.1819)	0.0015 (4.4890)[a]	0.83
United Kingdom[c]	1.5455 (0.2703)	0.0171 (1.3379)	-0.0037 (-1.3649)[c]	0.1617 (2.5097)[a]	-0.0297 (-2.1487)[a]	0.0012 (0.4304)	0.53
Italy	0.0038 (0.0138)	-0.0038 (-2.5559)[a]	0.0008 (2.4631)[a]	0.0029 (0.4177)	-0.0004 (-0.3077)	0.0009 (6.3070)[a]	0.95
Japan[d]	1.0313 (3.0036)[a]	0.0047 (1.9527)[b]	-0.0015 (-2.9410)[a]	0.0239 (2.0840)[b]	-0.0046 (-1.8884)[b]	0.0006 (3.6015)[a]	0.96
Australia	2.8282 (2.5271)[a]	-0.0027 (-0.4023)	0.0002 (0.1494)	0.0060 (0.1991)	-0.0017 (-0.2692)	0.0008 (1.7957)[b]	0.75

Table 12 (continued)

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[a]All variables are defined in the text; the same code for the significance of the coefficients (Table 8) applies here, as well as time periods for United Kingdom (1952-1970) and Japan (1953-1970). The values for the Durbin-Watson statistic are, as before, inconclusive.

[b]For significance of the coefficients the code is:

- a statistically significant at the 5 percent level;
- b statistically significant at the 10 percent level;
- c statistically significant at the 20 percent level.

[c]Time period 1952-1970.

[d]Time period 1953-1970.

noticed that the coefficient of determination is higher for all but three countries (United States, United Kingdom, and Germany); in addition, the improvement of the income variable with respect to the significance of its coefficient is apparent. The additional computations required to obtain the price coefficients will now be shown for the case of the United States (for price of cocoa beans). Since the procedure is the same for all other countries (and price of soybean oil), only the final results will be shown for them. Following the procedure outlined by Chen et al. (1972), and our previous specification (footnote 67), we may write:

$$Z_1 = 4P_t + 3P_{t-1} + 2P_{t-2} + P_{t-3} \qquad (44)$$

$$Z_2 = 16P_t + 15P_{t-1} + 12P_{t-2} + 7P_{t-3} \qquad (45)$$

for the case of the variable price of cocoa beans; the same procedure can be applied to U_1 and U_2, which correspond to the variable price of soybean oil. In Chapter 4 we derived the following relation:

$$\beta_i = \gamma_i \ (k-i) + \gamma_2 \ (k^2 - i^2) \qquad (46)$$

with the first term in the right inside representing the linear, and the second one representing the quadratic term in the lag formulation. Since we know (from Table 12) that $\gamma_1 = -0.0051$ and $\gamma_2 = 0.0004$, we can (with Relation 46) obtain the price coefficients, a process the authors referred to above call "unscrambling," to obtain the following results:

Lag	Linear	Quadratic	Total
t	-0.02053	0.00662	-0.01391
t-1	-0.01539	0.00620	-0.00919
t-2	-0.01026	0.00496	-0.00530
t-3	-0.00513	0.00289	-0.00224

As a result of such "unscrambling," the estimated demand equation for the United States can be written[70] (t values in parentheses, same significance's code as before).[71]

$$Q_t = \underset{(3.0367)^a}{2.0481} - \underset{(-4.4218)^a}{0.0139P_t} - \underset{(-4.5398)^a}{0.0092P_{t-1}} - \underset{(-2.4456)^a}{0.0053P_{t-2}}$$

$$- \underset{(-1.3136)}{0.0022P_{t-3}} + \underset{(0.2208)}{0.0028P^v_t} + \underset{(2.8055)^a}{0.0151P^v_{t-1}}$$

$$+ \underset{(2.3905)^a}{0.0187P^v_{t-2}} + \underset{(2.0174)^b}{0.0014P^v_{t-3}} + \underset{(4.2095)^a}{0.0006Y_t} \qquad (47)$$

As a result of using the same procedure for all other countries, their respective demand equations can be obtained, and presenting only the final figures, they are listed as follows:

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[70]The coefficients of the variable price of soybean oil were obtained by applying a procedure similar to the one described in the text for price of cocoa beans, and using the relation

$$\Theta_i = \lambda_1 (k - i) + \lambda_2 (k^2 - i^2)$$

λ_1 and λ_2 being the coefficients given in Table 12.

[71]Following Chen et al. (1972), the t values for testing hypothesis with respect to the individual coefficients are obtained by the ratio $t_{\beta_i} = \frac{\beta_i}{\sqrt{\text{Var}(\beta_i)}}$, where Var (β_i) can be obtained from Relation 46 in the text.

Belgium:

$$Q_t = \underset{(3.2898)^{a}}{4.3089} - \underset{(-3.1505)^{a}}{0.0151P_t^v} - \underset{(-1.9959)^{b}}{0.0077P_{t-1}} - \underset{(-0.6694)}{0.0028P_{t-2}} \tag{48}$$

$$- \underset{(-0.0522)}{0.0002P_{t-3}} - \underset{(-0.2257)}{0.0057P_t^v} - \underset{(-0.7683)}{0.0098P_{t-1}^v}$$

$$- \underset{(-0.5501)}{0.0103P_{t-2}^v} - \underset{(-0.4447)}{0.0070P_{t-3}^v} + \underset{(2.4342)^{a}}{0.0013Y_t}$$

Denmark:

$$Q_t = \underset{(5.9508)^{a}}{4.6477} - \underset{(-5.7156)^{a}}{0.0256P_t} - \underset{(-3.6047)^{a}}{0.0081P_{t-1}} + \underset{(0.7214)}{0.0020P_{t-2}} \tag{49}$$

$$+ \underset{(2.0171)^{b}}{0.0047P_{t-3}} + \underset{(0.4098)}{0.0072P_t^v} - \underset{(-2.7004)^{a}}{0.0219P_{t-1}^v}$$

$$- \underset{(-2.7977)^{a}}{0.0340P_{t-2}} - \underset{(-2.5430)^{a}}{0.0264P_{t-3}^v} + \underset{(2.54047)^{a}}{0.0006Y_t}$$

Netherlands:

$$Q_t = \underset{(4.9643)^{a}}{15.2365} - \underset{(-5.0498)^{a}}{0.0816P_t} - \underset{(-4.4914)^{a}}{0.0435P_{t-1}} - \underset{(-1.6320)^{c}}{0.0173P_{t-2}} \tag{50}$$

$$- \underset{(-0.3317)}{0.0028P_{t-3}} - \underset{(-0.3712)}{0.0238P_t^v} - \underset{(-0.8795)}{0.0257P_{t-1}^v}$$

$$- \underset{(-0.5090)}{0.0224P_{t-2}^v} - \underset{(-0.3662)}{0.0138P_{t-3}^v} - \underset{(-2.3590)^{a}}{0.0029Y_t}$$

West Germany:

$$Q_t = \underset{(0.8586)}{1.6694} - \underset{(-3.1724)^a}{0.0233P_t} - \underset{(-2.9854)^a}{0.0137P_{t-1}} - \underset{(-1.3444)}{0.0066P_{t-2}} \qquad (51)$$

$$- \underset{(-0.5231)}{0.0020P_{t-3}} + \underset{(1.6754)^c}{0.0514P^v_t} + \underset{(1.1716)}{0.0231P^v_{t-1}}$$

$$+ \underset{(0.2037)}{0.0050P^v_{t-2}} - \underset{(-0.1347)}{0.0027P^v_{t-3}} + \underset{(3.7776)^a}{0.0023Y_t}$$

France:

$$Q_t = \underset{(0.5208)}{0.4757} - \underset{(-2.7734)^a}{0.0136P_t} - \underset{(-3.3217)^a}{0.0094P_{t-1}} - \underset{(-1.8129)^b}{0.0057P_{t-2}} \qquad (52)$$

$$- \underset{(-1.0623)}{0.0026P_{t-3}} + \underset{(0.3597)}{0.0071P^v_t} + \underset{(2.6037)^a}{0.0234P^v_{t-1}}$$

$$+ \underset{(2.0246)^b}{0.0277P^v_{t-2}} + \underset{(1.7043)^c}{0.0199P^v_{t-3}} + \underset{(4.4890)^a}{0.0015Y_t}$$

United Kingdom:

$$Q_t = \underset{(0.2703)}{1.5456} + \underset{(0.7640)}{0.0097P_t} - \underset{(-0.4458)}{0.0037P_{t-1}} - \underset{(-1.0963)}{0.0098P_{t-2}} \qquad (53)$$

$$- \underset{(-1.2625)}{0.0086P_{t-3}} + \underset{(3.3158)^a}{0.1717P^v_t} + \underset{(1.1724)}{0.0396P^v_{t-1}}$$

$$- \underset{(-0.7617)}{0.0330P^v_{t-2}} + \underset{(-1.3381)}{0.0462P^v_{t-3}} + \underset{(0.4304)}{0.0012Y_t}$$

Italy:

$$Q_t = \underset{(0.0138)}{0.0038} - \underset{(-3.1040)^a}{0.0031P_t} - \underset{(0.0689)}{0.0001P_{t-1}} + \underset{(1.6032)^c}{0.0015P_{t-2}} \tag{54}$$

$$+ \underset{(2.0346)^b}{0.0015P_{t-3}} + \underset{(0.8067)}{0.0044P^v_t} + \underset{(0.7547)}{0.0020P^v_{t-1}}$$

$$+ \underset{(0.1211)}{0.0005P^v_{t-2}} - \underset{(-0.0639)}{0.0002P^v_{t-3}} + \underset{(6.3070)^a}{0.0009Y_t}$$

Japan:

$$Q_t = \underset{(3.0036)^a}{1.0313} - \underset{(-2.0280)^b}{0.0048P_t} - \underset{(-5.4603)^a}{0.0080P_{t-1}} - \underset{(-5.2279)^a}{0.0083P_{t-2}} \tag{55}$$

$$- \underset{(-4.5625)^a}{0.0056P_{t-3}} + \underset{(2.4050)^a}{0.0218P^v_t} + \underset{(0.4443)}{0.0025P^v_{t-1}}$$

$$- \underset{(-1.0236)}{0.0076P^v_{t-2}} - \underset{(-1.3834)^c}{0.0084P^v_{t-3}} + \underset{(3.6015)^a}{0.0006Y_t}$$

Australia:

$$Q_t = \underset{(2.5271)^a}{2.8282} - \underset{(-1.1659)}{0.0077P_t} - \underset{(-1.3654)^c}{0.0051P_{t-1}} - \underset{(-0.7249)}{0.0030P_{t-2}} \tag{56}$$

$$- \underset{(-0.3712)}{0.0013P_{t-3}} - \underset{(-0.1071)}{0.0026P^v_t} - \underset{(0.7935)}{0.0069P^v_{t-1}}$$

$$- \underset{(0.5255)}{0.0079P^v_{t-2}} - \underset{(-0.4180)}{0.0056P^v_{t-3}} + \underset{(1.7957)^b}{0.0008Y_t}$$

The results obtained with the application of a polynomial lag function to the demand for cocoa beans tend to confirm those obtained by the use of Nerlove's formulation, that is, with respect to the actual existence of a lag in response. The existence of a lag in response to a change in price of cocoa beans appears to be evident from the above equations,[72] although the United Kingdom (a poor fit) and Italy might be exceptions. The length of the lag, however, appears to be different for many of the countries included, which would indicate that our _a priori_ specification of k = 4 is not a satisfactory one for all countries.[73] With respect to the variable price of soybean oil the results obtained can probably be said to be an improvement with respect to the earlier formulation (Nerlove), but still of a mixed nature. Evidence of being a significant variable as well as the existence of a lag in response appears for the United States and France (as substitute for cocoa beans), and Denmark (as complement); in addition, West Germany, United Kingdom, and Japan present evidence of a significant short-run (response in the same time period) relationship, with soybean oil being a substitute commodity.

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[72]Japan is the only case where the rate of consumption response (to a change in price of cocoa beans) first increases and then declines; this pattern of adjustment is more frequently observed, however, with respect to a change in price of soybean oil.

[73]In some cases, the signs of the lagged price of cocoa beans variable (mainly for P_{t-2} and P_{t-3}) are positive, contrary to the expected, although not significant; the specification of k = 4 might be a factor in such respect, indicating that for some countries the final time period covered by the lag function should be a shorter one (Schmidt and Waud, 1973, p. 13).

For purposes of comparison with the results obtained with the Nerlovian formulation, we will now proceed to calculate the short-run and long-run elasticities as well as the income elasticity of demand resulting from the polynomial lag formulation. Short-run elasticity will be defined to include (as in Nerlove's case) only the response occurring in the same time period t of the price change, whereas the long-run price elasticity will include the response occurring for the entire period considered (since k = 4, t - 3 is the last year to be included). For the long-run price elasticity (both cocoa beans and soybean oil) the following expression is utilized (Chen et al. 1972, p. 81):

$$\eta_{LR} = \sum_{i=0}^{3} \frac{\partial Q_t}{\partial P_{t-i}} \frac{\overline{P}}{\overline{Q}} \qquad (57)$$

Accordingly, the short-run price elasticity corresponds only to the first term (i = 0) in Relation 57; Table 13 presents the results so obtained with the polynomial lag formulation.

When comparing the elasticities shown in Table 13 with those from the Nerlovian formulation of Tables 9 and 11, it is apparent that the figures are quite similar, in a country-by-country basis. Probably the only exceptions are those for the long-run elasticity in France and Japan, the values of Table 13 being somewhat higher. The income elasticities are, however, higher for almost all countries in Table 13, and as a result more in line with the results obtained by Behrman (1968). We also recall that the income per capita variable (see Table 12) performed very well (in terms of significance of the coefficients, only the one for the United Kingdom was not significant at the 10 percent level), when compared with the results from Nerlove's formulation.

Table 13. Elasticities of demand for bean-equivalents: Polynomial lag formulation[a]

Country	Elasticity of demand with respect to		
	P (short-run)	P (long-run)	Y
United States	-0.14	-0.31	0.51
Belgium	-0.12	-0.21	0.41
Denmark	-0.31	-0.33	0.29
Netherlands	-0.73	-1.31	-0.95
Germany	-0.18	-0.36	0.73
France	-0.18	-0.42	0.74
United Kingdom	-	-0.10	0.35
Italy	-0.13	-	0.88
Japan	-0.29	-1.61	0.78
Australia	-0.09	-0.20	0.44

[a]Elasticities were obtained from figures in Table 12 and Equations 47-56 in the text. It should be mentioned that some of the coefficients used in the computations were not significantly different from zero, with the wrong sign occurring in some cases. This is the reason for not reporting the short-run price elasticity for the United Kingdom and long-run elasticity for Italy.

Demand Projections

We have estimated (in the previous section) the demand functions for cocoa beans in ten of the most important consuming nations, and using two different approaches. Since the objectives of this study refer to different market arrangements at a future year (1980), our next step must be the one of projecting the relationships obtained so far, to that future period. Since the approach to be used in dealing with our objectives involves the use of the reactive programming procedure, we must have demand (and supply) functions including only two variables, that is, cocoa price and quantity. In such a situation, the procedure of obtaining estimates of these functions in 1980 will involve the elimination of all regressors, with the exception of price of cocoa beans (see our discussion in Chapter 2, and Schmitz, 1968, pp. 93-95). Since our interests refer to obtaining an estimate of the long-run demand equations in 1980, only the projection procedure appropriate to this case will be described below. This is so because in analyzing the world cocoa economy in 1980 under three alternative market situations, we have interest in knowing what equilibrium solutions will be after enough time has passed to allow all possible adjustments to a given market change.[74] Short-run responses, for instance, would provide us with an inappropriate information with respect to either elimination of tariffs or introduction of an international cocoa agreement. Starting the discussion with Nerlove's partial

[74] Nerlove (1958) discusses the problem of short- and long-run demand relationships. The considerations presented in Chapter 4 relating to availability of substitutes, investment in research and development, and alternative sources of supply would be relevant here; see also Helleiner (1972, Chapter 3, p. 55).

adjustment model, we have the following equation which was estimated for the United States (from Table 10 above):

$$Q_t = 1.3761 - 0.0155P_t + 0.0129P_t^V + 0.0002Y_t \qquad (58)$$

$$+ 0.5414Q_{t-1}$$

where as before, Q = per capita grindings, P = price of cocoa beans, P^V = price of soybean oil, Y = income per capita, Q_{t-1} = lagged per capita grindings. The coefficients of the long-run demand equation can be obtained by subtracting the coefficient of Q_{t-1} from one (1 - 0.5414 = 0.4586) and then dividing the coefficients of the remaining variables by the resulting number (0.4586), which is the estimate of β, the coefficient of adjustment in the United States' case (Nerlove and Addison, 1958, p. 864). The resulting long-run function is:

$$Q_t = 3.0001 - 0.0338P_t + 0.0281P_t^V + 0.0004Y_t \qquad (59)$$

Since the above relation is expressed in per capita terms, and we want an estimate of the function for total consumption of cocoa beans (Q^T), population must be introduced (N in Relation 60):

$$Q_t^T = 3.0001(N) - 0.0338(N)P_t + 0.0281(N)P_t^V + 0.0004(N)Y_t \qquad (60)$$

To obtain an estimate of the long-run function in 1980, we must have estimates for the variables N, P^V and Y at that year. The estimate for P^V will be taken as the mean value of this variable during the period of analysis ($\bar{P}^V$ = 17.295 for all countries). Appendix C Tables 1 and 2 present estimates of Y and N for all countries, resulting from estimating a function of the form $Y = a + bt$ and $N = c + dt$, t being time in years,[74] respectively, for income per capita and population. If we substitute the values $P^V = 17.295$, $N = 234{,}058$, and $Y = 4{,}748$ in Equation 60 we obtain:

$$Q^T = 1{,}260.47 - 7.91P \tag{61}$$

which is the estimated demand function for cocoa beans in the United States in 1980, Q^T being total grindings expressed in million of pounds.

