Analysis of the World Cocoa Market

Takamasa Akiyama and Ronald C. Duncan

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The World Bank
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This paper reports the results from a new world cocoa model constructed to project consumption, output and price over the next decade. The projections are based on econometric analysis of cocoa demand and production in major consuming and producing countries and regions. The concentration of consumption of cocoa and cocoa products within the industrial countries, with their expected low population and income growth and low elasticities of income and price, points to a continuation of the slow growth in consumption. Production capacity was stimulated by the high prices prevailing in 1976 and 1977 and the sharp increase in output has depressed prices; until the growth in output is dampened by the low prices now being experienced there will be a further downwards pressure on prices. The model predicts that the phase of low prices will continue until the late 1980s, when some recovery will take place. Simulations of the model were carried out to show the susceptibility of cocoa prices and export revenues to increases in production at rates faster than the growth in demand resulting from population and income increases. Other simulations analysed the market impact of the recently adopted Buffer Stock Scheme.
PREFACE

This paper describes an econometric model of the world cocoa economy. The model was constructed for use in the analysis of trends in the world cocoa market and for the forecasting of prices, consumption, production and trade—the basic function of the Division. The paper was also intended to serve as background for the Bank's discussion on lending for cocoa projects. Hence, there is an emphasis in the paper on production and on the impact of different rates of growth in production on prices and export revenues of cocoa exporting countries.

Much of the work on the original specification and estimation of the model was done by Dr. K.B. Mehta who was working under contract to the Bank on behalf of the firm Primary Commodity Research Ltd., of London, U.K.

The authors wish to thank all those who contributed by their comments and the supply of data or of estimates of future production. Many of the Projects and Regional Staff of the Bank responded most helpfully in these various ways. The staff of the International Cocoa Organization was also most responsive to our inquiries.

We are grateful to Enzo Grilli for his guidance and assistance in the project, to Sompheap Sem, Fataneh Semsarzadeh and Godwill Ukpong for research assistance and to Joan McAdam and Barbara Thompson for their patience and skill in typing the various drafts of this manuscript.
TABLE OF CONTENTS

PREFACE .......................................................................................................................... v
LIST OF TABLES .................................................................................................................. vii
LIST OF FIGURES ............................................................................................................... viii
SUMMARY AND CONCLUSIONS ..................................................................................... ix

I. RECENT TRENDS IN THE WORLD COCOA MARKET .................................................. 1
   A. Production and Exports ......................................................................................... 1
   B. Consumption and Imports .................................................................................. 7
   C. Price and Stocks .................................................................................................. 8

II. AN ECONOMETRIC MODEL FOR THE WORLD COCOA ECONOMY ....................... 13
   A. The Demand Block of the Model ........................................................................ 13
   B. The Supply Block of the Model .......................................................................... 15
   C. Prices and Stocks in the Model .......................................................................... 19

III. SIMULATION RESULTS OF THE ECONOMETRIC MODEL ..................................... 20
   A. Projections of the Cocoa Market up to 1990 .................................................... 20
   B. Effects of Production Changes on World Prices and Revenues ...................... 31
   C. Simulation Results on Revenues when Production is Increased
      for Some Individual Countries ............................................................................. 35

IV. THE NEW INTERNATIONAL COCOA AGREEMENT AND ITS IMPLICATIONS FOR
    BANK LENDING ......................................................................................................... 38
   A. Background to the Present Agreement .............................................................. 38
   B. Main Features of the Agreement ....................................................................... 40
   C. Implications for Lending .................................................................................... 40

Annex I: Structure and Estimated Equations of the New Econometric Model of the World Cocoa Economy ............................................................ 43
Annex II: Data Used in Estimating Demand Elasticities ........................................... 56
Annex III: Distributing of Votes in the International Cocoa Council ...................... 58
Annex IV: Consumption of Cocoa, by Major Regions ............................................. 59
# LIST OF TABLES

<table>
<thead>
<tr>
<th>Table</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>World Production by Main Countries</td>
<td>2</td>
</tr>
<tr>
<td>2</td>
<td>Trends in Real Producer Prices in Major Producing Countries</td>
<td>5</td>
</tr>
<tr>
<td>3</td>
<td>Net Export of Cocoa Beans and Processed Cocoa by Major Producing Countries</td>
<td>6</td>
</tr>
<tr>
<td>4</td>
<td>Total Imports of Beans and Processed Cocoa</td>
<td>9</td>
</tr>
<tr>
<td>5</td>
<td>Apparent World Cocoa Consumption, by Main Regions</td>
<td>10</td>
</tr>
<tr>
<td>6</td>
<td>Supply, Demand, Stocks and Prices of Cocoa 1950/51-1980/81</td>
<td>11</td>
</tr>
<tr>
<td>7</td>
<td>Income and Price Elasticities of Demand for Cocoa</td>
<td>14</td>
</tr>
<tr>
<td>8</td>
<td>Income and Price Elasticities of Demand Estimated by the ICCO for Some Major Consuming Countries</td>
<td>14</td>
</tr>
<tr>
<td>9</td>
<td>Price Elasticities of Cocoa Supply with Respect to Producer Price</td>
<td>18</td>
</tr>
<tr>
<td>10</td>
<td>Elasticities of Cocoa Average Response with Respect to Producer Price</td>
<td>18</td>
</tr>
<tr>
<td>11</td>
<td>Estimated Buffer Stock Purchases and Sales and Three-Months Cocoa Futures Prices</td>
<td>21</td>
</tr>
<tr>
<td>12</td>
<td>Results of Main Variables of Simulations</td>
<td>22</td>
</tr>
<tr>
<td>13</td>
<td>Projections of World Cocoa Market With High and Low Income Growth Scenarios</td>
<td>32</td>
</tr>
<tr>
<td>14</td>
<td>Results of Simulations Using Independently Projected Cocoa Supply</td>
<td>33</td>
</tr>
<tr>
<td>15</td>
<td>Simulation Results when Production was Increased by 100,000 Tons in the Ivory Coast and Ghana in 1983-1990</td>
<td>37</td>
</tr>
<tr>
<td>Figure</td>
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</tr>
<tr>
<td>--------</td>
<td>-----------------------------------------------------------------------------------------------</td>
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<tr>
<td>1</td>
<td>World Cocoa Production and Grindings</td>
<td>3</td>
</tr>
<tr>
<td>2</td>
<td>Real World Cocoa Prices and Stocks</td>
<td>12</td>
</tr>
<tr>
<td>3</td>
<td>Projections of Real Cocoa Prices: Base Run</td>
<td>23</td>
</tr>
<tr>
<td>4</td>
<td>Projections of Current Three-Months' Cocoa Future Prices: Base Run</td>
<td>24</td>
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<td>25</td>
</tr>
<tr>
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<td>26</td>
</tr>
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<td>27</td>
</tr>
<tr>
<td>8</td>
<td>Actual and Projected Cocoa Consumption in North America: Base Run</td>
<td>28</td>
</tr>
<tr>
<td>9</td>
<td>Actual and Projected Cocoa Consumption in West Europe: Base Run</td>
<td>29</td>
</tr>
<tr>
<td>10</td>
<td>Actual and Projected Cocoa Consumption in Centrally Planned Economies: Base Run</td>
<td>30</td>
</tr>
<tr>
<td>11</td>
<td>Projections of Real World Cocoa Prices Under Different Supply Scenarios</td>
<td>34</td>
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SUMMARY AND CONCLUSIONS

1. This paper presents an analysis of the world cocoa market with emphasis on its future prospects. It was intended to serve as a background to the policy paper on Bank lending for tropical beverages. The paper expands the analysis contained in the memorandum of June 2, 1981 on the "Medium-Term Outlook of the World Cocoa Market" and examines the implications of the International Cocoa Agreement, which came into force on August 1, 1981, for Bank lending as well as for the prospects of the world cocoa market itself.

2. Because of low price elasticities of demand and supply and relatively long adjustment lags, world cocoa production and prices have moved in a cyclical manner—several years of high prices and low production growth rate are followed by sharply declining prices and increasing production. The high world cocoa prices and stagnant world production which prevailed in the mid to late 1970s, have caused a new phase of low prices and increasing production beginning around 1980. Econometric model simulation results indicate that the phase of low real prices will continue until the late 1980s, when some recovery will take place. If producing countries continue to increase cocoa production in the early to mid-1980s at rates faster than projected with the model, world cocoa prices in real terms can be expected to decline even faster than the current projected levels. To reach and maintain a balance with world demand it is estimated that supply should not grow faster than about 2% per annum throughout the next decade. Incorporation of supply projections made independently by Bank staff for the major cocoa producing countries result in a decrease in total world revenue (in real terms) of from 6 percent to 36 percent by 1990, by comparison with the supply responses generated within the model.

3. Model simulation exercises conducted to evaluate the effect of large increments in production in some large producing countries (such as may be expected from large cocoa projects), on the revenues of these countries, show that, as expected, the incremental revenue is lower the higher the market share of the country in the world cocoa production. Also, since the global elasticity of demand is low, i.e. -0.16 in the short term and -0.30 in the long term, substantial increases in production in any large producing country will cause sharp declines in the total world revenue from cocoa.

4. A new factor in the world cocoa market is the International Cocoa Agreement which came into effect on August 1, 1981. The Agreement has a buffer stock scheme aimed at reducing price fluctuations. Simulations performed to test the impact of the operation of the buffer stock indicate that the buffer stock operation, given the maximum allowable stocking of 250,000 tons, can maintain market prices in the short-term within the present price range of 110c-150c/lb. In the medium to long term, however, such success of the buffer stock operation is possible only when long term supply and demand are in reasonable balance, since a buffer stock operation cannot per se alter the long term fundamentals of any market. It should be noted, moreover, that even the maintenance of the current nominal price range for the next three years through the operation of the buffer stock implies declining cocoa prices in real terms. In these circumstances of precarious short-term market balance and unfavorable longer term market prospects, any Bank lending that will result in an acceleration of the world production growth beyond a norm of about 2% per annum will worsen the long-term balance between supply and demand, reduce total revenue to producers (in real terms), and will damage the market price stabilization prospects of the newly negotiated international Agreement.
I. RECENT TRENDS IN THE WORLD COCOA MARKET

1. Cocoa beans are produced only in the developing countries of the tropics. Traditional varieties of cocoa trees start producing cocoa beans about five years after they are planted. The hybrid variety, which has been increasingly planted since the early 1970s, has a gestation period of about 3 years. Yields increase with time and reach a peak at around year 11 for the traditional varieties and at around year 7 for hybrid varieties. With proper maintenance yields do not decline for up to 20 to 25 years.

2. After harvesting, cocoa beans are fermented and dried. Beans are then ground followed by further processing into cocoa liquor, cake, butter and powder. Cocoa is consumed in the form of chocolate, cocoa drinks and other confectionaries. Most of the cocoa produced in developing countries is exported to industrialized and centrally planned economies either as beans or in one of the processed forms.

A. Production and Exports

3. World cocoa production since World War II shows a cyclical behavior (see Table 1 and Figures 1 and 2) which consists of 7 to 11 years of increasing production and declining real prices followed by stagnant production and increasing real prices. Stagnant production until 1957 was followed by sharp increases during the period 1957-64. World production stagnated after 1964 until the late 1970s. The high level of world production reached in 1964/65 of 1,508,000 tons was not surpassed until 1972/73. With increasing real prices in the late 1970s, world production started increasing again in 1979 and reached record production levels of 1,620,000 and 1,638,000 tons in 1979/80 and 1980/81 respectively. A brief description of the sources of production cycles that have occurred in the post World War II period, i.e., 1946-57, 1957-64, 1964-76 and 1976 to date, is useful to put into perspective the current problem:

(i) Period 1946-57. In this period world production was recovering from the low levels of the World War II era. The moderate growth of world output--2.6% per annum--that occurred during this period was determined by the large increases that occurred in Brazil and Cameroon, while supply in the two largest producing countries of the time, Ghana and Nigeria, stagnated.

(ii) Period 1957-64. Due to the high real prices which prevailed until the late 1950s (see Figure 2), 1/ world production increased during this period at a very high rate of 7.8% per annum, with all the large producers, except Brazil, contributing to it. During this period Ivory Coast, Ghana and Nigeria increased their production at the very rapid rate of 13-15% per annum.

(iii) Period 1964-76. In this period production of the world's two largest producers, Ghana and Nigeria, declined at an average

1/ The deflator used to compute real prices is the Bank's IPI.
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<td>354</td>
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<td>-6.6</td>
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<td>9.7*</td>
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<td>31</td>
<td>48</td>
<td>61</td>
<td>72</td>
<td>90</td>
<td>98</td>
<td>82</td>
<td>6.4*</td>
<td>4.3*</td>
<td>3.7*</td>
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<tr>
<td>Ivory Coast</td>
<td>36</td>
<td>46</td>
<td>148</td>
<td>180</td>
<td>230</td>
<td>312</td>
<td>379</td>
<td>412</td>
<td>5.6*</td>
<td>15.9*</td>
<td>5.6*</td>
<td>13.4*</td>
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<tr>
<td>Ghana</td>
<td>195</td>
<td>210</td>
<td>566</td>
<td>392</td>
<td>320</td>
<td>250</td>
<td>280</td>
<td>258</td>
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<td>13.2*</td>
<td>-2.0*</td>
<td>-2.6</td>
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<tr>
<td>Nigeria</td>
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<td>82</td>
<td>298</td>
<td>308</td>
<td>165</td>
<td>137</td>
<td>169</td>
<td>155</td>
<td>0.4</td>
<td>14.8</td>
<td>-1.8</td>
<td>3.9</td>
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<tr>
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<td>65</td>
<td>91</td>
<td>112</td>
<td>82</td>
<td>106</td>
<td>124</td>
<td>118</td>
<td>4.4*</td>
<td>5.7*</td>
<td>1.3</td>
<td>7.9</td>
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</tr>
<tr>
<td>Others</td>
<td>66</td>
<td>134</td>
<td>188</td>
<td>218</td>
<td>177</td>
<td>207</td>
<td>215</td>
<td>215</td>
<td>4.9*</td>
<td>4.3*</td>
<td>0.1</td>
<td>4.7*</td>
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</tr>
<tr>
<td>World</td>
<td>623</td>
<td>786</td>
<td>1,508</td>
<td>1,499</td>
<td>1,339</td>
<td>1,480</td>
<td>1,616</td>
<td>1,654</td>
<td>2.6*</td>
<td>7.8*</td>
<td>0.8</td>
<td>4.9*</td>
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* Significant at 95% level.

/ a Growth rates were calculated by regression analysis.

Figure 1: WORLD COCOA PRODUCTION AND GRINDINGS

('000 mt)
annual rate of 2% and 1.8% respectively. Output in Brazil and Ivory Coast rose sharply, but not fast enough to compensate for the decline in the other two major producers. World production in 1976/77 was in fact 11% lower than in 1964/65.

(iv) Period 1976-1982 Production in Ghana and Nigeria declined again during this period, but this decline was more than compensated by production increases in Brazil and Ivory Coast, which increased output at rates of 9.7% and 13.4% respectively. This resulted in a world production growth rate of 4.9% per annum. This rapid growth was the result of new plantings that took place mainly in Brazil, Ivory Coast and Malaysia in response to the high prices in the early and mid-1970s.

4. World cocoa production is concentrated in a few countries. Brazil, Ivory Coast, Ghana, Nigeria and Cameroon accounted for about 77% of total world production in 1979/80. Production growth rates in the past in these countries differed significantly. As a result of these differences, Ghana and Nigeria—the two largest producers of cocoa in 1970/71, with world production shares of 26% and 21% respectively—held only 16% and 9% of the total by 1980/81, while Brazil and Ivory Coast increased their shares from 12% to 22% and 12% to 24% respectively during the same period.

5. The divergence observed in the production growth rates of the major cocoa producing countries was mainly due to differences in movements of real producer prices. Real producer prices which affect critically the profitability of production, are the main determinant of output growth. This is clearly shown by our analysis of production responses in the various countries, as well as by earlier analysis. Although producer prices in general follow world market prices, 1/ different exchange rate movements and inflation rates in the various producing countries have yielded different real producer prices.

1/ The relationships between producer prices and the world price is given below.

Brazil: (1967-78) log PP = -1.776+1.190 log PI  $R^2 = 0.99$
(31.9)

Cameroon: (1963-78) log PP = 0.943+0.514 log PI  $R^2 = 0.78$
(7.3)

Ghana: (1967-78) log PP = 0.135+0.748 log PI  $R^2 = 0.89$
(9.6)

Ivory Coast: (1962-78) log PP = 0.653+0.609 log PI  $R^2 = 0.80$
(8.0)

Nigeria: (1969-78) log PP = 0.357+0.748 log PI  $R^2 = 0.76$
(5.4)

Where: PP = Producer price in terms of US dollars.
PI = Average of daily prices, New York/London (3 months futures)
US$/lb.
prices. Government policies have also influenced the behavior of producer prices and returns in those countries where domestic prices were controlled by the national authorities and input prices and credit costs were manipulated to influence production. Table 2 show the trends in real producer prices in major cocoa producing countries.

Table 2: TRENDS IN REAL PRODUCER PRICES /a IN MAJOR PRODUCING COUNTRIES

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<tr>
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<tbody>
<tr>
<td>Brazil</td>
<td>5.6</td>
<td>-0.8</td>
<td>14.1</td>
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<tr>
<td>Ivory Coast</td>
<td>-0.1</td>
<td>-4.8</td>
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<td>Cameroon</td>
<td>-2.3</td>
<td>-3.6</td>
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<tr>
<td>World/b</td>
<td>4.4</td>
<td>2.5</td>
<td>8.6</td>
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/a Producer prices deflated by the consumer price indexes of the various countries.

/b US import unit values deflated by the Manufactured Exports Unit Value (MUV).

Source: International Cocoa Organization (ICCO).

6. Declining production in Ghana and Nigeria in the 1960s and 1970s appears to have been the result of declining real producer prices. In these countries, stagnating or declining real producer prices were the consequence of high domestic inflation rates and of over-valued currencies. In Ivory Coast and Brazil, recovery of production in the 1970s appears to have been influenced by the positive trend of real producer prices. In addition, various kinds of subsidies were extended to producers by governments. In Cameroon production increased in spite of negative real producer price trends, due to Government-sponsored hybrid plantings which increased yields significantly.