A similar procedure can be applied to the demand equations estimated by the polynomial lag formulation with a view of obtaining the relationship for 1980. Equation 47 above describes the function as estimated for the United States. If we use the values $P^V = 17.295$ for the current and lagged variable price of soybean oil, and $Y = 4{,}748$ as above, we obtain the relation:

$$Q_t = 5.7668 - 0.0139P_t - 0.0092P_{t-1} - 0.0053P_{t-2} - 0.0022P_{t-3} \quad . \tag{62}$$

To obtain the long-run relationship correspondent to the above demand equation, all price coefficients will be added to form the coefficient of a single price variable (with the assumption of full adjustment in the period of one year). This will place the relationship estimated by the polynomial lag formulation in a situation comparable to that estimated by the Nerlove approach and presented above. As a result we obtain the following relation, still expressed in per capita terms:

[74] 1951 = 1 and 1970 = 20.

$$Q_t = 5.7668 - 0.0306P_t \quad . \tag{63}$$

By introducing the projected population (N = 234,058), we can obtain a relation in terms of total consumption (Q^T):

$$Q^T = 5.7668(N) - 0.0306(N)P_t \tag{64}$$

with the N value for 1980 (N = 234,058), the resulting relation is given by:

$$Q^T = 1,349.77 - 7.16\ P \tag{65}$$

with Q^T again being expressed as total grindings of cocoa beans in million of pounds.

Table 14 presents the results obtained when estimating the demand functions for each of the countries in 1980 and using the procedure described above for the two techniques. These demand functions will be the ones to be used in the next chapter when obtaining the equilibrium solutions with the reactive programming procedure.[75]

The Estimated Supply Equations

In the discussion of Chapter 4, when reviewing previous research and presenting the models for estimation of supply functions, we emphasized some of the problems created by the lack of data with respect to acreage

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[75] Certain limitations must be recognized with respect to the projected demand functions: since we are working with the fixed exchange rates as prevailing in 1970, any change occurring with them is not taken into account here (Schmitz, 1968, pp. 214-215). In addition, we are concerned with the demand function of a future year, and if we introduced specification bias by dropping the variable price of sugar (or leaving aside some other relevant variable), our predictions would also be biased (Theil, 1971, pp. 122-124).

Table 14. Estimated demand functions in 1980[a]

Country	Nerlove	Polynomial lag
United States	$Q^T = 1,260.47 - 7.91P$	$Q^T = 1,349.77 - 7.16P$
Belgium	$Q^T = 82.04 - 0.23P$	$Q^T = 71.49 - 0.26P$
Denmark	$Q^T = 33.23 - 0.19P$	$Q^T = 41.12 - 0.14P$
Netherlands	$Q^T = 103.52 - 2.02P$	$Q^T = 180.73 - 2.11P$
Germany	$Q^T = 671.90 - 4.03P$	$Q^T = 675.17 - 2.99P$
France	$Q^T = 285.96 - 0.79P$	$Q^T = 334.88 - 1.75P$
United Kingdom	$Q^T = 424.59 - 2.61P$	$Q^T = 368.29 - 0.73P$
Italy	$Q^T = 108.95 - 0.17P$	$Q^T = 99.59 - 0.01P$
Japan	$Q^T = 219.13 - 2.37P$	$Q^T = 264.32 - 3.00P$
Australia	$Q^T = 66.94 - 0.23P$	$Q^T = 65.13 - 0.25P$

[a]Procedure used is described in the text; Q^T is total grindings of cocoa beans in million of pounds and P is price of cocoa beans in cents per pound.

planted with cocoa and climatic variables. Since the results previously obtained by Behrman (1968) were not entirely satisfactory for some of the countries included, an attempt was made here to obtain estimates of the supply equations by using the polynomial lag formulation, which was considered to be a more flexible distributed lag model, mainly as applied to a perennial crop. Discussion of this formulation was presented in Chapter 4, and above, in the section about demand estimation. At this point we must say that a decision had to be made with respect to k, that is, the number of time periods covered by the lag function. Results obtained by Behrman (1968) indicated that two significant increases in yields per unit of area for cocoa occurs in the period of 6-14 years after planting; a decision was *a priori* made of choosing k = 10 for all countries (Ghana, Nigeria, Brazil, Ivory Coast, and Cameroon), the basic reason being related to the small number of degrees of freedoms we would have (with k > 10) in the usual postwar time series.[76] Repeating the equation to be estimated as:

$$Q_t = a_o + \alpha_1 W_1 + \alpha_2 W_2 + \delta_1 V_1 + \delta_2 V_2 + dt + u_t \qquad (66)$$

where:

$$W_1 = \sum_{i=0}^{k} (i-k) P_{t-i}$$

---

[76]The alternatives of trying different k values or of simply picking a k value closer to 15 for instance were not possible here because of the constraint in terms of the number of observations available. It is possible, however, that by using k = 10, we are understating the length of the lag and, as a result, causing specification error (Schmidt and Waud, 1973, p. 13).

$$W_2 = \sum_{i=0}^{k} (i^2 - k^2) \, P_{t-i}$$

$$V_1 = \sum_{i=0}^{k} (i - k) \, P^c_{t-i}$$

$$V_2 = \sum_{i=0}^{k} (i^2 - k^2) \, P^c_{t-i}$$

with the above equation being estimated linearly, for each of the five countries listed above, by ordinary least squares (period 1946-1970); the variables can again be defined as:

Q_t = Quantity produced of cocoa beans in million of pounds, time t.

P_t = Real spot price of cocoa beans (Ghana's product) in New York in cents per pound, time t.

P^c_t = Real spot price of coffee (Uganda's product) in New York in cents per pound, time t.

t = Technology variable represented by a time proxy: 1955 = 1, 1970 = 16.

k = Number of time periods covered by the lag function (i = 0, 1, ... , k); k = 10 in our case.

u = Random disturbance, with the properties assumed in Chapter 4, plus the normality assumption.

Table 15 presents the results obtained for the estimated supply equations in the five countries included in the analysis, when using the polynomial lag formulation. The regression results are mixed: the results for supply response are satisfactory for Ghana and Ivory Coast not only in terms of the coefficients of determination but also with respect to significance of the individual coefficients; the remaining

Table 15. Least squares estimates of cocoa supply, polynomial lag formulation, 1955-1970[a]

Country	Least squares estimates (t values in parentheses)[b]						R^2
	Constant	W_1	W_2	V_1	V_2	t	
Ghana	-2.3551	-5.0137	0.4562	1.7312	-0.1738	54.3745	0.84
	(-0.0018)	(-2.5305)[a]	(2.3181)[a]	(1.5701)[c]	(-1.8232)[b]	(1.3135)	
Nigeria	318.0579	-1.5355	0.1226	0.5443	-0.0479	21.6630	0.81
	(0.3634)	(-1.1520)	(0.9260)	(0.7338)	(-0.7473)	(0.7779)	
Brazil	-788.5234	-0.2864	0.0369	0.4743	-0.0253	33.9020	0.58
	(-1.2737)	(-0.3039)	(0.3946)	(0.9041)	(-0.5578)	(1.7214)[c]	
Ivory Coast	-404.4218	-0.9754	0.0981	0.8091	-0.0692	33.9851	0.92
	(-1.0765)	(-1.7051)[c]	(1.7266)[c]	(2.5416)[a]	(-2.5155)[a]	(2.8436)[a]	
Cameroon	-104.6910	-0.1817	0.0210	0.1116	-0.0092	13.4358	0.93
	(-0.7795)	(-0.8885)	(1.0344)	(0.9809)	(-0.9381)	(3.1445)[a]	

[a]All variables are defined in the text; the same code for the significance of the coefficients introduced in Table 8 applies here. See footnote 67 for estimation procedure with respect to variables W and V. The results for the Durbin-Watson statistic were all inconclusive

[b]For significance of the coefficients the code is:

- a statistically significant at the 5 percent level;
- b statistically significant at the 10 percent level;
- c statistically significant at the 20 percent level.

countries have less satisfactory results, with the one for Brazil being poor in terms of both criteria mentioned above.

The additional computations which are required to obtain the price coefficients were already shown in the section dealing with demand estimation; since the procedure for "unscrambling" and for testing the resulting coefficients are exactly the same, they will not be repeated here. As a result only the final figures in the supply equation for each of the five countries will be presented. They are:

<u>Ghana</u>:

$$Q_t = \underset{(-0.0018)}{2.3551} - \underset{(-1.7898)}{4.5189P_t} + \underset{(0.0133)}{0.0386P_{t-1}} \tag{67}$$

$$+ \underset{(0.9783)}{3.6837P_{t-2}} + \underset{(1.4200)^c}{6.4165P_{t-3}} + \underset{(1.6534)^c}{8.2369P_{t-4}} + \underset{(1.7938)^c}{9.1450P_{t-5}}$$

$$+ \underset{(1.8865)^b}{9.1407P_{t-6}} + \underset{(1.9519)^b}{8.2241P_{t-7}} + \underset{(2.0003P^b}{6.3951P_{t-8}} + \underset{(2.0375)^b}{3.6537P_{t-9}}$$

$$- \underset{(-0.0286)}{0.0701P^c_t} - \underset{(-0.8569)}{1.6275P^c_{t-1}} - \underset{(-1.6333)^c}{2.8373P^c_{t-2}} - \underset{(-2.0276)^b}{3.6994P^c_{t-3}}$$

$$- \underset{(-2.1480)^b}{4.2138P^c_{t-4}} - \underset{(-2.1661)^b}{4.3807P^c_{t-5}} - \underset{(-2.1460)^b}{4.1998P^c_{t-6}} - \underset{(-2.1211)^b}{3.6713P^c_{t-7}}$$

$$- \underset{(-2.0961)^b}{2.7952P^c_{t-8}} - \underset{(-2.0733)^b}{1.5714P^c_{t-9}} + \underset{(1.3135)}{54.3745t}$$

Nigeria:

$$
\begin{array}{llllll}
Q_t = & 318.0579 & - \; 3.0963P_t & - \; 1.6834P_{t-1} & - \; 0.5157P_{t-2} & (68) \\
& (0.3634) & (-1.8704) & (-0.8793) & (-0.2058) & \\
& + \; 0.4069P_{t-3} & + \; 1.0843P_{t-4} & + \; 1.5165P_{t-5} & + \; 1.7035P_{t-6} & \\
& (0.1347) & (0.3230) & (0.4438) & (0.5244) & \\
& + \; 1.6454P_{t-7} & + \; 1.3421P_{t-8} & + \; 0.7936P_{t-9} & + \; 0.6435P^c_t & \\
& (0.5819) & (0.6254) & (0.6591) & (0.3903) & \\
& + \; 0.153P^c_{t-1} & - \; 0.2472P^c_{t-2} & - \; 0.5518P^c_{t-3} & - \; 0.7606P^c_{t-4} & \\
& (0.1200) & (-0.2116) & (-0.4497) & (-0.5764) & \\
& - \; 0.8735P^c_{t-5} & - \; 0.8905P^c_{t-6} & - \; 0.8117P^c_{t-7} & - \; 0.6370P^c_{t-8} & \\
& (-0.6412) & (-0.6764) & (-0.6971) & (-0.7101) & \\
& - \; 0.3664P^c_{t-9} & + \; 21.6630t & & & \\
& (-0.7187) & (0.7779) & & &
\end{array}
$$

Brazil:

$$
\begin{array}{llllll}
Q_t = & -788.5234 & + \; 0.8300P_t & + \; 1.0795P_{t-1} & + \; 1.2551P_{t-2} & (69) \\
& (-1.2737) & (0.7078) & (0.9192) & (0.7076) & \\
& + \; 1.3569P_{t-1} & + \; 1.3847P_{t-4} & + \; 1.3386P_{t-5} & + \; 1.2067P_{t-6} & \\
& (0.6350) & (0.5867) & (0.5537) & (0.5249) & \\
& + \; 1.0249P_{t-7} & + \; 0.7571P_{t-8} & + \; 0.4155P_{t-9} & + \; 2.2123P^c_t & \\
& (0.5124) & (0.4987) & (0.4879) & (1.8931)^b &
\end{array}
$$

$$+ \underset{(1.9458)^b}{1.7634P^c_{t-1}} + \underset{(1.6407)^b}{1.3650P^c_{t-2}} + \underset{(1.1690)^b}{1.0173P^c_{t-3}} + \underset{(0.7701)}{0.7201P^c_{t-4}}$$

$$+ \underset{(0.4909)}{0.4736P^c_{t-5}} + \underset{(0.2979)}{0.2777P^c_{t-6}} + \underset{(0.1606)}{0.1323P^c_{t-7}} + \underset{(0.0593)}{0.0376P^c_{t-8}}$$

$$- \underset{(-0.0180)}{0.0065P^c_{t-9}} + \underset{(1.7214)^c}{33.9020t}$$

Ivory Coast:

$$Q_t = \underset{(-1.0765)}{-404.4218} + \underset{(0.0783)}{0.0557P_t} + \underset{(1.1340)}{0.9331P_{t-1}} + \underset{(1.4996)^c}{1.6142P_{t-2}}$$

$$+ \underset{(1.6189)^c}{2.0991_{t-3}} + \underset{(1.6673)^c}{2.3878P_{t-4}} + \underset{(1.6907)^c}{2.4803P_{t-5}} + \underset{(1.7034)^c}{2.3767P_{t-6}}$$

$$+ \underset{(1.7110)^c}{2.0768P_{t-7}} + \underset{(1.7158)^c}{1.5807P_{t-8}} + \underset{(1.7190)^c}{0.8885P_{t-9}} + \underset{(1.6511)^b}{1.1687P^c_t}$$

$$+ \underset{(0.7622)}{0.4180P^c_{t-1}} - \underset{(-0.3478)}{0.1744P^c_{t-2}} - \underset{(-1.2099)}{0.6373P^c_{t-3}} - \underset{(-1.6980)^c}{0.9617P^c_{t-4}}$$

$$- \underset{(-1.9629)^b}{1.1476P^c_{t-5}} - \underset{(-2.1151)^b}{1.1951P^c_{t-6}} - \underset{(-2.2093)^b}{1.1040P^c_{t-7}} - \underset{(-2.2713)^a}{0.8745P^c_{t-8}}$$

$$- \underset{(-2.3145)^a}{0.5065P^c_{t-9}} + \underset{(2.8436)^a}{33.9851t}$$

Cameroon:

$$Q_t = \underset{(-0.7795)}{-104.6910} + \underset{(1.1170)}{0.2842P_t} + \underset{(1.5124)^c}{0.4449P_{t-1}} + \underset{(1.4643)^c}{0.5635P_{t-2}} \quad (71)$$

$$+ \; 0.6402P_{t-3} + 0.6748P_{t-4} + 0.6674P_{t-5} + 0.6186P_{t-6}$$
$$(1.3810)^{c} \quad (1.3179) \quad (1.2725) \quad (1.2401)$$

$$+ \; 0.5265P_{t-7} + 0.3930P_{t-8} + 0.2175P_{t-9} + 0.1932P^{c}_{t}$$
$$(1.2133) \quad (1.1933) \quad (1.1772) \quad (0.7630)$$

$$+ \; 0.0908P^{c}_{t-1} + 0.0068P^{c}_{t-2} - 0.0586P^{c}_{t-3} - 0.1057P^{c}_{t-4}$$
$$(0.4627) \quad (0.0381) \quad (-0.3112) \quad (-0.5216)$$

$$- \; 0.1342P^{c}_{t-5} - 0.1443P^{c}_{t-6} - 0.1359P^{c}_{t-7} - 0.1091P^{c}_{t-8}$$
$$(-0.6418) \quad (-0.7142) \quad (-0.7606) \quad (-0.7923)$$

$$- \; 0.0638P^{c}_{t-9} + 13.4358t$$
$$(-0.8150) \quad (3.1445)^{a}$$

With respect to the pattern followed by the lag weights, the results obtained above tend to confirm our expectation for the cocoa supply response: the polynomial lag model used shows that the rate of output change first increases and then decreases (two countries have the maximum response with $i = 4$, two with $i = 5$ and one with $i = 6$ for the variable price of cocoa beans). The regressions for Ghana and Nigeria present the additional problem of negative sign for the coefficient of the price of cocoa beans variable in the current period. Since these two are the larger producing countries, we may be facing the problem of simultaneous equation bias (as mentioned in Chapter 4) in our statistical estimation. This problem, however, does not appear for the three smaller producing countries, Brazil, Ivory Coast, and Cameroon. The same problem appears in some countries with respect to the variable price of coffee (positive coefficient for the current and immediately preceding time period, although not significantly different from zero in most cases). The most serious case is that of Brazil where the variable price of coffee has a positive coefficient in all but the last period of time; the fact that coffee policy in Brazil disassociates the farmer's price from the world price may be a possible explanation for this unexpected result. It is also apparent that the prior specification of k = 10 does not perform satisfactorily for all countries; an example is Ghana's case where the size and significance of the coefficient at time t-9 (t value still increasing) would suggest a longer period for the formulation.

Short-run and long-run elasticities can be computed by using the same procedure as discussed under demand estimation. It should be kept in mind that the short-run elasticity (response in harvesting and husbandry in the same period as the price change) is reported in Table 16 only for the countries with the right sign for the price variable, although these same coefficients are not significantly different from zero. The long-run elasticities for Ghana and Ivory Coast are larger than those obtained by Behrman (1968) and shown in Table 5; on the other hand, figures for Nigeria and Cameroon are lower in our study, with the elasticity of supply in Brazil being of the same order of magnitude. Our results then indicate that the short-run response of cocoa production to a price change appears to be non-existent, but in a long-run perspective (recalling that we are dealing with a perennial crop), the output response is substantial.