7. Consumption of cocoa is very low in producing countries and thus most of the cocoa produced is exported, either in bean or processed form. As with production, exports of beans and cocoa products increased sharply in Brazil and Ivory Coast in recent years, while those of Nigeria and Ghana declined. In recent years, an increasing quantity of cocoa beans has been ground in producing countries. This trend, shown in Table 3, 1/ is the result of the increasing advantages that cocoa producing countries have in the processing of cocoa, relative to the industrialized countries. Rising labor costs in the latter countries have made it profitable for large confectionary firms to process

1/ At the time of writing this paper, cocoa product trade data were available from FAO trade tapes only up to 1978.
Table 3: NET EXPORT OF COCOA BEANS AND PROCESSED COCOA BY MAJOR PRODUCING COUNTRIES

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<td>80</td>
<td>85</td>
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<td>76</td>
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/a Calculated by regression
/b Implies no significant trend.

Sources: FAO, Production and Trade Yearbook, (various issues); Gill and Duffus Group Ltd., London.
cocoa in producing countries. 1/ Other factors which have contributed to this trend have been the incentives provided by producing governments for domestic processing of cocoa, as in Brazil and Ecuador, 2/ and the lowering of protection against cocoa products by the European Community under the Lomé Convention and by the US under GSP and MTN arrangements.

B. Consumption and Imports

8. In a number of past studies on cocoa demand, grindings were used as a proxy for consumption. This approach was taken because of the difficulty encountered in taking into account cocoa products trade. Because of the scarcity of information on trade and the complexity in handling the available data, cocoa demand was studied by taking grindings as an indicator of consumption. This procedure did not introduce serious biases in the estimation of demand functions at the country or regional level while trade in cocoa products remained a relatively minor factor. With its growth, however, grindings data became at the regional or country level a less and less reliable indicator of consumption. 3/ In this study an effort was made to proxy apparent consumption by taking grindings, plus the net imports of cocoa products (i.e. cocoa butter, cocoa powder, cocoa paste and cake). 4/

9. Even better apparent cocoa consumption data could be derived by taking chocolate trade and cocoa product stocks into account, but neither data are available over a sufficiently long time period. Chocolate trade data include all products, ranging from bulk chocolate to cakes with thin chocolate covering. The cocoa content of these products is, therefore, extremely difficult to determine with any sufficient degree of precision. However, given the limited intercontinental trade in chocolate products, consumption computed for regional aggregates of countries without taking into account trade in chocolate products should nevertheless come close to actual consumption. 5/ Despite its limitations, the way of calculating apparent consumption adopted here is much superior to simply taking grindings data, especially when consumption is examined at the regional level. In fact the data that we computed, compare well with those for the U.S. and Western Europe reported in a recent ICCO study where a great effort was made to provide, for a limited number of years, consumption data that included chocolate product trade. 6/


3/ At the world level, total grindings and total consumption are obviously the same.

4/ FAO Trade tapes from which trade data were derived, do not cover trade of cocoa liquor for Brazil. Exports of Brazilian cocoa liquor from Gill and Duffus publications were utilized.

5/ Except for changes in stocks, for which data is not available.

10. Major cocoa consuming regions are Western Europe, North America, the centrally planned economies of Eastern Europe and the USSR (Table 4). They together account for over 80% of world cocoa consumption. Consumption growth within Western Europe and North America has been stagnant for the last 10 years, while that of centrally planned economies (CPEs) showed a rapid increase until 1976, after which time it declined sharply, due to high prices that prevailed in the market. 1/ Cocoa consumption for these major consuming countries and regions has been graphed in semi-logarithmic scale in Annex IV to show these differing growth rates.

11. A notable trade trend that has emerged is the increasing importance of processed cocoa imports as opposed to cocoa beans (Table 4). While North America imported only 19% of all its cocoa in processed form in 1961, the corresponding figure in 1978 was 49%. Similarly Western Europe, which in 1961 imported only 16% of all its cocoa in processed form, has seen the share of processed cocoa doubling between 1961 and 1978.

12. In spite of sharp increases in cocoa product imports by all main consuming regions, the recent trend in total apparent consumption of cocoa is alarming (Table 5). For the period 1970-78 world consumption declined by 0.1 percent per annum. Stagnant world supply and ensuing high prices together with slow growth of the world economy since 1974 have largely determined this trend. In fact, world demand reached its peak in 1972/73 at 1,603 thousand metric tons; it declined to 1,371 thousand metric tons in 1978, to recover in 1980/81 to 1,541 thousand tons. When world supply increased and prices fell in 1980/81 and 1981/82, demand growth was hindered by unfavorable income conditions in the major consuming countries.

C. Price and Stocks

13. Because of the low price elasticity of world demand, cocoa prices tend to fluctuate widely in international markets in response to supply fluctuations. Because demand is relatively stable even in the face of wide fluctuations in prices, stocks fluctuate widely. The cyclical nature and the close correspondence between stock and price movements can be observed from Figure 2 and Table 6. The cycles coincide with those of production that were described above: in the 1946-57 period real prices and stocks fluctuated, but without any strong trend; in the 1957-64 period sharply increasing stocks were accompanied by a fall in real prices; and in 1964-76 period sharply declining stocks generated sharp increases in real prices; from 1976-to date increasing stocks have led again to declines in real prices.

---

1/ Even assuming that imports of cocoa are controlled in these countries by government authorities, higher prices tend to influence negatively availabilities to domestic consumers through the foreign exchange constraint faced by the planning authorities.
## Table 4: TOTAL IMPORTS OF BEANS AND PROCESSED COCOA

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/a Excluding Latin America.

Sources: FAO Production and Trade Yearbooks (various issues); Cocoa Statistics, Gill and Duffus Group Ltd., London.
Table 5: APPARENT WORLD COCOA CONSUMPTION, BY MAIN REGIONS

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/a World grindings do not necessarily equal regional totals due to the different sources of data used for grindings and cocoa product trade, i.e. grindings are from Gill & Duffus, Cocoa Statistics, while cocoa product data are from the FAO Trade tapes.

Source: FAO Production and Trade Yearbooks, (various issues); Cocoa Statistics, Gill and Duffus Group Ltd., London.
Table 6: SUPPLY, DEMAND, STOCKS AND PRICES OF COCOA 1950/51-1980/81

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<td>68</td>
</tr>
<tr>
<td>1976/77</td>
<td>1,339</td>
<td>1,326</td>
<td>1,738</td>
<td>1,423</td>
<td>315</td>
<td>-97</td>
<td>126</td>
</tr>
<tr>
<td>1977/78</td>
<td>1,503</td>
<td>1,488</td>
<td>1,803</td>
<td>1,371</td>
<td>432</td>
<td>+117</td>
<td>146</td>
</tr>
<tr>
<td>1978/79</td>
<td>1,480</td>
<td>1,465</td>
<td>1,897</td>
<td>1,425</td>
<td>472</td>
<td>+40</td>
<td>150</td>
</tr>
<tr>
<td>1979/80</td>
<td>1,620**</td>
<td>1,604**</td>
<td>2,076**</td>
<td>1,446**</td>
<td>630**</td>
<td>+158**</td>
<td>119</td>
</tr>
<tr>
<td>1980/81</td>
<td>1,638**</td>
<td>1,622**</td>
<td>2,252**</td>
<td>1,522**</td>
<td>730**</td>
<td>+100**</td>
<td>93</td>
</tr>
</tbody>
</table>

* World grindings exclude 5,000 tons of cocoa beans sold for non-traditional uses. These are deducted from stock.

** Estimated.

/a The net world crop is obtained by adjusting the gross world crop for one percent loss in weight.

/b Total availability represents opening stocks plus net world crop.

/c Deflated by Bank's MUV, 1978=100.

Figure 2: REAL WORLD COCOA PRICES and STOCKS

World stocks (see left scale)

Real cocoa prices (see right scale)

\(\text{U.S. Import unit value deflated by the Bank's IPI. (1978}=100\)

Source: Gill and Duffus.
II. AN ECONOMETRIC MODEL FOR THE WORLD COCOA ECONOMY

14. In order to evaluate the prospects of the world cocoa economy, and to understand better the economic characteristics of the market, an econometric model was built. Its components are described below. 1/ After testing it within the sample period of estimation, the model was simulated into the future on the basis of different assumptions concerning income growth. Alternative simulations were run incorporating exogenous supply projections coming from the Bank Staff. The model was also used to examine the impact of the operation of the ICCO Buffer Stock scheme on cocoa prices and production. These results are reported below.

A. The Demand Block of the Model

15. Income per capita and deflated world cocoa prices are the main variables used to explain the per capita consumption of six regions i.e. North America, Western Europe, other industrialized countries (Japan, South Africa, Australia, New Zealand), centrally planned economies of Eastern Europe and the USSR, Latin America and other developing countries. Income and price elasticities obtained from the demand equations are shown in Table 7.

16. Using 1978 consumption shares as weights, the price elasticity of world demand is estimated to be -0.16 in the short-term and -0.30 in the long-term. To check these estimates of the aggregate elasticities, another regression equation, specified in terms of total world grindings, world real GDP and current and one-year lagged deflated prices was estimated. The world income, short-term and long-term price elasticities obtained from this equation are 0.55, -0.20 and -0.24 respectively. The comparisons made with estimates obtained by other analysts who used similar definitions of consumption are encouraging. The short-term world price elasticity estimated here is similar to the short-term elasticity reported in the 1978 ICCO study. 2/ The aggregate long-term price elasticity is also close to that obtained by Behrman who used six-months' lagged price, 3/ and is only slightly lower than that obtained by Goreaux, who used one year lagged prices. 4/ As for the estimated regional price elasticities, they are of similar magnitude to those obtained by the ICCO in 1975 for several major consuming countries (see Table 8).