Table 16. Elasticities of supply of cocoa beans, polynomial lag formulation[a]

Country	Elasticity of supply with respect to P (short-run)	P (long-run)
Ghana	-	2.17
Nigeria	-	0.28
Brazil	0.08	1.07
Ivory Coast	0.008	2.51
Cameroon	0.06	0.99

[a]Elasticities were obtained from coefficients of Equations 67 through 71 in the text and mean values of the variables; for long-run elasticities an expression similar to Relation 57 above was used, i.e.,

$$\varepsilon_{LR} = \sum_{i=0}^{9} \cdot \frac{\partial Q_t}{\partial P_{t-i}} \frac{\overline{P}}{\overline{Q}}$$

with the short-run elasticity being the first term (i = 0) in the above expression. As discussed in the text, some of the coefficients which go in the above expression have the wrong sign, which affects the long-run elasticity (mainly for Nigeria).

Supply Projection

As pointed out by Chen et al. (1972, p. 82), estimation of supply response is still a problematic area of research. The reasons presented by the authors are twofold: the first one refers to the point made by Griliches (1967) in that a major shortcoming of most distributed lag models is their lack of theoretical substance,[77] which would create some difficulties with respect to what type of lag model to accept or reject. The second point refers to the fact that the elasticities (or, for this matter, the coefficients) obtained should have a special interpretation since the response of output is to several price changes, rather than a once-and-for-all price change. These considerations, in conjunction with the previously discussed question of predicting changes in technology (Chapter 4), should be kept in mind when projecting the supply function of cocoa to 1980.

The procedure to be used in projecting supply functions is similar to the one used for projecting demand functions, although the variables are different.[78] Since our variable time (t) is being assumed to be a proxy for technology, if we set its value for 1980 as $t = 26$ and use the mean value $\bar{P}^c = 50.113$ for the current and lagged variable price of coffee, each of the Equations 67 and 71 can be expressed only with the

[77] Exceptions are made for the two Nerlove models, that is adaptive expectations and partial adjustment, where the form of the lag is derived as an implication of the respective hypothesis made (Griliches, 1967, p. 42).

[78] As in the demand side, here we are interested in obtaining an estimate of the long-run supply function; since we want to introduce in our problem an estimation of the opportunity cost of the resources used to produce cocoa, enough time must be allowed for new capacity (in terms of cocoa trees) to be built (see also Helleiner, 1972, p. 55)

terms for the current and lagged price of cocoa beans in the right-hand inside. With the assumption of full adjustment in the period of one year, we can then add all coefficients of the variable price of cocoa beans to form the coefficient of a single price variable.

Table 17 presents the results obtained with our procedure of projecting cocoa supply functions to 1980. These will be the functions to be considered, for these particular countries, in the next chapter when the problem of obtaining the equilibrium solutions under three market alternatives (from our objective) will be dealt with.

Table 17. Estimated supply functions in 1980[a]

Country	Equation
Ghana	$Q = -45.20 + 50.42\ P$
Nigeria	$Q = 663.71 + 4.34\ P$
Ivory Coast	$Q = 227.91 + 16.49\ P$
Cameroon	$Q = 221.55 + 5.03\ P$

[a]The estimated supply function for Brazil was not projected to 1980 because of the problem with respect to the variable price of coffee as described in the text.

CHAPTER 6
THE EQUILIBRIUM SOLUTIONS

As stated in Chapter 1 (when defining the objectives of the analysis), some intermediate steps would be required before being able to accomplish our objectives. At that point we stated that two of such steps were involved: The first one would be to obtain estimates of unit transportation costs for cocoa beans in international trade, and the second one would be to estimate cocoa demand and supply functions for the most important countries, as well as projecting these relationships to 1980.

With respect to the first intermediate step, in Chapter 4 a discussion was presented and the selection of 32 regions and their representative centers was made, with the objective of characterizing the spatial nature of the world cocoa economy. With respect to the second intermediate step, Chapter 5 also presented the results for the estimated demand functions in ten countries and supply functions in five producing countries. Before dealing with the question of obtaining the equilibrium solutions for the three types of market arrangements, we thus need estimates of unit transportation costs and of demand and supply functions for the remaining countries. The first part of this chapter will then provide such information, after that we will be specifically dealing with the problem of obtaining the equilibrium solutions for our three different cases.

Transportation Costs for Cocoa Beans

It was previously assumed (in Chapter 4) that the representative centers selected for each of the 32 regions in the cocoa economy are specific locations where production and consumption take place in each of the regions (in most cases, countries); as a result, no allowances are made for possible costs occurring in the space and form dimension of the marketing process besides the transportation cost between two points.[79] Information regarding transportation costs for cocoa beans (including approximate freight and insurance costs) was provided to us by the Foreign Agricultural Service of the United States Department of Agriculture;[80] data about distance between two representative centers were obtained from a United States Department of the Navy (1965) publication.

The following function was then fitted to the data:

$$TC = a + bD \tag{72}$$

where TC is the transfer cost in cents per pound, D is distance in miles, and a and b are the parameters to be estimated. The regression result (with 9 observations) can be described in the following way:

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[79] The reason for so proceeding refers to the fact that no publication providing such information was located. These excluded costs involve those occurring from the point of production to the port (loading cost will be included in our estimates) as well as unloading and transfer to the consumption centers; to the extent that the relevant costs vary for different producing regions, the commodity flows might be affected.

[80] The original source of the data is reported to be the Federal Maritime Commission for freight rates and Marsh & McLellan, New York for insurance rates, according to a 1968 study by the U. S. Department of Commerce. It should be noted that all observations refer to American ports as destination.

$$TC = 1.60421 + 0.00009\ D \qquad R^2 = 0.73 \qquad (73)$$
$$\quad (19.6704) \qquad (4.3638)$$

with the t values being presented in parentheses.[81]

The estimated relationship as given by equation 73 was then used to estimate the transportation cost for cocoa beans for all possible pairs of representative centers.[82] These costs will then be used as input data when applying the reactive programming solution procedure.

Other Demand and Supply Functions

In Chapter 5 we obtained estimates of demand functions (by two methods) in ten countries, and of supply functions in five countries. Since one of the estimated demand functions will be disregarded when obtaining the equilibrium solutions due to its unsatisfactory results, we still need to obtain estimates for the demand functions in 23 countries for 1980.[83]

The procedure to be used for obtaining estimates of these remaining demand functions will, however, involve no statistical estimation; on

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[81] The two coefficients are significantly different from zero at the 1 percent level.

[82] A few approximations were made out of the almost 500 possible pairs; they refer to the calculation of some of the distances involved, since exact figures were not provided in U. S. Department of the Navy (1965) publication.

[83] As mentioned in Chapter 5, the results for the United Kingdom were unsatisfactory with both methods used, and they will be disregarded from here on. In addition, the only demand function to be considered for Italy will be the one estimated by the Nerlove model, since some of the cocoa price coefficients had the wrong sign in the polynomial lag formulation.

the contrary, a much simpler procedure will be used.[84] As previously mentioned (Chapter 4), a United Nations study (Food and Agriculture Organization of the United Nations, 1971) provides us with projections of cocoa consumption by country for 1980. Since these projections were based on price conditions prevailing during 1970, we can thus have a point (quantity and price) in each country's 1980 demand function. To obtain an estimate of the entire function (for each country) we assumed a uniform price elasticity of demand for cocoa beans (long-run) of -0.50.[85] Our procedure can be illustrated by referring to the United Kingdom's case. The required information for 1980, that is, quantity consumed (Q), price (P), and elasticity of demand (η), is given by:

$Q = 302.03$ (million of pounds)[86]

$P = 34.20$ (cents per pound)

$\eta = 0.50$

By definition η, the price-elasticity of demand, is expressed as:

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[84] It should be noted that the nine countries for which we will be using our own estimates for the demand functions are responsible for 55 percent of the world consumption of cocoa (in beans-equivalent, average 1967-1969), and close to two-thirds of world consumption after excluding countries of Eastern Europe.

[85] For most countries (or regions) no information was available of such elasticity; for others, only short-run estimates were available and in all cases (see Chapter 4, Table 6 and Footnote 50), they were lower than the above absolute value (0.50). Our long-run estimates also (see Table 9 and Table 13) indicate that only two out of ten countries have elasticities greater than the assumed absolute value of 0.50.

[86] The information for projected cocoa consumption refers to the alternative 1980 T, that is, using a trend assumption for private consumption expenditure (Food and Agriculture Organization of the United Nations, 1971, p. 404).

$$\eta = \frac{dQ}{dP} \frac{P}{Q} \tag{74}$$

Since we have assumed η, and have estimates of P, and Q, we can solve expression 74 for dQ/dP, which is identified as the slope of the United Kingdom's demand function; the result $\frac{dQ}{dP} = b = -4.4156$. Since we will be working with linear demand functions ($Q = a - bP$), the estimate of the intercept (a) can be calculated by the expression:

$$a = Q + bP \tag{75}$$

The result being a = 453.05; with the knowledge of a and b (parameter estimates), the 1980's demand function for cocoa beans in the United Kingdom is given by:

$$Q = 453.05 - 4.42\ P \tag{76}$$

The same procedure was used to obtain estimates of the demand functions in 1980 for the remaining 22 countries (or groups of countries), always using the FAO's projection of cocoa consumption (in beans-equivalent).[87] Table 18 presents the demand functions so estimated.

In Chapter 5 we also estimated cocoa supply functions for the five largest producing countries (Ghana, Nigeria, Brazil, Ivory Coast and Cameroon); some of the results obtained were not satisfactory, the

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[87] An approximation was made for the demand functions of Cameroon and Ivory Coast; FAO's projections indicate a zero level of consumption for both countries. Since we must have demand functions for all markets in the reactive programming procedure, we used a consumption level of one million pounds in each, which is not expected to alter our results in a significant way.

Table 18. Estimated demand functions in 1980, remaining countries (or regions)[a]

Country (region)	Demand function
Ghana	Q = 3.29 - 0.03P
Nigeria	Q = 3.29 - 0.03P
Ivory Coast	Q = 1.50 - 0.01P
Cameroon	Q = 1.50 - 0.01P
Other Africa Production	Q = 1.50 - 0.01P
Other Africa No Production	Q = 10.50 - 0.10P
Brazil	Q = 138.89 - 1.35P
Ecuador	Q = 33.08 - 0.32P
Venezuela	Q = 59.52 - 0.58P
Mexico	Q = 72.75 - 0.71P
Dominican Republic	Q = 13.23 - 0.13P
Canada	Q = 168.65 - 1.64P
Other America	Q = 234.79 - 2.29P
Other Asia	Q = 128.97 - 1.26P
Other Oceania	Q = 19.85 - 0.19P
United Kingdom	Q = 453.05 - 4.42P
Ireland	Q = 23.15 - 0.23P
Norway, Sweden, Finland and Iceland (NSFI)	Q = 95.90 - 0.93P
Spain, Portugal	Q = 171.96 - 1.67P
Austria, Switzerland	Q = 142.20 - 1.39P
Eastern Europe 1	Q = 188.49 - 1.84P
Eastern Europe 2	Q = 221.57 - 2.16P
Soviet Union	Q = 575.40 - 5.61P

[a]Source: See discussion in the text; Q is expressed in millions of pounds and P in cents per pound.

cases of Nigeria, Cameroon, and Brazil, being the most important in such respect.[88] Since Behrman (1968) obtained estimates of the long-run supply elasticity of cocoa for Brazil and Cameroon, they will be used here to obtain a new supply function for these countries.[89]

A procedure similar to that used above for estimating the remaining demand functions will be employed for estimating the supply functions of Nigeria, Brazil, Ivory Coast, and Cameroon; we can illustrate the procedure by using Brazil as the example. The required information for 1980 is given by Q = 418.87 millon pounds (Food and Agriculture Organization of the United Nations, 1971, p.227, basic projection), P = 34.2 cents per pound and $\varepsilon = 0.95$ (Behrman, 1968, p. 704, Table 1) for the long-run supply elasticity of cocoa, which can be defined as:

$$\varepsilon = \frac{dQ}{dP} \frac{P}{Q} \qquad (77)$$

---

[88] From Chapter 5 we recall that the problem with Nigeria's result was the negative coefficient of the cocoa price variable for the first three years; with Brazil the problem was the positive coefficient of the coffee price variable in all but the last year.

[89] Our estimated elasticity for Nigeria should be an underestimation of the true one (because of three negative price coefficients in Equation 68; as a result we used $\varepsilon = 0.90$ as our estimated supply elasticity, which is approximately three times the value estimated by us, but closer to the range of values for other countries. Now, for the case of Ivory Coast, our estimated intercept term in the equation of Table 17 should be overestimated; this is so because of the wrong (positive) sign for two coefficients of the coffee price variable (Equation 70). We then used our estimate of the slope (16.49, cocoa price variable in Table 17) and FAO's point projection of output (at 1970's price) to estimate a new supply curve, as described in the text (Relation 48, since only a new intercept is needed). Ghana's supply function was kept as in Chapter 5, although it is recognized that the slope may be slightly underestimated (because of negative coefficient of the price variable in the current year).

with the knowledge of the above information (Q, P, and ε), $d = \frac{dQ}{dP}$, which is the slope of the supply function, can be obtained, the result being d = 11.6353. The estimate of the intercept is obtained from a linear supply function as:

$$c = Q - dP \tag{78}$$

with the result being c = 20.78. With knowledge of the intercept and the slope (parameter estimates), the 1980's supply function of cocoa beans in Brazil is given by:

$$Q = 20.78 + 11.64\ P \tag{79}$$

A similar procedure was applied to obtain an estimate of the supply functions for the other three countries, the results being reported in Table 19. For the remaining countries (or regions), a fixed supply[90] (instead of a supply function) was used to represent the production conditions to prevail in 1980, the information being obtained from FAO's production projection and also reported in Table 19.

Free Trade Solutions

After presenting the estimates of unit transportation costs as well as demand and supply functions (or fixed supplies) for the remaining countries, we can now proceed to obtain the equilibrium solutions under the three different market arrangements described in Chapter 1. Appendix C Tables 3 and 4 put together the cocoa demand and supply

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[90] A fixed quantity for 1980 implies that the supply function is a perfectly inelastic one; these countries constituted only 22 percent of the world production as an average for the period 1968/69 - 1970/71 (see Table 4).

Table 19. Estimated supply functions and fixed supplies in 1980, remaining countries (or regions)[a]

Country (region)	Supply function (or fixed supply)
Nigeria	Q = 70.55 + 18.57P
Ivory Coast	Q = 20.26 + 16.49P
Cameroon	Q = -250.00 + 16.33P
Other Africa Production	Q = 220.46
Brazil	Q = 20.78 + 11.64P
Ecuador	Q = 154.32
Venezuela	Q = 55.12
Mexico	Q = 57.32
Dominican Republic	Q = 83.77
Other America	Q = 112.43
Other Asia	Q = 39.68
Other Oceania	Q = 79.37

[a]Source: See discussion in the text; Q is expressed in millions of pounds and P in cents per pound.

estimates; the information in these two tables will form the basis (in terms of input data) for obtaining the equilibrium solutions with the reactive programming procedure (see King and Ho, 1972); this procedure[91] (as mentioned in Chapter 2) allows us to obtain solutions to spatial equilibrium problems in such a way that net revenue to each shipper is maximized at the supply areas, for specified forms of market structure.

In the type of spatial problem being considered here, both quantity supplied and demanded are variables and their equilibrium values are determined simultaneously.[92] In addition, we also obtain the equilibrium prices in each region as well as the trade flows. We also recall that to obtain the final relationship of quantity (demanded or supplied) as a function of price in Chapter 5, we assumed some of the other explanatory variables in the estimated equations to have their average value in the period of the investigation. In such a context, the equilibrium solutions for 1980 should be interpreted accordingly, that is, as the results to prevail in an 'average' or 'normal' year. These 'normal' equilibrium solutions should be of greater relevance to producing countries (also with respect to the other market arrangements to be considered later) than the information provided for a year with an abnormally high or low value of these explanatory variables (see also Schmitz, 1968, pp. 255-257).

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[91]This solution procedure requires that the demand and supply equations be presented with price as the dependent variable; as a result, all the equations in Appendix C Tables 3 and 4 were solved to express price as a function of quantity.

[92]As a matter of fact, in the supply side we have five supply equations and eight regions with fixed supplies.

Model 1. Solution Using Demand Equations from Nerlove Model

This solution will provide us with the equilibrium values of the variables mentioned above and using the estimated demand equations obtained by Nerlove's partial adjustment model (these are the equations written as alternative a for eight countries in Appendix C Table 3); the other input data are the demand equations for the remaining 24 countries (Table 18 above) and the supply functions (or fixed supplies) presented in Appendix C Table 4. No barriers to trade (tariffs or trading blocs) exist in this case, such that in this situation of free trade, the price importers pay for cocoa beans is the price at the exporting region plus transportation costs.

This model predicted optimal trade patterns for cocoa in 1980 under the assumed condition of free trade; Appendic C Table 5 presents the least-cost trade flows of cocoa beans obtained by the application of this first model. Ghana exports cocoa beans to 11 of the 31 consuming regions included in the model, with Ivory Coast being second with shipments to five regions.[93] Table 20 presents information about equilibrium values for quantity supplied, exports, producers' prices, and revenues (foreign exchange earnings). Our prediction then shows Ghana as the largest producer and exporter, with foreign exchange revenue from cocoa almost reaching the level of 450 millions of dollars. Some changes occur with respect to the ranking of countries in terms of their cocoa production: the resulting order is Ghana, Nigeria, Ivory Coast, Brazil, and Cameroon, as compared to Ghana, Nigeria, Brazil,

[93]The total transportation cost resulting from the least-cost trade flows for cocoa beans reported in Appendix C Table 5 is US $74,462 millions.