---

1/ The model includes 8 equations for supply, 6 equations for demand and a price equation. All but the supply equations were estimated using Ordinary Least Squares regression method. The supply equations were estimated using Zellner's method for seemingly unrelated regression equations.


Table 7: INCOME AND PRICE ELASTICITIES OF DEMAND FOR COCOA

<table>
<thead>
<tr>
<th></th>
<th>Price</th>
<th>Income</th>
<th>/a</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Current</td>
<td>Lagged</td>
<td>Total</td>
</tr>
<tr>
<td>North America</td>
<td>-0.120**</td>
<td>-0.107*</td>
<td>-0.227</td>
</tr>
<tr>
<td>Western Europe</td>
<td>-0.135**</td>
<td>-0.075*</td>
<td>-0.210</td>
</tr>
<tr>
<td>Other Industrialized Countries</td>
<td>-0.235**</td>
<td>-0.452**</td>
<td>-0.687</td>
</tr>
<tr>
<td>Centrally Planned Economies</td>
<td>-0.269**</td>
<td>-0.847</td>
<td>0.240/c</td>
</tr>
<tr>
<td>Latin America/b</td>
<td>-0.105*</td>
<td>-0.105</td>
<td>0.229*</td>
</tr>
<tr>
<td>Other Developing Countries</td>
<td>-0.333*</td>
<td>-0.197</td>
<td>0.530</td>
</tr>
</tbody>
</table>

** = Significant at 99% level
* = " 95% level.

/a The long-term income effect was found to be significant only for the Centrally Planned Economies.
/b The demand equation using consumption per capita did not produce good results. Results shown here are for total consumption.
/c Specification of the equation is such that the income elasticity declines with income. The figure given here is for year 1980.

Source: Economic Analysis and Projections Department.

Table 8: INCOME AND PRICE ELASTICITIES OF DEMAND ESTIMATED BY THE ICCO FOR SOME MAJOR CONSUMING COUNTRIES

<table>
<thead>
<tr>
<th>Country</th>
<th>Price Time Lag/a (Months)</th>
<th>Elasticities at 1973 Level</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Income</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1st Lag/a</td>
</tr>
<tr>
<td>Germany</td>
<td>6;18</td>
<td>0.37</td>
</tr>
<tr>
<td>France</td>
<td>9</td>
<td>0.47</td>
</tr>
<tr>
<td>Italy</td>
<td>6</td>
<td>0.55</td>
</tr>
<tr>
<td>Netherlands</td>
<td>6</td>
<td>0.23</td>
</tr>
<tr>
<td>Sweden</td>
<td>6</td>
<td>0.39</td>
</tr>
<tr>
<td>Switzerland</td>
<td>9</td>
<td>0.30</td>
</tr>
<tr>
<td>United Kingdom</td>
<td>6;18</td>
<td>0.32</td>
</tr>
<tr>
<td>United States</td>
<td>6</td>
<td>0.36</td>
</tr>
<tr>
<td>Japan</td>
<td>9;21</td>
<td>0.52</td>
</tr>
<tr>
<td>Australia</td>
<td>9;21</td>
<td>0.28</td>
</tr>
</tbody>
</table>

/a The ICCO indicator price, deflated by the CPI, was lagged differently for different countries. For example, in estimating German consumption, deflated prices with lags of 6 and 18 months are used while for France, a price with lag of 9 months is used.

Source: Excerpts from Appendix Table XIV, ICCO, Study of Cocoa Production and Consumption Capacity, August, 1975.
17. Beyond comparing results, a careful comparative analysis of these elasticities is difficult since the period of estimation, the types of consumption, income and price data used, and the specifications of the equations are different. The elasticity values obtained here are statistically sound. Noteworthy is that the price term in all equations is statistically significant. An interesting finding is that regions with high income have low price elasticities, compared to regions with lower income. The exception is Latin America, which is a major cocoa producing region. The estimated world elasticity implies that a 1% increase in supply will cause a decline in price of 6% in the short run and 3% in the long run.

18. Per capita income elasticities of demand are estimated to range between 0.11 and 1.54 for the various regions. The average world income elasticity, obtained by using 1978 consumption as weights, is 0.32 in the short run and 0.45 in the long run. This implies that if world per capita income increased by 10% uniformly over the regions, demand would increase by 3.2% in the short-run and 4.5% in the long-run. The income elasticity estimate for the world is of the same magnitude as obtained by the ICCO. Income elasticities obtained by Behrman for a number of industrialized countries are higher than those obtained here. Behrman's high elasticities are probably due to the time period his data covers i.e. 1947/48 through 1963/64, when the cocoa consumption level in many industrialized countries was until low but rising fast. A comparison of Tables 7 and 8 indicates that the regional income elasticities estimated here are very close to the ones estimated by the ICCO for various individual countries.

19. Apart from own prices and income, sugar prices were found to be a factor influencing cocoa consumption in some regions i.e., North America and developing countries other than Latin America. Increases in the price of sugar, considered to be a complement to cocoa products, have a negative impact on cocoa consumption.

20. Although not analyzed in the present study because of lack of data, the prices of substitutes such as vegetable fats and oils are considered to have an influence on cocoa consumption, since they tend to be used as cocoa butter substitutes when cocoa is scarce.

B. The Supply Block of the Model

21. In an attempt to evaluate the supply response to price in major cocoa producing countries, supply equations were estimated for Brazil, Ivory Coast, Cameroon, Ecuador, Papua New Guinea, Nigeria, Ghana and rest-of-world.

22. The production decision is viewed as a two-stage process: firstly as a decision about investment in tree stocks, and secondly a decision about the rate of production given a particular level of tree stocks.

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1/ See Annex 11.

23. Estimation of an area-of-trees equation is only possible for countries for which time-series data on acreage are available—Ivory Coast, Brazil, Cameroon, Ecuador and Papua New Guinea. Even for these countries, however, reliable time-series data only go back to the early to mid-1960s, so that effectively the sample of available data for each country covers little more than the experience of two production price cycles in the world cocoa economy.

24. To alleviate the constraint posed by the inadequate number of observations, area-of-trees equations were estimated by pooling time-series data, but allowing some coefficients to take country-specific values.

25. Lack of reliable long-term data on cocoa acreage for Ghana and Nigeria made it impractical to estimate area-of-trees equations for these countries. Available agricultural census data indicate that acreage in these countries has stayed virtually constant over the last 10 years. Prior to that, Ghanaian cocoa acreage fell during the early sixties as a result of the campaign to contain Swollen Shoot disease. Thus, for Nigeria and Ghana a pooled regression approach, explaining the change in production as a function of changes in the real cocoa price and the discrepancy between lagged and desired production, was adopted. Three other variables—the discrepancy between rainfall in the previous year and optimal rainfall, the ratio of neighboring country to domestic producer price (to take account of smuggling) and spraying to control Black Pod disease—were also included in the specification. For all the remaining countries the production of cocoa was related via a distributed lag to real cocoa producer prices, harvested acreage at the beginning of season, a rainfall variable (when available), and the relative importance of the high yielding hybrids in harvested acreage.

26. The area-of-trees equations for Ivory Coast, Brazil, Cameroon, Ecuador and Papua New Guinea are essentially of the same form. They specify the area response in terms of a distributed lag on 2-5 year lagged real cocoa producer prices, production lagged 30 years and the ratio of cocoa futures market price to producer price lagged 2 periods. In the absence of a long time series on acreage, production lagged 30 years was included to pick up the effect of the natural loss of acreage through aging. The ratio of cocoa futures price to producer price serves as a proxy for the effects of any grants or subsidies the government (which retains the excess of the market price over producer price) may make available to the cocoa sector.

27. The estimated price elasticities of supply in Table 9 are significantly lower than the elasticity of 0.39 obtained by Ady 1/ for Ghana, but of roughly the same magnitude as those estimated by Bateman 2/ for Ghana and Behrman 3/ for Ghana, Nigeria, Ivory Coast, Cameroon and Brazil, which ranged

---


between 0.06 and 0.18 in the short-run. In the model presented here prices begin to affect supply with a 1 year lag, while in the Bateman model between 8 and 12 years elapse before the price feeds back. Furthermore, in the model presented here the price effect is distributed over several periods, while in the Bateman model the lag distribution is concentrated at years 8 and 12. There seems to be little theoretical justification for constraining the lag distribution in the Bateman fashion. In fact the cost of this constraint shows up in the standard error of regression of the estimates, which is of the order of 0.11, while in the model presented here it is of the order of 0.06. The long-run price elasticities that were obtained are in the neighborhood of 0.6. They are lower than those obtained by Behrman, although the differences in the data samples used make precise comparison difficult.

28. The price elasticities of acreage change are generally much higher (in the neighborhood of 0.9), in the long-run, which in the case of cocoa can be taken as 15-20 years.

29. As can be seen from Tables 9 and 10, short-run elasticities of both acreage and production response are fairly small. The exceptions are Ghana and Ivory Coast, but in these cases the interpretation of the elasticities is different from the norm. In these two countries, in fact, supply responds both to changes in domestic producer prices as well as to the change in the neighboring country’s producer price. Thus an increase in Ghana’s real cocoa producer price stimulates production through altering the relative returns from cocoa versus other crops as well as by altering the relative returns from smuggling into Ivory Coast. A similar effect has operated in Ivory Coast in the past decade, when annual supply has consistently diverged from production due to smuggling from Ghana. In the Ivory Coast equation (Table 9) the Ivory Coast-Ghana relative producer price variable was dropped because of its collinearity with another price variable—the ratio measuring the world futures price in relation to the Ivorian producer price. However, if the relative producer price variable is maintained in the equation, the short-term price elasticity drops from 0.26 to 0.14.