Table 20. Equilibrium values of production, exports, prices, and revenues, free trade Model 1, 1980

Producing country (region)	Production	Exports	Prices	Revenue
	(millions of pounds)		(cents/pound)	(millions of dollars)
Ghana	1,478.03	1,475.66	30.46	449.49
Nigeria	684.66	682.28	30.43	207.64
Ivory Coast	528.41	527.21	30.47	160.66
Cameroon	251.54	250.34	30.40	76.11
Other Africa Production	220.35	219.15	30.39	66.60
Brazil	358.78	260.97	30.50	79.60
Ecuador	154.32	131.07	30.61	40.12
Venezuela	55.12	13.31	30.70	4.09
Mexico	57.32	6.44	30.72	1.98
Dominican Republic	83.77	74.53	30.73	22.91
Other America	112.43		32.28	
Other Asia	39.68		32.72	
Other Oceania	79.37	65.40	30.98	20.26
Total[a]	4,103.77	3,706.36		1,129.46

[a]In this and the following tables, figures for total production may not equal column sums because of rounding.

Ivory Coast, and Cameroon, as the ranking for average production in the period 1965/66-1969/70 (see Table 1). In addition, Appendix C Table 6 presents information about the consumption side of the cocoa economy, that is, equilibrium values for quantity consumed, prices, and expenditures on cocoa beans. From Table 2 we know that for the period 1967-1969, the five largest consuming countries were United States, West Germany, United Kingdom, Soviet Union and France; the only change occurring in 1980 refers to the Soviet Union becoming number three and the United Kingdom as number four.

Model 2. Solution Using Polynomial Lag Formulation in Demand

This solution will provide us with the equilibrium values for the same variables as those of Model 1, the only difference being that we now use the demand functions estimated according to the polynomial lag formulation (equations written as alternative b for eight countries in Appendix C Table 3); the other demand and supply equations are the same as in Model 1.

The least-cost trade flows obtained by using this model are presented in Appendix C Table 7; these flows are very similar to those shown in Appendix C Table 5 (Model 1), with the exception of only a few pairs (Ghana shipping to the United States, Italy, Netherlands, and not shipping to Eastern Europe 2, Nigeria not shipping to United Kingdom and Ivory Coast to Netherlands). Ghana and Ivory Coast (tied with Other Africa Production) are again the supply areas shipping to the greater number of consuming regions (thirteen and four, respectively).[94]

[94]The total transportation cost resulting from the least-cost trade flows in this Model 2 is US $79,057 millions.

Table 21. Equilibrium values of production, exports, prices, and revenues, free trade Model 2, 1980

Producing country (region)	Production	Exports	Prices	Revenue
	(millions of pounds)		(cents/pound)	(millions of dollars)
Ghana	1,573.18	1,570.86	32.36	508.39
Nigeria	722.89	720.57	32.34	233.07
Ivory Coast	560.12	558.94	32.38	180.97
Cameroon	283.16	281.99	32.30	91.08
Other Africa Production	220.33	219.15	32.30	70.78
Brazil	380.13	284.92	32.42	92.37
Ecuador	154.32	131.69	32.55	42.86
Venezuela	55.12	14.42	32.62	4.71
Mexico	57.32	7.81	32.65	2.55
Dominican Republic	83.77	74.78	32.66	24.42
Other America	112.43		34.20	
Other Asia	39.68		34.62	
Other Oceania	79.37	65.77	32.92	21.65
Total	4,321.81	3,930.90		1,272.85

Information about the equilibrium values for quantity supplied, exports, producers' prices and foreign exchange revenues are reported in Table 21. Again, Ghana is the largest producer with a great quantity difference occurring with respect to the other four larger producers, which are, in declining order, Nigeria, Ivory Coast, Brazil, and Cameroon (the same order as in Model 1). Finally, Appendix C Table 8 presents information about consumption of cocoa beans for the same variables reported in the previous model. The same order of importance in consumption as in Model 1, that is, United States, West Germany, Soviet Union, United Kingdom, and France, was obtained with application of Model 2. In both cases, these countries accounted for a share of total consumption in the neighborhood of 60 percent.

Comments on the Two Free Trade Models

As mentioned above, the predictions of the two models in terms of the least-cost trade flows for cocoa beans are very similar. However, the results obtained for the trade flows will not be overemphasized here. One of the reasons for this is related to the fact that most of the African producing nations are located very close to each other. The consequence of this location pattern is that the net prices of cocoa beans in the different producing areas are very similar.[95] As pointed out by Zusman *et al*. (1969, p. 18), when such narrow price differentials

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[95]As mentioned in Chapter 2, net prices (R_{ij}) can be defined by the expression:

$$R_{ij} = P_j - P^i - T_{ij}$$

where P_j is price at market j, p^i is price at origin i and T_{ij} is the respective transfer cost.

trade flows,[96] since it would be extremely difficult for exporters to detect such differentials in practice (there is a cost involved in increasing the accuracy of price information). Other reasons for the existence of such deviations in trade flows would include the existence of transfer cost not considered by us, possible contractual agreements, product differentiation, as well as bilateral agreements. Thus, to repeat the point, the predicted trade flows should not be overemphasized (actual shipments would be expected to be more diversified) in these two models and the others to come; rather, they provide us with the optimum flows under the conditions assumed earlier in the analysis.

The results obtained for the other equilibrium values of desired variables[97] (prices, quantities supplied and demanded, revenues, and expenditures) are similar for both models, although those values obtained with the use of demand functions estimated by the polynomial lag formulation (Model 2) are in a somewhat higher level (the exceptions are, of course, the consumption figures for those countries whose demand functions remain the same in both models).

In Chapter 5, after estimating cocoa demand functions with the use of two different models, we indicated that some improvements were obtained by the use of the polynomial lag formulation. At that time we mentioned that these improvements related to the fact that the coefficient of determination was higher for most of the countries

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[96]The same problem is probably occurring with respect to the Central American countries, and also Brazil and the African nations in terms of European markets.

[97]A better perspective for the values of some of the variables will only be obtained after a comparison is made with the values of the same variables in the other two types of market arrangements.

estimated, and also with respect to the significance of the coefficients of the included variables. In such a situation, it was decided to obtain the equilibrium values of the variables being considered in the two remaining types of market arrangements by using only the demand functions estimated by the method of polynomial lags.

Trade under the Existence of Tariffs and EEC

The second type of market arrangement to be considered, as described in the first objective of our analysis, is one involving the existence of tariffs on cocoa as well as trading blocs (the EEC is the one to be specifically considered here). The equilibrium values of the same variables (as in the free trade model) will be obtained through the application of the reactive programming procedure.

Chapter 3 presented a theoretical discussion of the cocoa economy under the presence of these two types of commercial policies in international trade. At that time we pointed out that suggestions have been made for the elimination of tariffs on imports of raw materials from less developed countries as a move to increase their exchange earnings. The information available (Food and Agriculture Organization of the United Nations, 1972) indicates that, at least for cocoa, the above suggestion has been already adopted by many countries (a comparison being made with the situation in the early 1960's). The best example is provided by the case of the United States and United Kingdom (together, 36 percent of world consumption in 1967-1969), where no tariffs presently exist for cocoa beans or products. The tariffs prevailing in 1972 (and assumed to prevail in 1980) for some of the countries included in our analysis are presented in Table 22 for two

Table 22. Current average tariffs on cocoa, selected countries, 1972[a]

Country	"Old" EEC (percent)	"New" EEC (percent)
United States	Free	Free
Japan	2.3	2.3
Belgium	6.8	6.8
France	6.8	6.8
West Germany	6.8	6.8
Denmark	1.4	6.8
Netherlands	6.8	6.8
Italy	6.8	6.8
United Kingdom	Free	6.8
Ireland	-	Free
NSFI[b]	Free	Free
Austria and Switzerland[c]	3.5	3.5

[a]The tariff rates refer to a weighted average of rates applying to cocoa beans and cocoa products (butter, powder, paste, and chocolate), the weights being given by the proportion of world imports in the period 1968-1970. The source for individual countries' rates is Food and Agriculture Organization of the United Nations (1972).

[b]Free for Norway, Sweden, and Finland; unknown for Iceland.

[c]The rate being used here is the one prevailing in Austria.

distinct cases: the "old" EEC (including the original six countries, France, Italy, West Germany, Netherlands, Belgium-Luxembourg), and the "new" EEC, that is, with the inclusion of the United Kingdom, Ireland, and Denmark, the assumption being made that the level of the Common External Tariff (CET) will remain the same.

The countries included in Table 22 do not constitute a complete coverage of the cocoa economy. However, they are a sizable proportion: the twelve consumption centers listed in that table correspond to two-thirds of the world consumption, and 78 percent after excluding Eastern European countries from the total. The information contained in Table 22 will then be used with a view of accomplishing the second part of our first objective. To achieve this, however, the following changes were made with respect to the input data in the previous free-trade model: (a) Since we have an ad valorem tariff for Japan, Denmark[98] and Austria-Switzerland, their respective demand functions will experience a downward shift (see the section on Import Tariffs in Chapter 3). Their new level can be estimated by the general expression

$$P = (1 - t)\ (a' - b'Q) \tag{80}$$

where t is the tariff rate of Table 22, with the demand curve being expressed with price as the dependent variable.[99] (b) To allow for the

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[98] Denmark is a member of the EEC, effective January 1, 1973 ("New" EEC), and so, item b will also apply to her.

[99] The solution using the reactive programming method will provide us with prices excluding the value of the tariff for Japan, Denmark and Austria-Switzerland; wholesale prices can be obtained by substituting the equilibrium quantities in the regular demand equations.

nature of the EEC (a customs union), an approximation with respect to the tariff rate was necessary; the weighted average of 6.8 percent (Table 22) was converted into an excise tariff by using a base price of 30 cents per pound (in the neighborhood of the free-trade solution above described), with the resulting figure (2.04 cents per pound) being added to the transfer cost between the affected country and the EEC.[100]

The introduction of the above modifications in the programming procedure allows us to obtain new equilibrium solutions for the case where tariffs and the EEC (old and new) exist; for convenience, the two cases to be discussed here will be referred to as Models 3 and 4.

Model 3. Solution with Tariff and EEC's Old Membership

This solution will provide us with the equilibrium values for the same variables as in the free trade solutions (Models 1 and 2), after the introduction of tariff rates on the importation of cocoa (in Japan, Denmark, and Austria-Switzerland), as well as the existence of the EEC (Belgium-Luxembourg, France, West Germany, Italy, and Netherlands) with its Common External Tariff (CET). Since the countries benefiting from such preferential treatment are only Cameroon, Ivory Coast, and Other Africa Production (mostly Togo), according to our division of production centers, it was originally thought that not only other African countries

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[100] For instance, Cameroon, Ivory Coast, and the group included as Other Africa Production, were not affected by this, since as signatories of the Yaounde Convention (Associated Overseas Countries) they have free access into the EEC market; Other Africa Production was included as a signatory because of Togo, the largest producer among its composition. All other countries had their transfer costs to the EEC countries increased by the above amount, to indicate the working of the common External Tariff.

(mainly Ghana and Nigeria) would lose, but also Latin American ones, with the implementation of such a policy. However, the solution (in terms of trade flows) obtained for Model 2 (that is, a free trade solution) provides us with a better indication of how trade might be affected by the introduction of the EEC. From Appendix C Table 7, we note that from all affected countries (in terms of application of the CET), only Ghana was shipping cocoa to EEC members under free trade conditions; none of the South or Central American countries did so. We would then expect trade in cocoa to be diverted (in terms of the EEC market) from Ghana to benefited suppliers.

The least cost trade flows obtained as the solution to the reactive programming procedure applied to Model 3 are reported in Appendix C Table 9. It can then be seen that the above prediction of trade flows, from Ghana to EEC members, being diverted to other consuming nations, is confirmed. In fact, exports of cocoa from Ghana become more diversified since now fourteen markets are the destinations as compared with thirteen in Model 2; we observe that the three African areas with preferential treatment in the EEC market (Ivory Coast, Cameroon, and Other Africa Production) now concentrate their exports in that market.[101] In fact, all EEC imports come from these three areas, with the exception of a small shipment from Ghana to Belgium. Nigeria, that originally

[101]The preferential treatment given by the EEC to the three African areas (two countries, and one region in our case) is so important in our model that they export their entire production to that market, and import their small consumption requirements from neighboring countries. It should be mentioned that we obtained the solution to the model including only the tariffs on the three countries cited (that is, disregarding the EEC). Although a few of the resulting flows were different than in Model 2, it is clear that the introduction of the EEC is responsible for the changes mentioned in the text.

(Model 2) was not shipping to the EEC market, has, however, its shipping pattern more diversified after the introduction of that customs union. Other areas, such as Latin America, Other Asia, and Other Oceania, which originally did not participate in the EEC market, keep the same shipping pattern as in Model 2.

The resulting effect on prices is on the upward direction in the EEC market (as well as for the benefited producing areas), and on the downward direction elsewhere. The consequence is that the variables quantity supplied, exports, and exchange earnings (see Table 23), have higher values for the three African regions benefiting from the EEC and lower values for the remaining ones. On the other hand, consumption of cocoa moves downward in the EEC and upward elsewhere, while expenditures move upward in the EEC market and downward elsewhere (see Appendix C Table 10). The basic result from Model 3 is that trade diversion occurs after the introduction of the EEC, but the volume of trade is practically not affected.[102]

Model 4. Solution with Tariffs and EEC's New Membership

The results to be obtained here will be referring to the situation which became effective January 1, 1973, that is, the expansion of EEC's membership to include United Kingdom, Ireland, and Denmark. The likely consequence of such expansion of the EEC, in terms of the cocoa trade, will be the inclusion of Ghana and Nigeria among those countries (Cameroon, Ivory Coast, and Other Africa Production, in our analysis)

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[102]Walter (1968, p. 540) argues that overall volume of trade should not necessarily change with the creation of a customs union, but only the direction of trade, which is in perfect agreement with the results obtained in the solution to Model 3.

Table 23. Equilibrium values of production, exports, prices, and revenues, Model 3, 1980

Producing country (region)	Production	Exports[a]	Prices[b]	Revenue[a,c]
	(millions of pounds)		(cents/pound)	(millions of dollars)
Ghana	1,546.06	1,543.72	31.82	491.23
Nigeria	712.24	709.90	31.81	225.83
Ivory Coast	585.04	585.04	33.87	198.17
Cameroon	307.98	307.98	33.79	104.06
Other Africa Production	220.46	220.46	33.79	74.48
Brazil	374.18	278.24	31.89	88.72
Ecuador	154.32	131.55	32.11	42.24
Venezuela	55.12	14.11	32.09	4.53
Mexico	57.32	7.50	32.21	2.42
Dominican Republic	83.77	74.71	32.12	24.00
Other America	112.43		33.67	
Other Asia	39.68		34.18	
Other Oceania	79.37	65.68	32.48	21.33
Total	4,327.96	3,938.89		1,277.01

enjoying preferential treatment (non-application of the Common External Tariff) in the EEC market; we will thus be assuming that Ghana and Nigeria will become participants in the Yaounde Convention,[103] with a view of obtaining the equilibrium solutions to Model 4.

In terms of movement of cocoa in international trade, Model 4 implies that no African producing nation (in our model) is discriminated against with the application of the Common External Tariff; only producing nations from other continents can argue as being negatively affected by that policy. However, we recall, from the solution of Model 2 (free-trade), that no producing areas (besides African ones) included in the analysis had shipments of cocoa to EEC member countries. In other words, we would expect that the expansion of the EEC, as assumed in Model 4, would represent a change in the cocoa trade towards the pattern prevailing in the free trade conditions of Model 2. The *ad valorem* tariffs prevailing in Japan and Austria-Switzerland, however, are the same as those of Model 3 above.

The least-cost trade flows obtained in the solution, with the modifications assumed in Model 4, are presented in Appendix C Table 11. A comparison of these trade flows with those of Model 2 (Appendix C Table 7) shows the identity of most of the flows, with only minor differences in quantities caused by the presence of tariffs (*ad valorem*)

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[103] The situation at present is still uncertain in this respect; Ghana and Nigeria have been offered participation in the Yaounde Convention but have not decided as yet. The alternative to them would be a trade agreement with EEC's member countries involving preference quotas (European Economic Community Tariff Changes, 1973, p. 7).

in the two countries mentioned above. At least for cocoa then, the expansion of the EEC would seem to be a move toward the pattern of trade dictated by free trade conditions. Table 24 reports the equilibrium values of production, exports, prices, and revenues. As it would be expected from the above considerations, these values are very similar to those under free trade, although we observe a very small downward adjustment in prices and quantities resulting from the tariffs of Japan and Austria-Switzerland. The similarity is also present on the demand side of the cocoa economy (Appendix C Table 12) with prices at the consumption centers slightly lower than under free trade, and quantities consumed, consequently, slightly higher (the exceptions being the two centers with tariffs, Japan and Austria-Switzerland).

Comments on the Two Models Including Trade Restrictions

It was mentioned in Chapter 3 that suggestions have been presented for the elimination of tariffs and other barriers to the free movements of goods in international trade, as a means of increasing the exchange earnings and income levels of less developed countries. The analysis above presented however, suggests that, at least for the case of cocoa, the increase in foreign exchange earnings resulting from the elimination of tariffs is of a very small magnitude (slightly over one million of dollars when moving from Model 4 to Model 2). It is true however that the above figure should be an underestimation of the possible increase in foreign exchange earnings; the reason for such a belief is related to the fact that the list of countries (and their tariff rates) presented in Table 22 is not a comprehensive one, and

Table 24. Equilibrium values of production, exports, prices, and revenues, Model 4, 1980

Producing country (region)	Production (millions of pounds)	Exports (millions of pounds)	Prices (cents/pound)	Revenue (millions of dollars)
Ghana	1,572.45	1,570.13	32.35	507.92
Nigeria	722.60	720.28	32.33	232.86
Ivory Coast	559.95	558.77	32.37	180.86
Cameroon	282.95	281.77	32.29	90.97
Other Africa Production	220.31	219.13	32.28	70.73
Brazil	379.90	284.66	32.40	92.23
Ecuador	154.32	131.68	32.53	42.83
Venezuela	55.12	14.42	32.62	4.70
Mexico	57.32	7.80	32.63	2.54
Dominican Republic	83.77	74.78	32.64	24.41
Other America	112.43		34.18	
Other Asia	39.68		34.61	
Other Oceania	79.37	65.76	32.90	21.64
Total	4,320.15	3,929.18		1,271.69

also because non-tariff barriers (import quotas, for instance) may exist in some of the countries (mainly with respect to cocoa products). It is doubtful however, that the potential increase in exchange earnings from cocoa would be large enough to justify the interest of less-developed countries concerning specific trade negotiations. Even if the gain in exchange earnings is ten times as large as our prediction, that magnitude constitutes less than 1 percent of their total earnings from cocoa (as predicted above).