30. The long run elasticities are fairly high, particularly for those countries where there is considerable scope for expanding acreage. Even so, it would appear that at the aggregate world level nearly 10 years elapse before 65% of the price effect on production is felt.

31. As regards the long-run elasticity of production with respect to acreage it is worth noting that evaluation of these parameters needs to take into account the contribution of the variable measuring the proportion of new plantings in total acreage. To illustrate this effect let \( Q_t, A_t \) and \( HYB_t \) represent production, acreage and new (hybrid) acreage respectively. Then the specifications used here can be simplified to

\[
\log Q_t = \alpha \log A_{t-1} + \beta \left( \frac{HYB_t}{A_t} \right)
\]

and hence the elasticity of supply with respect to acreage becomes:

\[
\epsilon_A = \alpha + \beta \left( \frac{\epsilon_{HYB} - 1}{A_t} \right) \left( \frac{HYB_t}{A_t} \right)
\]
Table 9: PRICE ELASTICITY OF COCOA SUPPLY WITH RESPECT TO PRODUCER PRICE

<table>
<thead>
<tr>
<th>Country</th>
<th>Short Run/a</th>
<th>Medium Term/b</th>
<th>Long Run/c</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ghana</td>
<td>.18*</td>
<td>.11</td>
<td>.126*</td>
</tr>
<tr>
<td>Nigeria</td>
<td>.099*</td>
<td>.105</td>
<td>.113</td>
</tr>
<tr>
<td>Ivory Coast</td>
<td>.259*</td>
<td>.32*</td>
<td>.59*</td>
</tr>
<tr>
<td>Brazil</td>
<td>.103**</td>
<td>.39</td>
<td>.54</td>
</tr>
<tr>
<td>Cameroon</td>
<td>.095*</td>
<td>.32*</td>
<td>.59*</td>
</tr>
<tr>
<td>Ecuador</td>
<td>.103**</td>
<td>.39</td>
<td>.54</td>
</tr>
<tr>
<td>Papua New Guinea</td>
<td>.103**</td>
<td>.39</td>
<td>.54</td>
</tr>
<tr>
<td>ROW</td>
<td>.022*</td>
<td>.159</td>
<td>.207</td>
</tr>
<tr>
<td>World</td>
<td>.138</td>
<td>.24</td>
<td>.42</td>
</tr>
</tbody>
</table>

* Significant at 95%
** Significant at 90%.

/a Current and 1 year lag.
/b Response after 6 years.
/c Steady-state long-run elasticities including feedback from acreage response. Based on simulation after 9 years.

Source: Economics Analysis and Projections Department.

Table 10: ELASTICITIES OF COCOA ACREAGE RESPONSE WITH RESPECT TO PRODUCER PRICE

<table>
<thead>
<tr>
<th>Country</th>
<th>Short run/a</th>
<th>Medium Term/b</th>
<th>Long Run/c</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ivory Coast</td>
<td>.0885</td>
<td>.30*</td>
<td>.60</td>
</tr>
<tr>
<td>Brazil</td>
<td>.03*</td>
<td>.29</td>
<td>.618</td>
</tr>
<tr>
<td>Cameroon</td>
<td>.0885</td>
<td>.30*</td>
<td>.60</td>
</tr>
<tr>
<td>Ecuador</td>
<td>.03*</td>
<td>.29</td>
<td>.618</td>
</tr>
<tr>
<td>Papua New Guinea</td>
<td>.03*</td>
<td>.29</td>
<td>.618</td>
</tr>
</tbody>
</table>

* significant at 99%.

/a Up to 3 years.
/b After 5 years. Based on simulation.
/c After 9 years. Based on simulation.

Source: Economics Analysis and Projections Department.
where \( e_{HYB} \) is the elasticity of hybrid acreage with respect to total acreage in countries where intramarginal cocoa land is available. This elasticity is likely to be in excess of unity because the share of hybrids is likely to increase as the area with traditional cocoa decreases with time. Hence the overall long-term (15-20 years) elasticity of production with respect to acreage is likely to be about unity. This is probably the case for Ivory Coast and Brazil and for some of the new producers. Elsewhere, particularly in Ecuador, expansion of cocoa acreage is likely to be in areas of suboptimal yields, so elasticities of output with respect to acreage of less than unity are not inconsistent with a priori reasoning.

C. Prices and Stocks in the Model

32. As can be seen from Figure 2, real world cocoa prices, proxied by the U.S. import unit value of cocoa deflated by Bank's MUV, have moved inversely with world stocks, i.e. when stocks increased prices declined. Stocks are one indicator of balance between supply and demand. When demand is greater than supply, the stock level will be reduced. In this situation upward pressure on prices will be exerted, and vice versa. Thus the price equation used here is specified as:

\[
DP_t = f\left( \frac{STK_t}{WDGR_t}, DP_{t-1} \right)
\]

where \( DP \) = Real world cocoa price.

\( STK \) = End of season world stock level.

\( WDGR \) = World grindings.

33. Similar specifications for prices can be found in the Bank's other commodity models. 1/

1/ See for example, Grilli et. al., An Econometric Model of the World Rubber Economy, World Bank, January 1979. p.29.
III. SIMULATION RESULTS OF THE ECONOMETRIC MODEL

A. Projections of the Cocoa Market up to 1990

34. The model was used to project the cocoa market up to 1990. Assumptions on the main exogenous variables were as follows: for income, the GDP per capita growth given in the "low case" of World Development IV was taken; for future inflation, the latest Bank's MUV was utilized. Simulation results obtained with these assumptions were taken as the "base model run". The "base model run" results are compared below with others derived from different assumptions concerning the paths of the exogenous variables.

35. Because the International Cocoa Agreement incorporating a Buffer Stock scheme came into effect on August 1, 1981, two scenarios, one with and one without market intervention by the Buffer Stock authority, were simulated. The Buffer Stock intervention rule used in the simulations was to maintain the three-months' cocoa futures price in the range of 110-150¢/lb, with adjustments for stock accumulation. Because of the low cocoa prices which prevailed in the first half of 1981, the rule implied supporting a market price floor level of 105¢/lb in 1981. Although the present Agreement will be in force until mid-1984, in the long term simulation exercises it was assumed that the Agreement, with the same buffer stock intervention rules, would continue operating after mid-1984. The estimated buffer stock sales and purchases and the three months' futures prices obtained in the new base model run, with buffer stock operations, are given in Table 11. Simulations were performed in all cases starting from 1979, making it possible to validate the model by comparing the simulation results with the actual market for years 1979 and 1980. A synopsis of the simulation results of the main variables of the model is shown in Table 12 and Figures 3-10.

36. An important finding of the simulation results is that most probably the International Cocoa Agreement will be able to support the agreed floor price for the next 3 years if the Buffer Stock Manager can obtain enough financing to buy more than 250,000 tons. The estimated required purchases by the Buffer Stock for 1981 and 1982 are 85,000 and 125,000 tons, respectively, and no purchase is shown to be necessary in 1983. The accumulated quantity of 210,000 tons is less than the agreed maximum of 250,000 tons. However, given the relatively small margin left (40,000 tons), if world production for 1981 and 1982 exceeds 1,673,000 and 1,737,000 tons respectively, by as little as 1%, the probability of the Buffer Stock being able to support the price drastically. Other short-term concerns are the sluggish economies and the high interest rates prevailing in many industrialized countries. If these economies do not recover soon and interest rates remain high for the next two years or so, substantial amounts of consumer stocks could be dumped into the market. This would make it harder for the Buffer Stock Manager to maintain the floor price. The simulation results also indicate that sales by the Buffer Stock would occur in 1987, 1988 and 1989, by which time the stock would be exhausted. This would occur only if the current Agreement's price range is maintained in nominal terms up to 1989. It can in fact be expected that the price range will not be changed in nominal terms until most of the stocks
accumulated in the early 1980s are sold. This, of course, would imply a substantial decline in real prices over this period. The fundamentals of the market, however, are such that a decline in real prices seems to be inevitable, as shown by the simulation results, with or without buffer stock intervention.

Table 11: ESTIMATED BUFFER STOCK PURCHASES AND SALES AND THREE-MONTHS' COCOA FUTURES PRICES

<table>
<thead>
<tr>
<th>Buffer Stock Purchases</th>
<th>Buffer Stock Sales</th>
<th>Three Months' Futures Price</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(-000 mt)</td>
<td>(USc/lb)</td>
</tr>
<tr>
<td>1981</td>
<td>85</td>
<td>0</td>
</tr>
<tr>
<td>1982</td>
<td>125</td>
<td>0</td>
</tr>
<tr>
<td>1983</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>1984</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>1985</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>1986</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>1987</td>
<td>0</td>
<td>-100</td>
</tr>
<tr>
<td>1988</td>
<td>0</td>
<td>-60</td>
</tr>
<tr>
<td>1989</td>
<td>0</td>
<td>-50</td>
</tr>
<tr>
<td>1990</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

/a Support price is lowered taking into account that the price is to be supported to 110c/lb only for the fourth quarter of 1981.

/b Ceiling price is lowered from 150c to 142c since, according to the Buffer Stock rules, the price range would be lowered by 8c if the Buffer Stock has accumulated more than 170,000 tons.

/c Sales of 50 thousand tons by the Buffer Stock are not sufficient to bring the price down to 142c.

Source: Economics Analysis and Projections Department.

1/ Desirability of maintaining the current price range in nominal terms for several years in view of increasing supplies was expressed by Mr. Plambeck, the Buffer Stock Manager of ICCO in a recent discussion with EPDC staff.
Table 12: RESULTS OF MAIN VARIABLES OF SIMULATIONS

<table>
<thead>
<tr>
<th>Year</th>
<th>World Production</th>
<th>World Grindings</th>
<th>World Stock</th>
<th>3 Months</th>
<th>US Import</th>
<th>Real US fob Import Unit Value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>With BS/Without BS/With BS</td>
<td>Without BS/Without BS/Without BS</td>
<td>With BS/Without BS/With BS</td>
<td>Without BS/Without BS/Without BS</td>
<td>With BS/Without BS/With BS</td>
<td>Without BS/Without BS/Without BS</td>
</tr>
<tr>
<td>1979</td>
<td>(1,481) fe 1,536 (1,424) fe 1,411 (481) fe (341)</td>
<td>867 759</td>
<td>105 97</td>
<td>106 88</td>
<td>117 109</td>
<td></td>
</tr>
<tr>
<td>1980</td>
<td>(1,627) fe 1,673 (1,458) fe 1,486 (633) fe 667</td>
<td>797 697</td>
<td>117 110</td>
<td>116 107</td>
<td>117 109</td>
<td></td>
</tr>
<tr>
<td>1981</td>
<td>1,673 1,673 1,552 1,565 687 759</td>
<td>105 97</td>
<td>106 88</td>
<td>117 109</td>
<td>117 109</td>
<td></td>
</tr>
<tr>
<td>1982</td>
<td>1,737 1,727 1,608 1,654 674 815</td>
<td>117 110</td>
<td>116 107</td>
<td>117 109</td>
<td>117 109</td>
<td></td>
</tr>
<tr>
<td>1983</td>
<td>1,725 1,705 1,671 1,732 726 771</td>
<td>117 110</td>
<td>116 107</td>
<td>117 109</td>
<td>117 109</td>
<td></td>
</tr>
<tr>
<td>1984</td>
<td>1,774 1,731 1,729 1,767 753 718</td>
<td>117 110</td>
<td>116 107</td>
<td>117 109</td>
<td>117 109</td>
<td></td>
</tr>
<tr>
<td>1985</td>
<td>1,801 1,765 1,774 1,776 741 689</td>
<td>117 110</td>
<td>116 107</td>
<td>117 109</td>
<td>117 109</td>
<td></td>
</tr>
<tr>
<td>1986</td>
<td>1,941 1,905 1,902 1,984 717 693</td>
<td>117 110</td>
<td>116 107</td>
<td>117 109</td>
<td>117 109</td>
<td></td>
</tr>
<tr>
<td>1987</td>
<td>1,829 1,848 1,838 1,805 789 717</td>
<td>117 110</td>
<td>116 107</td>
<td>117 109</td>
<td>117 109</td>
<td></td>
</tr>
<tr>
<td>1988</td>
<td>1,857 1,882 1,885 1,840 740 691</td>
<td>117 110</td>
<td>116 107</td>
<td>117 109</td>
<td>117 109</td>
<td></td>
</tr>
<tr>
<td>1989</td>
<td>1,863 1,900 1,922 1,877 776 744</td>
<td>117 110</td>
<td>116 107</td>
<td>117 109</td>
<td>117 109</td>
<td></td>
</tr>
<tr>
<td>1990</td>
<td>1,883 1,914 1,912 1,907 708 732</td>
<td>117 110</td>
<td>116 107</td>
<td>117 109</td>
<td>117 109</td>
<td></td>
</tr>
</tbody>
</table>

Source: Economics Analysis and Projections Department.
Figure 3: PROJECTIONS OF REAL COCOA PRICES: BASE RUN

(US$/lb)
Figure 4: PROJECTIONS OF CURRENT 3 MONTHS' COCOA FUTURE PRICES: BASE RUN

(US$c/1b)
Figure 5: PROJECTIONS OF WORLD COCOA PRODUCTION: BASE RUN

('000 mt)
Figure 6: PROJECTIONS OF WORLD COCOA GRINDINGS: BASE RUN
('000 mt)

Without Buffer Stocks — With Buffer Stocks
Figure 7: PROJECTIONS OF WORLD COCOA STOCKS: BASE RUN

(‘000 mt)

Without buffer stocks

With Buffer Stocks
Figure 8: ACTUAL AND PROJECTED COCOA CONSUMPTION IN NORTH AMERICA: BASE RUN

('000 mt)
Figure 9: ACTUAL AND PROJECTED COCOA CONSUMPTION IN WEST EUROPE: BASE RUN
('000 mt)
Figure 10: ACTUAL AND PROJECTED COCOA CONSUMPTION IN CENTRALLY PLANNED ECONOMIES: BASE RUN ('000 mt)

- Without Buffer
- With Buffer

Stocks

Without Buffer Stock

With Buffer Stocks

YEAR

37. With the expected low prices in the early 1980s, consumption in all regions analyzed is expected to increase fairly substantially. By 1982, world grindings will surpass the all-time high level of over 1,600,000 tons reached in 1972/73. After 1982, world grindings will grow at the rate of about 2% per annum. In the medium-term, the centrally planned economies have the largest potential for increases in demand, since the long-term income elasticities of demand are fairly high. However, in the other two large consuming regions, the U.S. and Western Europe, demand growth after 1982 will be much lower than the world average due to their low income elasticities of demand.

38. Production in Brazil and Ivory Coast is expected to increase substantially throughout the current decade, mainly due to the large plantings that were carried out in the late 1970s. However, in the other main producing countries, production will stay basically stagnant during the 1980s with the exception of Malaysia 1/ because of the expected low prices during this period.

39. To see the impact of higher income growth in the industrialized countries (where most of the world cocoa is consumed), simulations were performed using the WDR IV "high case" scenario of GDP growth beginning in 1983.

40. As can be seen from Table 13, because the income elasticities of cocoa are low, there is little difference between the estimates of grindings and prices that are obtained under different income growth assumptions. Real prices are about 3 to 4% higher in the late 1980s in the high income growth case. As shown by the simulation results using different world production growth scenarios given below (Table 14), small changes in production growth would have a much larger impact on the future world cocoa market than small differences in income growth rates. The world cocoa economy is more sensitive to supply than to demand changes.

41. Given the assumptions made about income growth and the general price level, and given that main producing and consuming countries behave in a similar manner to the past, world real cocoa prices are expected to stay around the present low levels, with some recovery in the late 1980s with or without the Buffer Stock. The main factor keeping real prices at the present low levels is the large expected production from Brazil and Ivory Coast. The large-scale plantings that took place in these two countries in the late 1970s are expected to produce increasing quantities of cocoa. The base model run shows production of Brazil and Ivory Coast to be well over 500,000 tons by 1990, implying increases of 40% and 34%, respectively, compared with the 1981 level. Production from other countries is expected to stay rather stable since no extensive new plantings were carried out in the mid to late 1970s.

B. Effects of Production Changes on World Prices and Revenues

42. The supply responses discussed above are based on the simulations of a model consisting of regression equations which were derived by relating supply to other relevant variables, such as real producer prices and weather. Projections of supply from such regression equations would not be reasonable

1/ See below for the possible impact of likely increases in Malaysian production on the world market.
if past behavioral patterns are broken. If, for example, governments increase subsidies to cocoa farmers for social or political reasons, cocoa supply should increase faster than what the regression equations would indicate.

Table 13: PROJECTIONS OF WORLD COCOA MARKET WITH HIGH AND LOW INCOME GROWTH SCENARIOS

<table>
<thead>
<tr>
<th>Year</th>
<th>World Production Low/a</th>
<th>World Production High/a</th>
<th>World Grindings Low Case</th>
<th>World Grindings High Case</th>
<th>Real US import unit values Low Case</th>
<th>Real US import unit values High Case</th>
</tr>
</thead>
<tbody>
<tr>
<td>1983</td>
<td>1,705</td>
<td>1,705</td>
<td>1,732</td>
<td>1,733</td>
<td>65</td>
<td>65</td>
</tr>
<tr>
<td>1984</td>
<td>1,731</td>
<td>1,732</td>
<td>1,767</td>
<td>1,770</td>
<td>70</td>
<td>71</td>
</tr>
<tr>
<td>1985</td>
<td>1,765</td>
<td>1,766</td>
<td>1,771</td>
<td>1,779</td>
<td>76</td>
<td>77</td>
</tr>
<tr>
<td>1986</td>
<td>1,805</td>
<td>1,808</td>
<td>1,784</td>
<td>1,788</td>
<td>78</td>
<td>79</td>
</tr>
<tr>
<td>1987</td>
<td>1,848</td>
<td>1,852</td>
<td>1,805</td>
<td>1,810</td>
<td>77</td>
<td>79</td>
</tr>
<tr>
<td>1988</td>
<td>1,882</td>
<td>1,887</td>
<td>1,840</td>
<td>1,846</td>
<td>76</td>
<td>78</td>
</tr>
<tr>
<td>1989</td>
<td>1,900</td>
<td>1,906</td>
<td>1,877</td>
<td>1,885</td>
<td>76</td>
<td>78</td>
</tr>
<tr>
<td>1990</td>
<td>1,914</td>
<td>1,922</td>
<td>1,907</td>
<td>1,916</td>
<td>78</td>
<td>81</td>
</tr>
</tbody>
</table>

\(a\) WDR IV high and low income growth rate projections.