When comparing the results obtained with Model 3 with those of Model 2 (free-trade), it is clear that the EEC is contributing for an increase of 34 millions of dollars in the exchange revenue of the three African regions benefiting from the customs union (a decrease in revenue occurs for the other countries). Model 4 however (which is closer to the situation likely to prevail in the near future) would tend to correct this pattern by making the trade in cocoa move closer to a free-trade situation (as in Model 2).

Thus, the potential for further gains to developing countries from tariff reductions (or eliminations) for cocoa beans and products appears to be small. As pointed out in Food and Agriculture Organization of the United Nations (1972), the last ten years can be identified as the period for the most important reductions in tariff rates. One development was the Kennedy Round of Tariff Reductions, and the other was the introduction of the Generalized System of preferences for products originating in developing countries.

Solutions with an International Cocoa Agreement

At this point we recall that the second objective of this analysis, as stated in Chapter 1, involved the specific consideration of an international cocoa agreement; the goal of producing countries would be one of maximizing income or revenue earnings from cocoa. The distinction between these two cases was presented in Chapter 3, and relates to the fact that the maximization of total revenue does not imply a full exploitation of monopoly power.

As mentioned earlier, one approach to the question of an international cocoa agreement to be pursued here will involve downward adjustments in production and exports only for the five leading cocoa producing nations. These countries (Ghana, Nigeria, Ivory Coast, Brazil, and Cameroon) are the same five involved in the formation of the unsuccessful Cocoa Producers Alliance of 1964, and they, together, had close to 80 percent of world production as an average for the period 1965/66 to 1969/70. However, the participation of all other producing countries will be assumed when obtaining the equilibrium solutions, although no downward adjustment in production or exports will be occurring for them in our initial models.[104] An alternative approach will be considered next, the only difference being that, reductions in production and exports for the eight smaller countries (or regions) will be introduced. In addition, an attempt will also be made to determine, at least in an approximate way, the production and export levels that

[104] As previously mentioned, the inclusion of consuming nations as members of the agreement is not necessary to obtain the equilibrium solutions. They may be important, however, for an effective policing of an actual agreement.

would, under certain conditions, maximize total foreign exchange revenue for the five leading producing nations.

Model 5. Cocoa Agreement: Only Five Countries Reduce Output

This is the approach to a cocoa agreement mentioned above where only Ghana, Nigeria, Brazil, Ivory Coast, and Cameroon will carry the responsibility of a reduction in their cocoa output (and exports). The other producing nations (or regions, in our analysis), that is, Ecuador, Other Africa Production, Venezuela, Mexico, Dominican Republic, Other America, Other Asia, and Other Oceania, will participate in the agreement but will suffer no reduction in their cocoa output. The interesting point about such an arrangement is that it may set a lower bound for the gains to be had (by the above five nations) from such a type of restriction scheme. If this lower bound is a favorable one for these five countries, less difficulties may be involved in an actual process of negotiating the establishment of individual export quotas.

The equilibrium values in which we are interested (in this type of market arrangement) are those of the same variables considered in Model 1 through 4, that is, prices, production, exports, consumption, imports, revenues, expenditures, and trade flows.[105] The procedure to obtain the above equilibrium values will not be a direct one; rather, two steps will be involved. The first step will involve the substitution of marginal revenue functions (Seale and Tramel, 1963, p. 57) for the demand functions used so far (those presented in Appendix C Table 3) when obtaining the solutions by the use of reactive programming. This

[105] Trade flows and information about consumption will not be reported for each alternative to be considered; rather they will be presented only for one alternative, one with good possibilities of acceptance by the countries involved.

procedure is consistent with our first approach, that is, producing countries acting together in an attempt to exploit their collective monopoly power in the cocoa market. The results obtained after such substitution will provide us with the optimum output levels for the five leading producing countries (since the other eight will have fixed supplies), that is, after allowing for the spatial nature of the problem, marginal costs are equated across countries. The second step will involve using these levels (of step one) of equilibrium output (or alternative levels to be discussed later) as input data for a new solution procedure, that is, a reactive programming solution with fixed supplies in all producing countries (or regions). This second solution will then provide us with the equilibrium values for exports, consumption, imports, revenues, expenditures, and flows.[106] In what follows two alternative situations for an international cocoa agreement will be presented.

Model 5A: This will be the model representing the situation where the same output levels obtained in step one, for each of the five leading countries(the ones reducing their output as a consequence of the agreement), are used as the respective fixed supplies in step two. This model could then be identified with a situation where, although the agreement is operative, the condition for efficiency in world cocoa production is repeated (a minimum amount of resources would be used in the aggregate). Information about the resulting equilibrium values of production, exports, prices, and foreign exchange revenues are presented

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[106] This two step procedure to obtain such equilibrium values is considered to provide a more realistic situation in contrast to one resulting from the application of only the first step; this last one would be a price discrimination model, with the resulting incentives for arbitrage activities to develop in the market.

in Table 25; it is immediately apparent that price of cocoa beans is more than doubled in relation to the price level prevailing in Model 2 (free-trade). Quantity supplied is, of course, lower for all five countries; in proportion terms, the reduction is quite similar for Ghana, Nigeria, Ivory Coast, and Brazil (approximately, 50, 44, 47, and 46 percent, respectively). Cocoa output in Cameroon, however, is only 7 percent of the free trade production level. It also must be noted that foreign exchange revenue from cocoa exports is increased (in the aggregate) by more than 400 millions of dollars (in relation to the level of Model 2), an increase of almost one-third in relation to the free trade revenue.

With respect to exports of cocoa beans, Table 25 shows the optimum exports for all countries involved: the five leading nations have downward adjustments in their exports in relation to Model 2, while the eight smaller countries (regions) increase their exports. This last result is a direct consequence of monopoly prices prevailing and lower domestic consumption. Exchange earnings on the other hand increase for all producing nations with the exception of Cameroon; the smaller nations are, however, the largest beneficiaries from such arrangement, with the increase in their aggregate revenue being in excess of that occurring to the five leading countries (301 and 111 millions, respectively). These considerations point in the direction that the values referred to above for such a key variable as exports are very unlikely to be acceptable (for export quotas) to all participating countries.[107] The gains from

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[107] A possible alternative at this point refers to the application of an export tax in the case of the five leading countries, in an attempt to approximate the above results; negotiation among the five would then establish a scheme for distributing the proceeds (see Footnote 29, Chapter 3).

Table 25. Equilibrium values of production, exports, prices, and revenues, Model 5A, 1980

Producing country (region)	Production	Exports	Prices	Revenue
	(millions of pounds)		(cents/pound)	(millions of dollars)
Ghana	784.06	782.96	72.92	570.92
Nigeria	407.13	406.03	72.89	295.97
Ivory Coast	297.10	296.33	72.94	216.14
Cameroon	20.30	19.53	72.86	14.23
Other Africa Production	220.45	219.67	72.84	160.02
Brazil	204.54	164.10	72.95	119.71
Ecuador	154.32	144.62	73.01	105.58
Venezuela	55.12	37.99	73.16	27.79
Mexico	57.32	36.55	73.18	26.75
Dominican Republic	83.77	80.05	73.20	58.60
Other America	112.43	45.75	73.20	33.49
Other Asia	39.68	3.12	73.47	2.29
Other Oceania	79.37	73.46	73.38	53.90
Total	2,515.58	2,310.16		1,685.39

the agreement would be too unevenly distributed among the countries to generate an unanimous support for it (Cameroon would actually experience a considerable decrease in production, exports, and exchange revenue). An attempt will be made later to correct this imbalance by introducing output reduction also for the eight smaller countries.

Model 5B: Since the results (in terms of export levels) obtained with Model 5A were considered unlikely to be adopted in a potential cocoa agreement, the present model will be an alternative to be considered. Its basic difference in relation to Model 5A will refer to a different allocation (for the leading five nations) of cocoa production, although the aggregate (for 13 countries or regions) production is the same as that obtained in the previous model. In an attempt to make the gains from an agreement more evenly distributed among the five leading producers (and probably increasing the chances of its acceptance), the production level for these nations was set at approximately 48.7 percent of their free-trade output; this proportion is consistent with the reduction necessary to restrict output at the aggregate level of Model 5A above.

The results obtained (on the supply side) with the application of a fixed supply type of reactive programming procedure are reported in Table 26. As mentioned above, we observe that the gains in exchange earnings, which in Model 5A were accruing to four leading countries (with the exclusion of Cameroon, which had a loss), are now distributed among the five leading producers (that is, with the inclusion of Cameroon); their aggregate increase in revenue (over the free-trade situation of Model 2) is approximately 111 millions of dollars. For

Table 26. Equilibrium values of production, exports, prices, and revenues, Model 5B, 1980

Producing country (region)	Production	Exports	Prices	Revenue
	(millions of pounds)		(cents/pound)	(millions of dollars)
Ghana	765.79	764.69	72.92	557.60
Nigeria	351.87	350.76	72.89	255.66
Ivory Coast	272.64	271.87	72.93	198.28
Cameroon	137.81	137.04	72.85	99.83
Other Africa Production	220.46	219.69	72.85	160.04
Brazil	185.02	144.59	72.96	105.50
Ecuador	154.32	144.62	73.01	105.58
Venezuela	55.12	38.00	73.17	27.81
Mexico	57.32	36.57	73.20	26.77
Dominican Republic	83.77	80.06	73.21	58.61
Other America	112.43	45.76	73.20	33.50
Other Asia	39.68	3.12	73.47	2.29
Other Oceania	79.37	73.45	73.38	53.90
Total	2,515.59	2,310.22		1,685.37

individual countries, the increase in exchange earnings (again, over their free-trade levels of Table 21) is slightly less than 10 percent for the major African countries and 11.4 percent for Brazil.

With the exception of these changes, the results obtained with Model 5B are very similar to those of Model 5A. This is to be expected, however, since the only changes introduced were those of production levels in the five leading producing nations, with aggregate monopoly output remaining the same.

Model 6. Cocoa Agreement: All Countries Reduce Output

One of the main characteristics of the results obtained with Model 5 was that the eight smaller cocoa producing nations (or regions) were able to obtain a larger part of the increase in revenues than the five leading producers. The reason for this unbalanced distribution of the gains is that these smaller countries (regions) did not experience any reduction in output in the application of the reactive programming procedure. As a result, their exports were increased as compared with the levels prevailing in free-trade Model 2, since domestic consumption was decreased with the higher prices which resulted. We mentioned that the alternatives presented under Model 5 would probably provide us with a lower bound estimate of the gains to the five leading countries.[108] The increase in exchange earnings to the five countries reducing their output and exports was, in that case, close to 110 millions of dollars annually, or 10 percent of their revenue under free trade (Model 2).

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[108]A somewhat still lower bound would be obtained by an arrangement similar to the Cocoa Producers Alliance, where no participation of the eight smaller countries (regions) would be involved.

The alternative to follow will present a more favorable situation for the five larger producers, since output reductions will also be introduced for the smaller countries (regions).

The basic change introduced in Model 6 refers to a 30 percent reduction in the output levels of the eight smaller producing countries (regions) when starting the programming solution (i.e., as input data).[109] The same two-step procedure described in Model 5 was repeated here to obtain the equilibrium output and exports for the five leading producers (these with supply functions). A solution similar to that described for Model 5A was obtained but is not presented here since the same characteristic of uneven distribution of revenue gains of Model 5A was present here. Model 6 will then describe a situation similar to Model 5B, that is, the aggregate output obtained in step one was maintained but the output levels for the five leading nations were set at approximately 54.4 percent of their free-trade production; a fixed supply type of reactive programming procedure was then used to obtain the equilibrium values for the remaining variables.

The results obtained on the supply side are presented in Table 27. The increase in aggregate exchange revenue (over the free-trade situation of Model 2) is 412 millions of dollars, of which 274 millions of dollars are accruing to the five producing nations. In proportion terms these figures represent a 25 percent increase in foreign revenue for the five leading countries, and

[109]The reduction of 30 percent is only intended to be illustrative. However, it appears to be a reasonable figure when compared with the output reductions for the five leading countries in Model 5A, 5B and the present one.

Table 27. Equilibrium values of production, exports, prices, and revenues, Model 6, 1980

Producing country (region)	Production	Exports	Prices	Revenue
	(millions of pounds)		(cents/pound)	(millions of dollars)
Ghana	855.17	854.09	73.78	630.15
Nigeria	392.95	391.87	73.76	289.04
Ivory Coast	304.47	303.71	73.79	224.11
Cameroon	153.93	153.16	73.71	112.90
Other Africa Production	154.31	153.55	73.72	113.19
Brazil	206.63	167.37	73.83	123.56
Ecuador	108.02	98.59	73.87	72.83
Venezuela	38.58	21.96	74.03	16.26
Mexico	40.12	19.98	74.07	14.80
Dominican Republic	58.64	55.04	74.07	40.76
Other America	78.70	14.03	74.07	10.39
Other Asia	27.78			
Other Oceania	55.56	49.81	74.24	36.98
Total	2,474.86	2,283.16		1,684.97

83 percent increase for the remaining nations (or regions). It then appears that, even in terms of revenue earnings, the five larger producers (Ghana, Nigeria, Ivory Coast, Cameroon, and Brazil) have a considerable gain with the agreement, at the same time that the gains in revenue for the smaller nations (138 millions of dollars), although decreased in relation to Model 5B, are more in line with their importance as cocoa producers.[110] In terms of the five individual producing nations, the increase in exchange revenues with Model 6 represents 24 percent of the free-trade levels for the four African producers, while for Brazil the same proportion is 34 percent.[111]

It appears that the situation described by Model 6 has more chances of adoption than the others so far considered; it presents a more balanced picture of the cocoa economy in terms of output reduction and also with the gains more evenly distributed among producing nations. As a result, we present the resulting information about flows and the consumption side in Appendix C Tables 13 and 14. It can be noted (after comparing with the results in Appendix C Table 8, the free-trade situation) that the countries experiencing increases in their total expenditures on cocoa are United States, Australia, Belgium, France, West Germany, Denmark, and Italy, which had the demand curves with the

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[110] The share in total output in Model 2 (free-trade) for the eight smaller producing nations (regions) was approximately 19 percent; their gain in total revenue in Model 6 is one-third of their free-trade level.

[111] The greater proportional gain for Brazil is explained by the higher level of Brazil's demand curve when compared to those of African countries, and consequent larger absolute reduction in consumption with the price rise.

lowest price elasticities in absolute value (see Table 13). Netherlands and Japan which had a price-elastic demand curve for cocoa have, as expected, a lower total expenditure on cocoa imports.

Model 7, Cocoa Agreement: Maximizing Total Revenue

It was previously mentioned that the goal of the agreement's member countries may be one of maximizing foreign exchange revenue from cocoa, rather than one of profit (income) maximization, as discussed in previous sections. From the theoretical discussion of Chapter 3 we would expect that by seeking the above goal, export quantities would be increased and cocoa prices would be decreased. The situation to be presented here will be one where the goal of the five leading member countries is one of maximizing their aggregate total revenue[112] from cocoa but subject to the condition that output levels for the eight smaller nations are the same as those prevailing in Model 6 (that is, a 30 percent reduction in relation to their free-trade output levels of Model 2). In other words, the output levels of the five leading producers will be changed[113] in the downward direction (equal reductions for all five with respect to levels of Model 2) until maximum aggregate

[112] The application of the reactive programming solution procedure will allow us to maximize aggregate revenue from cocoa and not foreign exchange revenues; this is so because the domestic sector will also be included in the procedure. For the four African nations (included among the five leading producers) the difference will be very small (because of their extremely low consumption), but not necessarily so for the case of Brazil.

[113] The process used was a trial-and-error one where outputs (of the five countries) were set at different levels until the output maximizing aggregate revenue was located. Since the spacing of each individual country's output in the relevant range was 2.5 percent, our results must be considered only as an approximation and will be used only for illustrating this type of arrangement.

revenue is attained. This will allow us to make an attempt at comparing the obtained results with those of Model 6, where the monopoly power is fully exploited by these five countries given a 30 percent reduction in the output levels of the eight smaller areas. The comparison, however, will be limited to the situation involving only the five larger producers (Ghana, Nigeria, Ivory Coast, Cameroon, and Brazil), since they will be the ones experiencing changes in their output levels.[114]

The results obtained with the solution by the reactive programming method are reported in Table 28. As expected, aggregate production and exports are at higher levels than in Model 6 above, while producers' prices are approximately 22 percent lower; aggregate foreign exchange revenue for the five leading nations, on the other hand, is increased by 98 millions of dollars, which is about 7 percent of their aggregate revenue under the monopoly situation of Model 6.[115] Output levels for the five major producers are at 75 percent of their free-trade output but well above the levels prevailing in the monopoly situation of Model 6. In addition, foreign exchange revenues for Ghana, Nigeria, Ivory Coast, Cameroon, and Brazil are increased by 46, 21, 17, 8, and 5 millions of dollars, respectively (as compared with the levels of Model 6),

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[114] It should be emphasized that the specific objective being used in this model, that is maximizing the five leading nations' aggregate revenue from cocoa given that the output levels of the eight smaller areas are kept at their levels in Model 6, is only one of several possible alternatives. In addition to it, we might mention one of maximizing the same aggregate revenue given that the output of the above eight countries is kept at their free trade levels (Model 5B), or yet maximizing aggregate revenue with no constraint in the output of any country (i.e., equal reductions for all).