Source: Economic Analysis and Projections Department.

43. Since production projections up to 1990 are available from the Bank Programs and Projects staff and other sources for some important producers, model simulations were performed using these projected production figures in place of the supply equations. 1/ Three cases were simulated, the "high" and "low" cases given in the exogenous supply projections, and a third case which is the average of the two. (For the aggregate projections used and the results of the simulations see Table 14 and Figure 11).

44. All these three exogenous production estimates are higher than those obtained from "the base model run". This stems from the fact that in the "base model run" production declines in the late 1980s in response to the low prices in the early 1980s generated by the model (see Table 14). Under these higher production scenarios, total world revenue (in real terms) 2/, as well as real


2/ World revenue is an indicator measuring total revenue of cocoa producers from cocoa bean, that is, including those sold to domestic users. World revenue should not be confused with world export revenue from cocoa beans. However, since most cocoa, either in raw or processed form, is exported from producing countries, world revenue should have a close correspondence with world export revenue.
Table 14: RESULTS OF SIMULATIONS USING INDEPENDENTLY PROJECTED COCOA SUPPLY /a

<table>
<thead>
<tr>
<th></th>
<th>World Production</th>
<th>World demand</th>
<th>World Stocks</th>
<th>Real Price/b</th>
<th>Real revenue/b</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(-000 mt)</td>
<td></td>
<td></td>
<td>(US$/lb)</td>
<td>(US$ million)</td>
</tr>
<tr>
<td>Actual 1980</td>
<td>1,622</td>
<td>1,522</td>
<td>730</td>
<td>93.0</td>
<td>3,114</td>
</tr>
<tr>
<td>Base model run</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1982</td>
<td>1,727</td>
<td>1,654</td>
<td>815</td>
<td>63.5</td>
<td>2,309</td>
</tr>
<tr>
<td>1985</td>
<td>1,765</td>
<td>1,776</td>
<td>689</td>
<td>75.8</td>
<td>2,960</td>
</tr>
<tr>
<td>1990</td>
<td>1,914</td>
<td>1,907</td>
<td>732</td>
<td>78.1</td>
<td>3,279</td>
</tr>
<tr>
<td>Low Case</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1982</td>
<td>1,680</td>
<td>1,608</td>
<td>750</td>
<td>66.1</td>
<td>2,396</td>
</tr>
<tr>
<td>1985</td>
<td>1,812</td>
<td>1,793</td>
<td>760</td>
<td>70.1</td>
<td>2,764</td>
</tr>
<tr>
<td>1990</td>
<td>1,980</td>
<td>1,949</td>
<td>795</td>
<td>71.8</td>
<td>3,081</td>
</tr>
<tr>
<td>Medium Case</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1982</td>
<td>1,702</td>
<td>1,649</td>
<td>794</td>
<td>64.9</td>
<td>2,355</td>
</tr>
<tr>
<td>1985</td>
<td>1,908</td>
<td>1,851</td>
<td>870</td>
<td>59.9</td>
<td>2,439</td>
</tr>
<tr>
<td>1990</td>
<td>2,176</td>
<td>2,120</td>
<td>1,038</td>
<td>53.7</td>
<td>2,506</td>
</tr>
<tr>
<td>High Case</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1982</td>
<td>1,722</td>
<td>1,653</td>
<td>811</td>
<td>63.8</td>
<td>2,318</td>
</tr>
<tr>
<td>1985</td>
<td>2,003</td>
<td>1,905</td>
<td>994</td>
<td>52.1</td>
<td>2,184</td>
</tr>
<tr>
<td>1990</td>
<td>2,376</td>
<td>2,286</td>
<td>1,313</td>
<td>41.6</td>
<td>2,093</td>
</tr>
</tbody>
</table>

/b 1978 prices.

Source: Economic Analysis and Projections Department.
Figure 11: PROJECTIONS OF REAL WORLD COCOA PRICES UNDER DIFFERENT SUPPLY SCENARIOS (US$/lb)

PRICE 1 = Base model run (endogenous supply)
PRICE 2 = Low case (exogenous supply)
PRICE 3 = Medium case (exogenous supply)
PRICE 4 = High case (exogenous supply)
prices, are shown to decline sharply. Total real revenues obtained in 1990 for the "low", "medium" and "high" cases, are 6%, 24% and 36% lower, respectively, than those of the base model run. These results indicate that increasing production beyond the level resulting from normal price responses will adversely affect world real cocoa revenues.

45. It is to be noted here that the "high case" given in Table 14 could prove to be conservative. Brazil's "PROCACAO" program aimed at increasing cocoa production in Brazil up to 700,000 by the early 1990s and Malaysia's increasing production trend could push world cocoa production above the "high case" figures.

C. Simulation Results on Revenues when Production is Increased for Some Individual Countries

46. The econometric model was also used to evaluate the impact of production increases, such as may be forthcoming from large projects, in specific countries on the revenue of those countries, as well as on world prices and revenues. For this purpose, world production was increased in the model by 100,000 tons, during the period 1983-1990, on the assumption that this increase would come from either Ivory Coast or Ghana. These country specific examples were chosen to illustrate the impact of a 100,000 tons increment in production in countries that have different levels of output and, therefore, different market shares (in 1980 Ghana's output was 16% of world production while Ivory Coast held 24%). In calculating the impact, it was assumed that:

(1) Due to the increase in production, world prices would go down, which in turn would reduce the production of non-project areas of the country concerned. Thus, a project yielding 100,000 tons in Ivory Coast by 1990 will not increase total production in Ivory Coast to 623,000 tons (i.e. the sum of 523,000 tons, which is the base case production projection for the Ivory Coast, and 100,000 tons); rather it would be 610,000 tons, which is the sum of Ivorian production coming from non-project areas when world prices are lower as a result of increased production, and 100,000 tons.

(2) All of the increase in production will not be sold. Using the above example, when the Ivorian production is increased to 610,000 tons, some of it would be accumulated as stocks. It is assumed that Ivorian revenue will be the production share of the Ivory Coast in world production multiplied by world cocoa real revenue, which in turn is calculated by multiplying the world real cocoa price by the total world grindings. This
implicitly assumes that world stocks are held proportionately to each producing country's production share.1/

47. With these assumptions, the model was run to calculate the Ivorian and Ghanaian real revenues as well as real revenues of rest-of-world. The results (see Table 15) show that in the case where the Ivory Coast has a new project which yields production of 100,000 tons during the period 1983-1990, Ivorian real revenue increases by 8% and 3.5% in 1983 and 1990 respectively, compared with the case of no project. An important variable to evaluate is the sum of Ivorian annual real revenues during the period 1983-1990. They are US$6,143 million with no project and US$6,448 million with the project. The increase in accumulative real revenue is 5% while the increment in production was intended to be 21%. 2/ The percentage increase in revenue is much smaller than the percentage increase in production. Another important impact to watch is that on cumulative real revenues of the world, excluding Ivory Coast. These revenues decline by 13% (or US$2,261 million), since the Ivorian incremental production reduces total world accumulative real revenue, including Ivory Coast, by 8% (or US$1,956 million.)

48. The same exercise for Ghana indicates that its accumulative real revenue during the period 1978-1990 increases by 17.6%. A 100,000 tons increase implies a 34% increase in total production. The ratio of incremental cumulative real revenues to incremental production for Ghana (0.52) is much higher than for the Ivory Coast (0.24). The difference stems from the fact that marginal revenue is higher for countries with a lower world market share. However, world cumulative real revenues falls by as much as it does for the case of Ivory Coast above, because the net addition to world production is the same in each case.

1/ Mathematically, the Ivorian real revenues are calculated as:

\[
\text{RREVI}_{t} = RP_{t} \times GRWD_{t} \times (PRIV_{t}/PRWD_{t}) : \text{Base case}
\]

\[
\text{RREVI}_{t} = RP_{t} \times GRWD_{t} \times (PRIV_{t}+100 \text{ tons})/PRWD_{t} : \text{Case when Ivory Coast's production is increased by 100,000 tons.}
\]

where \( \text{RREVI} \) = Real revenue of Ivory Coast from cocoa.
\( RP \) = Real US import unit-value.
\( GRWD \) = World grindings.
\( PRIV \) = Production of Ivory Coast.
\( PRWD \) = World production.