[115] The increase in total revenue (including the domestic sectors) is somewhat higher, 105 millions of dollars.

Table 28. Equilibrium values of production, exports, prices, and revenues, Model 7, 1980

Producing country (region)	Production	Exports	Prices	Revenue
	(millions of pounds)		(cents/pound)	(millions of dollars)
Ghana	1,179.88	1,178.31	57.44	676.80
Nigeria	542.17	540.60	57.42	310.42
Ivory Coast	420.09	419.16	57.46	240.83
Cameroon	212.37	211.44	57.39	121.35
Other Africa Production	154.32	153.39	57.39	88.03
Brazil	285.09	223.74	57.48	128.62
Ecuador	108.02	93.37	57.54	53.73
Venezuela	38.58	12.46	57.70	7.19
Mexico	40.12	8.39	57.72	4.84
Dominican Republic	58.64	52.91	57.73	30.55
Other America	78.70			
Other Asia	27.78			
Other Oceania	55.56	46.73	58.05	27.13
Total	3,201.31	2,940.50		1,689.49

which represents approximately an increase of 7 percent for the African nations and 4 percent for Brazil.[116]

Welfare and Revenue Comparisons

The last section of Chapter 3 presented a framework for analyzing the welfare aspects of an international cocoa agreement as compared with a free-trade situation; Figure 5 at that point was intended to show the possible gains to a representative country (any one among the five leading ones, that is, those with supply functions rather than a fixed supply) from the type of market agreement involving an international cocoa agreement. We were then able to show the economic surplus accruing to such representative country with free-trade and under a cocoa agreement. By subtracting the former from the latter (for each of the five countries involved), we would obtain a measure of the change in welfare taking place.

All the information necessary for obtaining the above measure of welfare change (in terms of the relevant areas of Figure 5) was obtained and presented in our discussion concerning Models 2, 5B, 6, and 7.[117] As a result, Table 29 presents the figures we obtained when comparing the two types of market arrangements for cocoa in welfare

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[116] Since output levels for the eight smaller areas remained fixed at the levels of Model 6, and with lower prices prevailing, we have the result of higher domestic consumption and lower exports; consequently exchange revenues of the smaller areas are decreased.

[117] Information about supply prices necessary for the necessary computations can be obtained by solving the supply functions in Appendix C Table 4 with the appropriate quantities.

Table 29. Measures of welfare change in millions of dollars with an international cocoa agreement, 1980

Country (region)	Model 5B	Model 6	Model 7
Ghana	245.24	302.56	281.11
Nigeria	106.17	132.84	122.63
Ivory Coast	85.17	105.81	98.68
Cameroon	49.04	58.19	51.25
Brazil	30.93	44.90	49.27

terms.[118] Table 30, on the other hand, is only summarizing the information about foreign-exchange revenues for the same countries and models (that is, revenue under free trade subtracted from those of Models 5B, 6 and 7), that is already known at this point.

The results for the measure of welfare change in Table 29 shows that considerable gains can be made by the leading producing nations from an international cocoa agreement which would exploit the collective monopoly power of cocoa producers. The three larger producers, Ghana, Nigeria, and Ivory Coast, have, in Model 6, increases in welfare valued at more than 100 millions of dollars with the one for Ghana, in particular, in excess of 300 millions of dollars. Although these three models are not intended to be a comprehensive coverage of the possibilities under an international cocoa agreement, they at least show that considerable gains in welfare can be achieved.[119] Model 6

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[118] An exact welfare comparison between Models 6 and 7 is not possible with our formulation because, in both cases, marginal cost of cocoa production is not equalized across the five countries considered; the consequence is that each country's output is not at the optimum levels (the outputs that would result from the first step mentioned in Model 6 for instance). This is the reason for the measure of welfare change for Brazil to be greater in Model 7 than in 6, since Brazil's output level in Model 6 is below its optimum level (as given by the first step of the procedure). By using the correct output and supply price the situation is reversed, that is, the measure of welfare change in Model 7 is lower than in 6. An indication that aggregate welfare (for the five countries) is less with Model 7 than with Model 6 can be obtained by comparing the sum of the two relevant columns in Table 29.

[119] Special situations can be solved by the member countries; for instance, the case of Brazil as mentioned in the previous footnote, may call for a higher output level and exports than that reported in Model 6. Although not indicated in Table 29, it should be interesting to note that by adopting Model 5B instead of 5A (with efficient allocation of cocoa beans production) aggregate welfare of the five major countries is decreased by slightly less than five millions of dollars; this magnitude is less than 1 percent of the aggregate welfare gain obtained with Model 5B.

Table 30. Foreign-exchange revenue changes in millions of dollars with an international cocoa agreement, 1980

Country (region)	Model 5B	Model 6	Model 7
Ghana	49.21	121.76	168.41
Nigeria	22.59	55.97	77.35
Ivory Coast	17.31	43.14	59.86
Cameroon	8.75	21.82	30.27
Other Africa Production	89.26	42.41	17.25
Brazil	13.13	31.19	36.25
Ecuador	62.72	29.97	10.87
Venezuela	23.10	11.55	2.48
Mexico	24.22	12.25	2.29
Dominican Republic	34.19	16.34	6.13
Other Oceania	32.25	15.33	5.48

in particular appears to be the one where the welfare gain to the five leading countries is largest at the same time that increases in foreign exchange revenue are experienced by all producing nations in a more balanced pattern. This last point may be of importance for the success of negotiations leading to an agreement.

CHAPTER 7
SUMMARY AND CONCLUSIONS

This study was limited to a single commodity in international trade, that is predicting various aspects of the world cocoa economy in 1980. The importance of this commodity for several of the less developed countries of the world was emphasized in the introductory chapter, mainly with respect to foreign exchange earnings, income, and employment. Since cocoa is an internationally traded commodity, interdependence must be allowed for a full understanding of the market forces at work. This implies that supply and demand relations should be introduced at the same time that the spatial distribution of production and consumption is considered.

In the last decade some developments occurred in the world economy with possible repercussion for the cocoa sector; the most important ones can be identified as the creation of the European Economic Community as well as its enlargement (with three more countries) as of January 1, 1973, the movement toward trade liberalization (Kennedy Round) and preferential tariff treatment to products from developing countries (Generalized System of Preferences), and the renewed interest shown by producers of primary products in the arrangement known as international commodity agreements. In such a context, a good decision making with respect to economic policies of cocoa producing nations requires that information be available concerning how the pattern of trade would be affected by policy changes occurring either in the production or in the consumption sectors of the cocoa economy.

The first specific objective of the analysis related to obtaining estimates of prices, production, exports, consumption, revenues expenditures, and trade flows in the cocoa economy under the assumption of free-trade conditions prevailing in 1980. The assumption of free-trade was relaxed in a second stage by introducing the existence of tariffs on cocoa in some countries as well as the market arrangement known as European Economic Community (EEC).

The second objective of the analysis was related to the formation of a possible international cocoa agreement among producing countries which would involve reductions in their output and exports. Estimates of the variables mentioned above were to be obtained and comparisons (in welfare and revenue terms) made with the market arrangements of the first objective.

The spatial equilibrium framework in international trade was the approach chosen with the objective of providing the equilibrium values for the variables being considered. Chapter 2 presented the reactive programming method as the specific spatial solution procedure to be used in the analysis. Two intermediate steps were also required before the equilibrium solutions could be obtained: they were first, to obtain estimates of unit transportation costs for cocoa beans in international trade, and second, to obtain estimates of cocoa demand and supply functions for all countries in 1980.

Part of the second required step was the subject considered in Chapters 4 and 5. In Chapter 4 two models for estimation of demand functions, one a partial adjustment model and one based on a polynomial lag formulation, were presented. The same chapter presented a model for estimating supply functions of cocoa also based on a polynomial lag formulation. Chapter 5 reported the results of the estimation of demand functions in ten major consuming nations as well as of supply functions for the five leading cocoa producers. The obtained results were more satisfactory on the demand than on the supply side. As a matter of fact, only one of the functions on the demand side (the one for the United Kingdom) was considered to be unsatisfactory with both models, such that an alternative technique was used. On the supply side, on the other hand, three of the functions estimated were entirely disregarded when obtaining the equilibrium solutions in Chapter 6 (the ones for Nigeria, Brazil, and Cameroon) because of the poor results obtained, with an alternative estimating technique then being employed.

Since the world cocoa economy in this analysis included 32 countries (or regions), the alternative estimating technique was applied to obtain the parameter estimates of the demand functions for the 23 remaining countries (or regions) as well as of supply functions for three countries (plus the intercept term in Ivory Coast's function). The remaining eight smaller nations on the supply side were assumed to have a perfectly inelastic supply function in 1980. The alternative technique mentioned involved the use of point projections of cocoa consumption and production for 1980 by the Food and Agriculture Organization of the United Nations (1971) and estimates of supply and demand elasticities, to obtain estimates of the intercept and slope in the two respective functions. Early in Chapter 6 we also considered the first step mentioned above, by obtaining estimates of unit transportation costs for all pairs of centers with the use of a simple linear regression of unit cost on distance among pairs.

With the information obtained as the result of accomplishing these two intermediate steps, the reactive programming procedure could then be applied for obtaining the equilibrium solutions for the variables of interest under the three types of market arrangements for the world cocoa economy in 1980 as listed in our objectives.

Models 1, 2, 3, and 4 in Chapter 6 were concerned with obtaining the equilibrium values of the variables, that is, prices, production, exports, consumption, revenues, expenditures, and trade flows. The first two models dealt with a free-trade situation in 1980, and the other two with a market arrangement including the existence of tariffs and the European Economic Community (EEC). It was found that the introduction of the EEC (the old membership) caused some changes in the cocoa economy; when comparing the results of Models 2 and 3, we observed that trade was diverted from Ghana to those African nations benefited by the EEC policy (Ivory Coast, Cameroon, and Other Africa Production). These results were, however, reversed in Model 4, where the assumption was made that Ghana and Nigeria would become signatories to the Yaunde Convention and thus enjoy trade preferences from the enlarged EEC. The overall volume of trade (exports) was practically unaffected with the introduction of tariffs and EEC, which pointed in the direction that most of the gains to be obtained by producing nations from tariff reductions or removals were already made during the 1960's. Total exchange revenues were slightly below 1.3 billion dollars which is practically double the value prevailing as an average for the period 1965-1969. Very similar figures were obtained in Models 2, 3, and 4. Ghana is by far the largest cocoa producer as predicted by such models, followed by Nigeria, Ivory Coast, Brazil, and Cameroon; Brazil then loses to Ivory Coast the position of the third largest producer.

The possibility of producing nations acting together to exploit their collective monopoly power in the world market was introduced in Models 5, 6, and 7 under different arrangements. It was found that producing countries can make considerable welfare gains (including the five major producers, although Ghana, Nigeria, and Ivory Coast are the ones to gain the most) at the same time that all producing countries can increase their foreign exchange revenues. Model 6 resulted in the more balanced distribution of the increase. With respect to the increase in foreign exchange revenues, a better perspective can be obtained by comparing the annual increase of 412 millions of dollars (Model 6 over Model 2), with the estimate of revenue transfer to all developing countries of approximately 100 millions of dollars resulting from the working of the Generalized System of Preferences (Murray, 1973) based on 1971 conditions. The release of resources engaged in cocoa production also must be considered as a positive contribution of an international agreement to the process of economic development, although special adjustment policies might be required to facilitate the transition to other productive enterprises.

It should also be mentioned, however, that several difficulties may be present not only during the negotiating process but afterward as well. In the first case we should point to difficulties in reaching an agreement among producers with respect to output and export levels, in other words, the distribution of the gains. In addition, the inclusion of consuming countries was considered earlier to be of considerable importance in terms of effective policing of an agreement. In a second stage, we also must mention the incentive created by the rise in price for increased investment in research and development with the purpose of obtaining substitutes for cocoa products. The distribution of quotas over time and its relation to an efficient allocation of resources in the cocoa sector should also be mentioned. Our results only show that considerable benefits can be obtained by producing nations from such an agreement, but costs appearing now and in the future should not be disregarded by these same countries when reaching a decision concerning this important matter.

LIST OF REFERENCES

Amoa, R. C. 1965. A study in demand: An analysis of the cocoa bean and cocoa products markets of the United States. Unpublished Ph.D. thesis, Department of Economics, Massachusetts Institute of Technology. University Microfilms, Ann Arbor, Michigan.

Bateman, M. J. 1965. Aggregate and regional supply functions for Ghanaian cocoa, 1946-1962. Journal of Farm Economics 47(2): 384-401.

Bateman, M. J. 1969. Supply relations for tree crops in the less developed countries, pp. 243-256. In C. R. Wharton, Jr. (ed), Subsistence Agriculture and Economic Development. Aldine Publishing Co., Chicago, Illinois.

Bawden, D. L. 1966. A spatial price equilibrium model of international trade. American Journal of Agricultural Economics 48(4):862-874.

Behrman, J. R. 1965. Cocoa: A study of demand elasticities in the five leading consuming countries, 1950-1961. Journal of Farm Economics 47(2):410-417.

Behrman, J. R. 1968. Monopolistic cocoa pricing. American Journal of Agricultural Economics 50(3):702-719.

Berry, R. A. 1972. A review of the problems in the interpretation of producer's surplus. Southern Economic Journal 39(1):79-92.

Bjarnason, H. F. 1967. An economic analysis of 1980 international trade in feed grains. Unpublished Ph.D. thesis, Department of Economics, University of Wisconsin. University Microfilms, Ann Arbor, Michigan.

Bjarnason, H. F., M. J. McGarry, and A. Schmitz. 1969. Converting price series of internationally traded commodities to a common currency prior to estimating national supply and demand equations. American Journal of Agricultural Economics 51(1):189-191.

Brandt, S. A. 1967. Spatial analysis of the world coffee market: The Brazilian competitive position. Unpublished Ph.D. thesis, Department of Agricultural Economics, Ohio State University. University Microfilms, Ann Arbor, Michigan.

Bronfenbrenner, J. 1953. Sources and sizes of least-squares bias in a two-equation model, pp. 221-235. In W. C. Hood and J. C. Koopmans (ed.), Studies in Econometric Method. Yale University Press, New Haven, Connecticut.

Buse, R. C. 1958. Total elasticities -- A predictive device. Journal of Farm Economics 40(4):881-891.

Chen, D., R. Courtney and A. Schmitz. 1972. A polynomial lag formulation of milk production response. American Journal of Agricultural Economics 54(1):77-83.

Chenery, H. B. and N. G. Carter. 1973. Foreign assistance and development performance, 1960-1970. American Economic Review 63(2):459-469.

Committee for Economic Development. Trade policy toward low-income countries. New York.

Commodity Research Bureau. 1952-1971. Commodity Yearbook. Various issues. New York.

Currie, J. M., J. A. Murphy and A. Schmitz. 1971. The concept of economic surplus and its use in economic analysis. Economic Journal 81(3):741-799.

Dantzig, G. B. 1951. Application of the simplex method to a transportation problem, pp. 359-373. In T. C. Koopmans (ed.), Activity Analysis of Production and Allocation. John Wiley and Sons, New York.

Elliott, D. P. 1972. Converting national supply and demand equations to a common currency for internationally traded commodities. American Journal of Agricultural Economics 54(3):538.

Enke, S. 1951. Equilibrium among spatially separated markets: Solution by electric analogue. Econometrica 19(1):40-47.

European Economic Community Tariff Changes. 1973. Cocoa Market Report 249:7.

Ferguson, C. E. 1969. Microeconomic Theory. Richard D. Irwin, Inc., Homewood, Illinois.

Food and Agriculture Organization of the United Nations. 1958-1972. Cocoa statistics. Various issues. Rome, Italy.

Food and Agriculture Organization of the United Nations. 1962. Agricultural Commodities and the European Market. Rome, Italy.

Food and Agriculture Organization of the United Nations. 1966. The longer-term outlook for cocoa production and consumption. Monthly Bulletin of Agricultural Economics and Statistics 15 (March 1966):10-17.

Food and Agriculture Organization of the United Nations. 1971. Agricultural Commodity Projections, 1970-1980. Rome, Italy.

Food and Agriculture Organization of the United Nations. 1972. Import duties, internal taxes, and non-tariff import restrictions on cocoa and cocoa products. Rome, Italy.

Food and Agriculture Organization of the United Nations. 1973a. Cocoa statistics. 16(1):35. Rome, Italy.

Food and Agriculture Organization of the United Nations. 1973b. Recent developments in agricultural commodity markets. Monthly Bulletin of Agricultural Economics and Statistics 22(3):1-5.

Freeman, A. M., III. 1971. International Trade: An Introduction to Method and Theory. Harper and Row, Publishers, New York.

French, B. C. and J. L. Matthews. 1971. A supply response model for perennial crops. American Journal of Agricultural Economics 53(3):478-490.

Gardner, B. 1972. Minimum wages and the farm labor market. American Journal of Agricultural Economics 54(3):473-476.

Grayson, L. E. 1973. The role of suppliers' credit in the industrialization of Ghana. Economic Development and Cultural Change 21(3):477-499.

Griliches, Z. 1967. Distributed lags: A survey. Econometrica 35(1):16-49.

Grubel, H. 1964. Foreign exchange earnings and price stabilization schemes. American Economic Review 54(3):378-385.

Gwyer, G. D. 1972. Formal or informal commodity agreements: The case of sisal. Oxford Agrarian Studies 1(1):67-79.

Hale, S. L. 1967. The world cocoa market, pp. 136-148. In T. K. Warley (ed.), Agricultural Producers and Their Markets. Augustus M. Kelley, Publishers, New York.

Helleiner, G. K. 1972. International Trade and Economic Development. Penguin Books. Baltimore, Maryland.

Henderson, J. M. and R. E. Quandt. 1958. Microeconomic Theory: A Mathematical Approach. McGraw-Hill Book Company, New York.

Hitchcock, F. L. 1941. Distribution of a product from several sources to numerous localities. Journal of Mathematics and Physics 20:224-230.

Hsiao, J. C. and M. W. Kottke. 1968. Spatial equilibrium analysis of the dairy industry in the northeast region: an application of quadratic programming. Bulletin 405, Storrs Agriculture Experiment Station, Storrs, Connecticut.

Huang, D. S. 1970. Regression and Econometric Methods. John Wiley and Sons, Inc., New York.

Hueth, D. and A. Schmitz. 1972. International trade in intermediate and final goods: Some welfare implications of destabilized prices. Quarterly Journal of Economics 86(3):351-365.

Hushak, L. J. 1971. A welfare analysis of the voluntary corn diversion program, 1961 to 1966. American Journal of Agricultural Economics 53(2):173-181.

International Federation of Agricultural Producers. 1972. Cocoa—Oh No! World Agriculture 21(2):38-40.

Jellema, B. M. 1972. Analysis of the world market for groundnuts and groundnuts products. Unpublished Ph.D. thesis, Department of Economics, North Carolina State University at Raleigh. University Microfilms, Ann Arbor, Michigan.

Johnson, H. G. 1961. Optimum tariffs and retaliation. Review of Economic Studies 19(48):28-35.

Johnson, H. G. 1967. Economic Policies toward Less Developed Countries. Frederick A. Praeger, Publishers, New York.

Johnson, P. R. 1965. The social cost of the tobacco program. Journal of Farm Economics 47(2):242-255.

Johnston, J. 1963. Econometric Methods. McGraw-Hill Book Company, New York.

Killick, T. 1967. Commodity agreements as international aid. Westminster Bank Review (February 1967):18-30.

Kindleberger, C. P. 1968. International Economics. Richard D. Irwin, Inc., Homewood, Illinois.

King, R. A. and W. R. Henry. 1959. Transportation models in studies of interregional competition. Journal of Farm Economics 41:997-1011.

King, R. A. and F. S. Ho. 1972. Reactive programming: A market simulating spatial equilibrium algorithym. ERR-21, Department of Economics, North Carolina State University at Raleigh.

Klein, L. R. 1960. Single equation vs. equation system methods of estimation in econometrics. Econometrica 28(4):866-871.

Kravis, I. B. 1968. International commodity agreements to promote aid and efficiency: The case of Brazil. Canadian Journal of Economics 1(2):295-317.

Kreinin, M. E. 1971. International Economics: A Policy Approach. Harcourt Brace Javanovitch, Inc., New York.

Law, A. D. 1970. International commodity agreements: Policies and problems. Journal of Economic Issues 4(23):87-102.

Murray, T. 1973. How helpful is the generalized system of preferences to developing countries? Economic Journal 83(330):449-455.

Nerlove, M. 1958. Distributed lags and estimation of long-run supply and demand elasticities: Theoretical considerations. Journal of Farm Economics 40(2):301-314.

Nerlove, M. and W. Addison. 1958. Statistical estimation of long-run elasticities of supply and demand. Journal of Farm Economics 40(4):861-880.

Olayide, S. O. 1972. Some estimates of supply elasticities for Nigeria's cash crops. Journal of Agricultural Economics 23(3): 263-276.

Pendse, D. C. 1967. Interregional and interseasonal competition in the United States beef industry, 1967: An integrated analysis. Unpublished Ph.D. thesis, Department of Agricultural Economics, Oregon State University. University Microfilms, Ann Arbor, Michigan.

Pincus, J. 1965. Economic Aid and International Cost Sharing. The Johns Hopkins Press, Baltimore, Maryland.

Prais, S. J. 1962. Econometric research in international trade: A review. Kyklos 25:560-579.

Repetto, R. 1972. Optimal export taxes in the short and long run, and an application to Pakistan's jute export policy. Quarterly Journal of Economics 86(3):396-406.

Rogers, C. D. 1973. International commodity agreements. Lloyds Bank Review 108:33-47.

Samuelson, P. A. 1952. Spatial price equilibrium and linear programming. American Economic Review 42(3):282-303.

Schmidt, P. and R. N. Waud. 1973. The Almon lag technique and the monetary vs. fiscal policy debate. Journal of the American Statistical Association 68(341):11-19.

Schmitz, A. 1968. An economic analysis of the world wheat economy in 1980. Unpublished Ph.D. thesis, Department of Economics, University of Wisconsin. University Microfilms, Ann Arbor, Michigan.

Schultz, T. W. 1956. Reflections upon agricultural production, output and supply. Journal of Farm Economics 38(3):613-631.

Schutjer, W. A. and E. J. Ayo. 1967. Negotiating a world cocoa agreement--analysis and prospects. Bulletin 744, College of Agriculture, Pennsylvania State University, University Park, Pennsylvania.

Seale, A. D., Jr. and T. E. Tramel. 1963. Reactive programming models, pp. 47-58. In R. A. King (ed.), Interregional Competition Research Methods. Agricultural Policy Institute, North Carolina State University, Raleigh.

Staley, C. E. 1965. An evaluation of some recent contributions to the political economy of the stabilization of international price and commodity fluctuations. Weltwirtschaftliches Archiv No. 2:337-347.

Stemberger, A. P. 1959. Evaluating the competitive position of North Carolina eggs by use of transportation model. Journal of Farm Economics 41:790-798.

Stigler, G. J. 1966. The Theory of Price. The Macmillan Company, New York.

Takayama, T. 1967. International trade and mathematical programming. Australian Journal of Agricultural Economics 11(1):36-48.

Takayama, T. and G. G. Judge. 1963. Nonlinear formulations of spatial equilibrium models and methods for obtaining solutions. AERR 66, Agriculture Experiment Station, University of Illinois, Urbana.

Takayama, T. and G. G. Judge. 1964a. International trade models. Illinois Agricultural Economics 4(3):53-63.

Takayama, T. and G. G. Judge. 1964b. Spatial equilibrium and quadratic programming. Journal of Farm Economics 46(1):67-93.

Theil, H. 1971. Principles of Econometrics. John Wiley and Sons, Inc., New York.

Tramel, T. E. 1965. Reactive programming, an algorithm for solving spatial equilibrium problems. Technical Publication 9, Agriculture Experiment Station, Mississippi State University, State College.

Tramel, T. E. and A. D. Seale, Jr. 1959. Reactive programming of supply and demand relations -- Applications to fresh vegetables. Journal of Farm Economics 41(5):1012-1022.

United Nations. 1950-1972. Monthly Bulletin of Statistics. Various issues. New York.

United Nations. 1973. Monthly Bulletin of Statistics. 27(4):110-117. New York.

U. S. Department of the Navy. 1965. Distance between ports. H. O. Publication No. 151, U. S. Naval Oceanographic Office, Washington, D. C.

Viton, A. 1970. The Prospect and Promise of Cocoa. Study Group on Cocoa: Food and Agriculture Organization of the United Nations, Rome, Italy.

Walter, I. 1968. International Economics: Theory and Policy. Ronald Press Company, New York.

Weymar, F. H. 1968. The Dynamics of the World Cocoa Market. M.I.T. Press, Cambridge, Massachusetts.

Wu, S. and J. Pontney. 1967. An Introduction to Modern Demand Theory. Random House, New York.

Zusman, P., A. Melamed and I. Katzir. 1969. Possible trade and welfare effects of EEC tariff and 'reference price' policy on the European-Mediterranean Market for winter oranges. Giannini Foundation Monograph 24, Agriculture Experiment Station, University of California, Davis.

APPENDICES

Appendix A. The Elasticity of Demand for A Country's Export

Define

Q_t = the world demand for imports of the product.

Q_o = the quantity exported by other sources besides the country being examined.

$Q_D = Q_t - Q_o$, as the quantity demanded from the country in question.

We, in addition, define the elasticity of demand for the country's export of the specific product (Kreinin, 1971, p. 354) as:

$$\eta_x = \frac{\Delta Q_D}{\Delta P}\,\frac{P}{Q_D} = \frac{\Delta(Q_t - Q_o)}{\Delta P}\cdot\frac{P}{(Q_t - Q_o)} \tag{81}$$

$$= \frac{\Delta Q_t}{\Delta P}\,\frac{P}{(Q_t - Q_o)} - \frac{\Delta Q_o}{\Delta P}\,\frac{P}{(Q_t - Q_o)} \quad .$$

Multiplying and dividing the first term of the right-hand inside by Q_t and the second term by Q_o, we obtain:

$$\eta_x = \frac{\Delta Q_t}{\Delta P}\,\frac{P}{Q_t}\,\frac{Q_t}{(Q_t - Q_o)} + \frac{\Delta Q_o}{\Delta P}\,\frac{P}{Q_o}\,\frac{Q_o}{(Q_t - Q_o)} \quad . \tag{82}$$

Since $\eta = \frac{\Delta Q_t}{\Delta P}\,\frac{P}{Q_t}$ is identified as the world demand elasticity for the product, and $\varepsilon_o = \frac{\Delta Q_o}{\Delta P}\,\frac{P}{Q_o}$ is the supply elasticity from other sources, (82) can be rewritten as:

$$\eta_x = \eta\left(\frac{Q_t}{Q_t - Q_o}\right) - \varepsilon_o\left(\frac{Q_s}{Q_t - Q_o}\right) \quad . \tag{83}$$

Since $s = \frac{Q_t - Q_o}{Q_t}$ is the share of the country in question in the world market for the product, we obtain the following final expression from (83):

$$\eta_x = \eta\left(\frac{1}{s}\right) - \varepsilon_o\left(\frac{1-s}{s}\right) \quad . \tag{84}$$

From (84) we can see that the elasticity of demand for the country's product (in absolute value) is inversely related to its share in the world market and directly related to the supply elasticity from other sources.

Appendix B. List of Countries Included in Producing and Consuming Regions

(a) Region 5: Other Africa Production: Angola, Congo, Equatorial Guinea, Gabon, Liberia, Madagascar, Sao Tome, Sierra Leone, Tanzania, Togo, and Zaire.

(b) Region 6: Other Africa No Production: Algeria, Gambia, Kenya, Libya, Mauritius, Morocco, Mozambique, Reunion, Rhodesia, Malawi, Zambia, Somalia, South Africa, Sudan, Tunisia, United Arab Republic, Burundia, Dahomey, Mali, Ethiopia, Rwanda, Uganda, Mauritania, Niger, Senegal, Upper Volta, Chad, C. A. Republic.

(c) Region 14: Other America: Argentina, Bolivia, Chile, Colombia, Ecuador, Guyana, Paraguay, Peru, Surinan, Uruguay, Coasta Rica, El Salvador, Guatemala, Honduras, Nicaragua, Panama, Caribbean Islands, Cuba, Haiti, Jamacia, Puerto Rico, Trinidad-Tobago.

(d) Region 16: Other Asia: Afghanistan, Cyprus, Iran, Israel, Iraq, Jordan, Lebanon, Saudi-Arabia, Yemen, Syria, Turkey, Yemen Arab Republic, Ceylon, India, Nepal, Pakistan, Burma, Khmer Republic, Taiwan, Hong-Kong, Indonesia, Republic of Korea, Laos, Malaysia, Philippines, Republic of Vietnam, China, North Korea, Mongolia, North Vietnam.

(e) Region 18: Other Oceania: New Zealand, New Guinea and Papua, Fiji, Western Samoa, New Hebrides.

(f) Region 27: NSFI: Norway, Sweden, Finland, Iceland.

(g) Region 30: Eastern Europe 1: Yugoslavia, Bulgaria, Rumania, Hungary, Albania, Greece.

(h) Region 31: Eastern Europe 2: Poland, East Germany, Czechoslovakia.

Appendix C. Data and Results of the Variables for the Cocoa Economy in 1980

Appendix C Table 1. Estimates of income per capita in 1980 by country

Country	Equation[a]	Y_{1980}	R^2	D. W.
United States	Y = 2,390.99 + 78.56t (35.62) (14.02)	4,748	0.92	0.5227
Belgium	Y = 922.87 + 51.92t (29.98) (20.20)	2,480	0.96	0.3375
Denmark	Y = 587.06 + 85.24t (11.95) (20.78)	3,144	0.96	0.2782
Netherlands	Y = 749.60 + 57.47t (29.97) (27.53)	2,474	0.98	0.7755
Germany	Y = 659.42 + 83.60t (23.08) (35.04)	3,167	0.99	0.9931
France	Y = 664.93 + 70.47t (21.61) (27.43)	2,779	0.98	0.4372
United Kingdom	Y = 1,076.71 + 31.22t (84.08) (29.21)	2,013	0.98	0.9886
Italy	Y = 348.02 + 48.88t (17.00) (28.52)	1,814	0.98	0.2950
Japan	Y = 100.49 + 61.96t (2.30) (16.95)	1,959	0.94	0.2313
Australia	Y = 1,298.95 + 41.17t (22.28) (8.46)	2,534	0.80	0.4761

[a]The period covered is 1951-1970 for all countries; t values are shown in parentheses.

Appendix C Table 2. Estimates of population in 1980 by country

Country	Equation[a]	N_{1980} (1,000)	R^2	D. W.
United States	N = 152,780.96 + 2,709.24t (327.60) (69.59)	234,058	0.996	0.1509
Belgium	N = 8,603.43 + 55.35t (776.36) (59.83)	10,264	0.995	0.5151
Denmark	N = 4,264.17 + 32.86t (947.02) (87.42)	5,250	0.998	0.3696
Netherlands	N = 10,026.83 + 149.55t (580.78) (103.77)	14,513	0.998	0.2513
Germany	N = 47,296.69 + 612.35t (502.03) (77.86)	65,667	0.997	0.5428
France	N = 41,022.14 + 494.62t (296.31) (42.80)	55,861	0.990	0.2873
Italy	N = 46,290.89 + 351.36t (441.00) (40.10)	56,832	0.989	0.2506
United Kingdom	N = 49,518.14 + 314.90t (443.24) (33.77)	58,965	0.984	0.2189
Japan	N = 83,787.57 + 956.02t (606.20) (82.86)	112,468	0.997	0.3325
Australia	N = 8,153.63 + 215.25t (645.01) (203.98)	14,611	0.999	0.6055

[a]The period covered for each country is 1951-1970; t values are shown in parentheses.

Appendix C Table 3. Cocoa demand functions for reactive programming procedure

Country (region)	Demand functions
Ghana	Q = 3.29 - 0.03P
Nigeria	Q = 3.29 - 0.03P
Ivory Coast	Q = 1.50 - 0.01P
Cameroon	Q = 1.50 - 0.01P
Other Africa Production	Q = 1.50 - 0.01P
Other Africa No Production	Q = 10.50 - 0.10P
Brazil	Q = 138.89 - 1.35P
Ecuador	Q = 33.08 - 0.32P
Venezuela	Q = 59.52 - 0.58P
Mexico	Q = 72.75 - 0.71P
Dominican Republic	Q = 13.23 - 0.13P
United States[a]	(a) Q = 1,260.47 - 7.91P (b) Q = 1,349.77 - 7.16P
Canada	Q = 168.65 - 1.64P
Other America	Q = 234.79 - 2.29P
Japan[a]	(a) Q = 219.13 - 2.37P (b) Q = 264.32 - 3.00P
Other Asia	Q = 128.97 - 1.26P
Australia[a]	(a) Q = 66.94 - 0.23P (b) Q = 65.13 - 0.25P
Other Oceania	Q = 19.85 - 0.19P
Belgium[a]	(a) Q = 82.04 - 0.23P (b) Q = 71.49 - 0.26P
France[a]	(a) Q = 285.96 - 0.79P (b) Q = 334.88 - 1.75P

Appendix C Table 3 (continued)

Country (region)	Demand functions
West Germany[a]	(a) Q = 671.90 - 4.03P (b) Q = 675.17 - 2.99P
Denmark[a]	(a) Q = 33.23 - 0.19P (b) Q = 41.12 - 0.14P
Italy	Q = 108.95 - 0.17P
Netherlands[a]	(a) Q = 103.52 - 2.02P (b) Q = 180.73 - 2.11P
United Kingdom	Q = 453.05 - 4.42P
Ireland	Q = 23.15 - 0.23P
NSFI	Q = 95.90 - 0.93P
Spain and Portugal	Q = 171.96 - 1.67P
Austria and Switzerland	Q = 142.20 - 1.39P
Eastern Europe 1	Q = 188.49 - 1.84P
Eastern Europe 2	Q = 221.57 - 2.16P
Soviet Union	Q = 575.40 - 5.61P

[a]Alternative (a) corresponds to the Nerlove model and (b) to the polynomial lag formulation.

Appendix C Table 4. Cocoa supply functions (fixed supplies) for reactive programming procedure

Country (region)	Supply function (fixed supply)
Ghana	Q = -45.20 + 50.42P
Nigeria	Q = 70.55 + 18.57P
Ivory Coast	Q = 20.26 + 16.49P
Cameroon	Q = -250.00 + 16.33P
Other Africa Production	Q = 220.46
Brazil	Q = 20.78 + 11.64P
Ecuador	Q = 154.32
Venezuela	Q = 55.12
Mexico	Q = 57.32
Dominican Republic	Q = 83.77
Other America	Q = 112.43
Other Asia	Q = 39.68
Other Oceania	Q = 79.37

Appendix C Table 5. Trade pattern for cocoa beans in 1980, Model 1

Supply region	Consuming region	Shipments (millions of pounds)
Ghana	Ghana	2.38
	Other Africa No Prod.	7.26
	Belgium	74.54
	West Germany	537.08
	Denmark	27.07
	United Kingdom	294.93
	Ireland	15.67
	NSFI	65.41
	Spain and Portugal	117.74
	Austria and Switzerland	97.07
	Eastern Europe 1	129.56
	Eastern Europe 2	109.34
Nigeria	Nigeria	2.38
	United States	672.52
	United Kingdom	9.76
Ivory Coast	Ivory Coast	1.20
	France	259.51
	Italy	103.48
	Netherlands	37.67
	Eastern Europe 2	43.05
	Soviet Union	83.51
Cameroon	Cameroon	1.20
	Soviet Union	250.34
Other Africa Production	Other Africa Production	1.20
	Canada	115.31
	Other Asia	48.47
	Soviet Union	55.38
Brazil	Brazil	97.80
	United States	213.74
	Other America	47.23
Ecuador	Ecuador	23.25
	Japan	131.07
Venezuela	Venezuela	41.81
	United States	13.31
Mexico	Mexico	50.88
	United States	1.85
	Japan	4.60

Appendix C Table 5 (continued)

Supply region	Consuming region	Shipments (millions of pounds)
Dominican Republic	Dominican Republic	9.24
	United States	74.53
Other America	Other America	112.43
Other Asia	Other Asia	39.68
Other Oceania	Japan	6.02
	Australia	59.38
	Other Oceania	13.97

Appendix C Table 6. Equilibrium values of consumption, imports, prices, and expenditures, free trade Model 1, 1980

Country (region)	Consumption	Imports	Prices	Expenditures
	(millions of pounds)		(cents/pound)	(millions of dollars)
Ghana	2.38	-	30.45	0.72
Nigeria	2.38	-	30.43	0.72
Ivory Coast	1.20	-	30.47	0.36
Cameroon	1.20	-	30.40	0.36
Other Africa Production	1.20	-	30.39	0.36
Other Africa No Production	7.26	7.26	32.37	2.35
Brazil	97.80	-	30.51	29.84
Ecuador	23.25	-	30.61	7.12
Venezuela	41.81	-	30.70	12.84
Mexico	50.88	-	30.72	15.63
Dominican Republic	9.24	-	30.73	2.84
United States	975.95	975.95	32.48	316.96
Canada	115.30	115.30	32.50	37.48
Other America	159.66	47.23	32.28	51.54
Japan	141.69	141.69	32.95	46.69
Other Asia	88.15	48.47	32.72	28.84
Australia	59.38	59.38	32.75	19.44
Other Oceania	13.97	-	30.98	4.32
Belgium	74.54	74.54	32.47	24.20
France	259.51	259.51	32.40	84.09
West Germany	537.08	537.08	32.45	174.28
Denmark	27.07	27.07	32.52	8.80
Italy	103.48	103.48	32.41	33.54
Netherlands	37.67	37.67	32.42	12.21
United Kingdom	304.69	304.69	32.42	98.78
Ireland	15.67	15.67	32.47	5.09
NSFI	65.41	65.41	32.48	21.24
Spain and Portugal	117.74	117.74	32.33	38.06

Appendix C Table 6. (continued)

Country (region)	Consumption	Imports	Prices	Expenditures
	(millions of pounds)		(cents/pound)	(millions of dollars)
Austria and Switzerland	97.07	97.07	32.41	31.46
Eastern Europe 1	129.56	129.56	32.48	42.08
Eastern Europe 2	152.38	152.38	32.48	49.50
Soviet Union	389.22	389.22	32.51	126.54
Total	4,103.77	3,706.37		1,328.30

Appendix C Table 7. Trade pattern for cocoa beans in 1980, Model 2

Supply region	Consuming region	Shipments (millions of pounds)
Ghana	Ghana	2.32
	Other Africa No Prod.	7.07
	United States	49.06
	Belgium	62.49
	West Germany	580.18
	Denmark	36.31
	Italy	16.25
	Netherlands	109.19
	United Kingdom	296.42
	Ireland	15.24
	NSFI	63.65
	Spain and Portugal	114.56
	Austria and Switzerland	94.42
	Eastern Europe 1	126.03
Nigeria	Nigeria	2.32
	United States	720.57
Ivory Coast	Ivory Coast	1.18
	France	275.53
	Italy	86.90
	Eastern Europe 2	148.24
	Soviet Union	48.28
Cameroon	Cameroon	1.18
	Soviet Union	281.99
Other Africa Production	Other Africa Production	1.18
	Canada	112.18
	Japan	12.48
	Other Asia	46.06
	Soviet Union	48.43
Brazil	Brazil	95.20
	United States	242.06
	Other America	42.86
Ecuador	Ecuador	22.63
	Japan	131.69
Venezuela	Venezuela	40.70
	United States	14.42
Mexico	Mexico	49.51
	Japan	7.81

Appendix C Table 7 (continued)

Supply region	Consuming region	Shipments (millions of pounds)
Dominican Republic	Dominican Republic	8.99
	United States	74.78
Other America	Other America	112.43
Other Asia	Other Asia	39.68
Other Oceania	Other Oceania	13.60
	Australia	56.46
	Japan	9.31

Appendix C Table 8. Equilibrium values of consumption, imports, prices, and expenditures, free trade Model 2, 1980

Country (region)	Consumption	Imports	Prices	Expenditures
	(millions of pounds)		(cents/pound)	(millions of dollars)
Ghana	2.32	-	32.36	0.75
Nigeria	2.32	-	32.35	0.75
Ivory Coast	1.18	-	32.37	0.38
Cameroon	1.18	-	32.30	0.38
Other Africa Production	1.18	-	32.30	0.38
Other Africa No Production	7.07	7.07	34.27	2.42
Brazil	95.20	-	32.43	30.87
Ecuador	22.63	-	32.55	7.37
Venezuela	40.70	-	32.62	13.28
Mexico	49.51	-	32.65	16.17
Dominican Republic	8.99	-	32.66	2.93
United States	1,100.90	1,100.90	34.39	378.65
Canada	112.18	112.18	34.41	38.60
Other America	155.29	42.86	34.20	53.11
Japan	161.29	161.29	34.89	56.27
Other Asia	85.74	46.06	34.62	29.69
Australia	56.46	56.46	34.68	19.58
Other Oceania	13.60	-	32.92	4.48
Belgium	62.49	62.49	34.37	21.48
France	275.53	275.53	34.31	94.53
West Germany	580.18	580.18	34.35	199.30
Denmark	36.31	36.31	34.45	12.51
Italy	103.15	103.15	34.39	35.47
Netherlands	109.19	109.19	34.33	37.49
United Kingdom	296.42	296.42	34.32	101.74
Ireland	15.24	15.24	34.37	5.24
NSFI	63.65	63.65	34.38	21.88
Spain and Portugal	114.56	114.56	34.23	39.22

Appendix C Table 8 (continued)

Country (region)	Consumption	Imports	Prices	Expenditures
	(millions of pounds)		(cents/pound)	(millions of dollars)
Austria and Switzerland	94.42	94.42	34.32	32.40
Eastern Europe 1	126.03	126.03	34.39	43.33
Eastern Europe 2	148.24	148.24	34.39	50.98
Soviet Union	378.69	378.69	34.41	130.29
Total	4,321.82	3,930.92		1,481.90

Appendix C Table 9. Trade pattern for cocoa beans in 1980, Model 3

Supply region	Consuming region	Shipments (millions of pounds)
Ghana	Ghana	2.34
	Ivory Coast	1.17
	Other Africa No Prod.	7.13
	United States	133.99
	Canada	113.04
	Belgium	6.16
	Denmark	36.33
	United Kingdom	298.72
	Ireland	15.37
	NSFI	64.15
	Spain and Portugal	115.46
	Austria and Switzerland	94.12
	Eastern Europe 1	127.02
	Eastern Europe 2	149.42
	Soviet Union	381.66
Nigeria	Nigeria	2.34
	Cameroon	1.17
	Other Africa Production	1.17
	United States	647.75
	Japan	13.19
	Other Asia	46.63
Ivory Coast	Belgium	55.95
	France	272.91
	West Germany	47.23
	Italy	102.90
	Netherlands	106.04
Cameroon	West Germany	307.98
Other Africa Production	West Germany	220.46
Brazil	Brazil	95.93
	United States	234.17
	Other America	44.08
Ecuador	Ecuador	22.77
	Japan	131.55
Venezuela	Venezuela	41.01
	United States	14.11
Mexico	Mexico	49.82
	Japan	7.50

Appendix C Table 9 (continued)

Supply region	Consuming region	Shipments (millions of pounds)
Dominican Republic	Dominican Republic	9.06
	United States	74.71
Other America	Other America	112.43
Other Asia	Other Asia	39.68
Other Oceania	Japan	9.11
	Australia	56.57
	Other Oceania	13.67

Appendix C Table 10. Equilibrium values of consumption, imports, prices and expenditures, free trade Model 3, 1980

Country (region)	Consumption	Imports	Prices	Expenditures
	(millions of pounds)		(cents/pound)	(millions of dollars)
Ghana	2.38	-	31.82	0.74
Nigeria	2.34	-	31.81	0.74
Ivory Coast	1.17	1.17	33.45	0.39
Cameroon	1.17	1.17	33.46	0.39
Other Africa Production	1.17	1.17	33.46	0.39
Other Africa No Production	7.13	7.13	33.73	2.40
Brazil	95.93	-	31.89	30.59
Ecuador	22.77	-	32.11	7.31
Venezuela	41.01	-	32.09	13.16
Mexico	49.82	-	32.21	16.05
Dominican Republic	9.06	-	32.12	2.91
United States	1,104.73	1,104.73	33.86	374.04
Canada	113.04	113.04	33.89	38.31
Other America	156.51	44.08	33.67	52.69
Japan	161.36	161.36	34.44	55.58
Other Asia	86.31	46.63	34.18	29.50
Australia	56.57	56.57	34.24	19.37
Other Oceania	13.69	-	32.48	4.45
Belgium	62.11	62.11	35.82	22.25
France	272.91	272.91	35.80	97.70
West Germany	575.67	575.67	35.84	206.31
Denmark	36.33	36.33	33.84	12.29
Italy	102.90	102.90	35.81	36.84
Netherlands	106.04	106.04	35.81	37.97
United Kingdom	298.72	298.72	33.80	100.95
Ireland	15.37	15.37	33.79	5.19
NSFI	64.15	64.15	33.84	21.71
Spain and Portugal	115.46	115.46	33.69	38.90

Appendix C Table 10 (continued)

Country (region)	Consumption	Imports	Prices	Expenditures
	(millions of pounds)		(cents/pound)	(millions of dollars)
Austria and Switzerland	94.12	94.12	33.78	31.79
Eastern Europe 1	127.02	127.02	33.85	42.99
Eastern Europe 2	149.42	149.42	33.85	50.58
Soviet Union	381.66	381.66	33.87	129.27
Total	4,327.96	3,938.93		1,483.77

Appendix C Table 11. Trade pattern for cocoa beans in 1980, Model 4

Supply region	Consuming region	Shipments (millions of pounds)
Ghana	Ghana	2.32
	Other Africa No Prod.	7.07
	United States	49.76
	Belgium	62.50
	France	85.38
	West Germany	580.22
	Denmark	36.31
	Italy	103.15
	United Kingdom	296.49
	Ireland	15.24
	Spain and Portugal	114.59
	Austria and Switzerland	93.37
	Eastern Europe 1	126.06
Nigeria	Nigeria	2.32
	United States	720.28
Ivory Coast	Ivory Coast	1.18
	France	190.17
	Netherlands	109.24
	NSFI	63.66
	Eastern Europe 2	148.28
	Soviet Union	47.42
Cameroon	Cameroon	1.18
	Soviet Union	281.78
Other Africa Production	Other Africa Production	1.18
	Canada	112.21
	Japan	11.25
	Other Asia	46.08
	Soviet Union	49.59
Brazil	Brazil	95.24
	United States	241.75
	Other America	42.92
Ecuador	Ecuador	22.64
	Japan	131.68
Venezuela	Venezuela	40.70
	United States	14.42
Mexico	Mexico	49.52
	Japan	7.80

Appendix C Table 11 (continued)

Supply region	Consuming region	Shipments
		(millions of pounds)
Dominican Republic	Dominican Republic	8.99
	United States	74.78
Other America	Other America	112.43
Other Asia	Other Asia	39.68
Other Oceania	Japan	9.30
	Australia	56.46
	Other Oceania	13.61

Appendix C Table 12. Equilibrium values of consumption, imports, prices, and expenditures, free trade Model 4, 1980

Country (region)	Consumption	Imports	Prices	Expenditures
	(millions of pounds)		(cents/pound)	(millions of dollars)
Ghana	2.32	-	32.35	0.75
Nigeria	2.32	-	32.34	0.75
Ivory Coast	1.18	-	32.36	0.38
Cameroon	1.18	-	32.28	0.38
Other Africa Production	1.18	-	32.28	0.38
Other Africa No Production	7.07	7.07	34.25	2.42
Brazil	95.24	-	32.41	30.86
Ecuador	22.64	-	32.53	7.36
Venezuela	40.70	-	32.62	13.28
Mexico	49.52	-	32.63	16.16
Dominican Republic	8.99	-	32.64	2.93
United States	1,100.98	1,100.98	34.38	378.55
Canada	112.21	112.21	34.39	38.59
Other America	155.35	42.92	34.18	53.09
Japan	160.02	160.02	34.87	55.80
Other Asia	85.76	46.08	34.61	29.68
Australia	56.46	56.46	34.66	19.57
Other Oceania	13.61	-	32.90	4.48
Belgium	62.50	62.50	34.35	21.47
France	275.55	275.55	34.30	94.50
West Germany	580.22	580.22	34.34	199.23
Denmark	36.31	36.31	34.43	12.50
Italy	103.15	103.15	34.37	35.45
Netherlands	109.24	109.24	34.31	37.48
United Kingdom	296.49	296.49	34.31	101.72
Ireland	15.24	15.24	34.36	5.24
NSFI	63.66	63.66	34.37	21.88
Spain and Portugal	114.59	114.59	34.21	39.21

Appendix C Table 12 (continued)

Country (region)	Consumption	Imports	Prices	Expenditures
	(millions of pounds)		(cents/pound)	(millions of dollars)
Austria and Switzerland	93.37	93.37	34.30	32.02
Eastern Europe 1	126.06	126.06	34.37	43.32
Eastern Europe 2	148.28	148.28	34.37	50.97
Soviet Union	378.78	378.78	34.39	130.26
Total	4,320.15	3,929.18		1,480.67

Appendix C Table 13. Trade pattern for cocoa beans in 1980, Model 6

Supply region	Consuming region	Shipments
		(millions of pounds)
Ghana	Ghana	1.08
	Other Africa No Prod.	2.93
	United States	68.63
	Belgium	51.74
	France	49.80
	West Germany	454.69
	Denmark	30.52
	Ireland	5.73
	Spain and Portugal	45.55
	Austria and Switzerland	36.92
	Eastern Europe 1	49.35
	Eastern Europe 2	58.23
Nigeria	Nigeria	1.08
	United States	391.87
Ivory Coast	Ivory Coast	0.76
	France	70.15
	Italy	96.11
	Netherlands	21.08
	United Kingdom	116.36
Cameroon	Cameroon	0.76
	France	82.93
	NSFI	25.31
	Soviet Union	44.92
Other Africa Production	Other Africa Production	0.76
	Canada	44.29
	Other Asia	5.53
	Soviet Union	103.73
Brazil	Brazil	39.26
	United States	167.37
Ecuador	Ecuador	9.43
	United States	66.21
	Japan	32.38
Venezuela	Venezuela	16.62
	United States	21.96
Mexico	Mexico	20.14
	United States	19.98

Appendix C Table 13 (continued)

Supply region	Consuming region	Shipments (millions of pounds)
Dominican Republic	Dominican Republic	3.60
	United States	55.04
Other America	United States	14.03
	Other America	64.67
Other Asia	Other Asia	27.78
Other Oceania	Japan	3.68
	Australia	46.13
	Other Oceania	5.75

Appendix C Table 14. Equilibrium values of consumption, imports, prices, and expenditures, free trade Model 6, 1980

Country (region)	Consumption	Imports	Prices	Expenditures
	(millions of pounds)		(cents/pound)	(millions of dollars)
Ghana	1.08	-	73.78	0.79
Nigeria	1.08	-	73.76	0.79
Ivory Coast	0.76	-	73.79	0.56
Cameroon	0.76	-	73.71	0.56
Other Africa Production	0.76	-	73.72	0.56
Other Africa No Production	2.93	2.93	75.69	2.22
Brazil	39.26	-	73.83	28.99
Ecuador	9.43	-	73.87	6.96
Venezuela	16.62	-	74.03	12.30
Mexico	20.14	-	74.07	14.91
Dominican Republic	3.60	-	74.07	2.67
United States	805.09	805.09	75.81	610.32
Canada	44.29	44.29	75.83	33.58
Other America	64.67	-	74.08	47.90
Japan	36.07	36.07	76.21	27.49
Other Asia	33.31	5.53	76.05	25.33
Australia	46.13	46.13	76.01	35.06
Other Oceania	5.75	-	74.24	4.27
Belgium	51.74	51.74	75.74	39.19
France	202.88	202.88	75.72	153.62
West Germany	454.69	454.69	75.76	344.49
Denmark	30.52	30.52	75.78	23.13
Italy	96.11	96.11	75.73	72.79
Netherlands	21.08	21.08	75.74	15.97
United Kingdom	116.36	116.36	75.74	88.13
Ireland	5.73	5.73	75.74	4.34
NSFI	25.31	25.31	75.78	19.18
Spain and Portugal	45.55	45.55	75.64	34.45

Appendix C Table 14 (continued)

Country (region)	Consumption	Imports	Prices	Expenditures
	(millions of pounds)		(cents/pound)	(millions of dollars)
Austria and Switzerland	36.92	36.92	75.72	27.96
Eastern Europe 1	49.35	49.35	75.79	37.40
Eastern Europe 2	58.23	58.23	75.80	44.13
Soviet Union	148.66	148.66	75.81	112.70
Total	2,474.86	2,283.17		1,872.75

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