2/ Incremental production from the project is 100,000 tons while average production without the project during the period 1983-90 is estimated to be 470,000 tons. Thus the incremental production ratio is 21%.
### Table 15: Simulation Results When Cocoa Production Is Increased by 100,000 Tons in the Ivory Coast and Ghana in 1983-90

<table>
<thead>
<tr>
<th></th>
<th>Production Base</th>
<th>Real Cocoa Price</th>
<th>Country Real Revenue /c</th>
<th>Accumulated Real Revenue /d</th>
<th>World Real Revenue Base</th>
<th>Accumulated Real Revenue World Revenue Base</th>
<th>Real Revenue of Rest-of-World Base</th>
<th>Accumulated Real Revenue Rest-of-World Base</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>100/b</td>
<td></td>
<td></td>
<td></td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Ivory Coast</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1983</td>
<td>433</td>
<td>544</td>
<td>64.7</td>
<td>59.5</td>
<td>625</td>
<td>675</td>
<td>2,465</td>
<td>2,286</td>
</tr>
<tr>
<td>1984</td>
<td>431</td>
<td>529</td>
<td>70.3</td>
<td>59.9</td>
<td>680</td>
<td>695</td>
<td>2,733</td>
<td>2,392</td>
</tr>
<tr>
<td>1985</td>
<td>437</td>
<td>529</td>
<td>75.8</td>
<td>63.5</td>
<td>733</td>
<td>747</td>
<td>2,960</td>
<td>2,584</td>
</tr>
<tr>
<td>1986</td>
<td>452</td>
<td>537</td>
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<td>67.6</td>
<td>767</td>
<td>805</td>
<td>3,065</td>
<td>2,787</td>
</tr>
<tr>
<td>1987</td>
<td>474</td>
<td>555</td>
<td>77.3</td>
<td>69.9</td>
<td>788</td>
<td>843</td>
<td>3,539</td>
<td>3,089</td>
</tr>
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<td>1988</td>
<td>496</td>
<td>576</td>
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<td>69.8</td>
<td>809</td>
<td>864</td>
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<tr>
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<td>511</td>
<td>594</td>
<td>76.0</td>
<td>69.3</td>
<td>845</td>
<td>889</td>
<td>5,247</td>
<td>4,552</td>
</tr>
<tr>
<td>1990</td>
<td>523</td>
<td>610</td>
<td>78.1</td>
<td>69.8</td>
<td>896</td>
<td>926</td>
<td>6,143</td>
<td>5,448</td>
</tr>
<tr>
<td>Ghana</td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1983</td>
<td>297</td>
<td>397</td>
<td>64.7</td>
<td>59.5</td>
<td>430</td>
<td>503</td>
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<td>2,286</td>
</tr>
<tr>
<td>1984</td>
<td>299</td>
<td>398</td>
<td>70.3</td>
<td>59.9</td>
<td>472</td>
<td>523</td>
<td>2,733</td>
<td>2,392</td>
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<tr>
<td>1985</td>
<td>296</td>
<td>394</td>
<td>75.8</td>
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<td>406</td>
<td>556</td>
<td>2,960</td>
<td>2,584</td>
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<td>1986</td>
<td>294</td>
<td>392</td>
<td>78.1</td>
<td>67.6</td>
<td>500</td>
<td>587</td>
<td>3,065</td>
<td>2,787</td>
</tr>
<tr>
<td>1987</td>
<td>293</td>
<td>391</td>
<td>77.3</td>
<td>69.9</td>
<td>489</td>
<td>595</td>
<td>3,065</td>
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<td>1988</td>
<td>292</td>
<td>390</td>
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<td>586</td>
<td>3,069</td>
<td>2,921</td>
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<tr>
<td>1989</td>
<td>292</td>
<td>389</td>
<td>76.0</td>
<td>69.3</td>
<td>482</td>
<td>582</td>
<td>3,138</td>
<td>2,949</td>
</tr>
<tr>
<td>1990</td>
<td>292</td>
<td>389</td>
<td>78.1</td>
<td>69.8</td>
<td>500</td>
<td>590</td>
<td>3,846</td>
<td>4,522</td>
</tr>
</tbody>
</table>

/a Base model run.
/b With additional 100,000 tons of supply in Ghana and Ivory Coast during 1983-90.
/c Revenue of Ivory Coast and Ghana calculated using the equation in footnote 1 on page 17.
/d Accumulated sum of real revenues from 1983.

Source: Economic Analysis and Projections Department.
IV. THE NEW INTERNATIONAL COCOA AGREEMENT AND ITS IMPLICATIONS FOR BANK LENDING

49. The Bank's policy on lending for commodities facing inelastic demand embodies the provision that for commodities for which an effective international commodity agreement exists, Bank financing of increased production should take place within the framework of the agreement 1/ The International Cocoa Agreement, 1980 came into force on August 1, 1981. Its background, main features and immediate and long-term prospects are described, together with an evaluation of the major implications for Bank lending for cocoa.

A. Background to the Present Agreement

50. The first International Cocoa Agreement went into effect on October 1, 1973 for a period of three years. It was aimed at reducing wide price fluctuations, stabilizing export revenues, and assuring adequate supplies of cocoa. The main instruments to be used under the Agreement to achieve these objectives were export quotas and a buffer stock scheme. A second agreement, basically a continuation of the first one, came into force on October 1, 1976 for a period of three years. It was extended in October 1979 but expired in May 1980.

51. During the period when the Agreements were in force, the international cocoa price never fell below the agreed prices at which the economic measures would have been implemented (see Figure 12). Thus, the measures foreseen by the Agreement have never been put to the test in this market.

52. Before and after the Agreement expired in March 1980, considerable efforts were made to establish a new agreement, which eventually did come into force on August 1, 1981. Producing countries accounting for 72% of world production and consuming countries accounting for 61% of world consumption have now joined the Agreement. However, the biggest producing country, the Ivory Coast and several important consuming countries such as the U.S., Japan and Australia have not joined the new Agreement. 2/

53. The reason given by the Ivory Coast for not joining the Agreement is that it considers the floor price of 110¢/lb to be too low. In early 1980 when the Ivory Coast and other producing countries strived to set the floor price at 120¢/lb, the prevailing cocoa price was around 140¢/lb. The reason for the U.S. not agreeing to join the Agreement is, on the other hand, that it considers the floor price of 110¢/lb to be too high and that with such a high floor price the buffer stock system could not work effectively in the long run to stabilize prices. Under pressure from other countries there is some possibility that the Ivory Coast will join the Agreement soon, but this may not be the case with the U.S., which was not a member of the previous agreements. It


2/ See Annex III for the list of members of the Agreement in August 1, 1981, and the distribution of votes in the Council.
Figure 12
COCOA PRICES AND INTERNATIONAL COCOA AGREEMENT

Source: J. de Vries, *International Commodity Agreement*, February 1980,
Economic Analysis and Projections Department, mimeo.
also appears that other countries which have not joined the Agreement remain skeptical of the Agreement’s effectiveness.

B. Main Features of the Agreement

54. In terms of instruments the main difference between the previous and current agreement is that the latter has only the buffer stock scheme as the instrument for supporting and stabilizing prices. The export quota system was omitted because coordination between the two instruments was thought to be extremely difficult. The buffer stock, whose maximum capacity is set at 250,000 tons of cocoa beans equivalent, is to intervene in the market to keep prices within the present bounds. The lower and upper intervention prices are US$110/lb and US$150/lb respectively, in terms of the ICCO indicator price, which is calculated by taking the average of daily quotations for cocoa beans of the nearest three active futures trading months in the New York Cocoa Exchange and in the London Cocoa Terminal Market. In order to finance buffer stock operations, the buffer stock account will receive transfers of approximately US$230 million from the buffer stock account of the previous agreement and regular revenues in the form of contributions charged on either cocoa exports or imports to the members of the Agreement, at the rate of 1¢ for each pound of cocoa bean equivalent traded.

55. In each cocoa season, the highest authority of the International Cocoa Organization (ICCO), the ICCO Council, is to review the price range and determine if revisions are needed. In conducting this review, the Council is to take into consideration the trend of cocoa prices, consumption, production, stocks, and the influence on cocoa prices of changes in the world economic situation or monetary system. It is stipulated in the Agreement that if consecutive purchases (sales) of 100,000 tons takes place, price will be revised downwards (upward) by 4¢/lb, and if an additional 75,000 tons of consecutive purchases (sales) occur, the floor (ceiling) price is to be lowered (raised) by another 4¢/lb.

C. Implications for Lending

56. It is unlikely that the cocoa buffer stock scheme can do more than other buffer stock or buffer fund schemes have done in the past. It can only be expected to smooth out rather short-term price fluctuations around the market price trend. The scheme cannot be expected to defend floor prices in the face of a long-run imbalance between supply and demand, especially since it is limited in terms of the funds available. Currently, with its financial resources of about US$230 million, the Buffer Stock Manager will be able to buy approximately 100,000 tons of cocoa beans. At this prospect, world cocoa prices increased from around 70¢/lb in mid-June 1981, to about 95¢/lb in July. Since then prices have been fluctuating around 95¢/lb. However, if cocoa producing countries are encouraged by this price rise to plant significant areas of cocoa trees, the already weak medium-term fundamentals of the market will worsen. The Buffer Stock Manager would then be required to accumulate increasing amounts of cocoa which could eventually place the Agreement in jeopardy. It is estimated that during the last four years surpluses of 379 thousand tons of cocoa have been generated. Thus, if the present over-supply trend continues for several years, the capacity of the Buffer Stock will be
soon exhausted. 1/ In brief, the economic provisions of the Agreement will be effective only if the long-term balance in the relationship between supply and demand can be achieved. The ICCO does not have a mandate to coordinate or control production in exporting countries. It is left to the producing countries to keep future production at a level compatible with demand.

57. Under existing guidelines for lending for cocoa, EPDCE is required to consult with the Secretariat of the International Cocoa Organization (ICCO) about the cocoa projects it is appraising for financing. These consultations, as well as exchanges of information and studies on cocoa markets, can provide the Bank with valuable insights on the viability of the projects and their possible impact on the world cocoa market.

58. One purpose of the consultations is to alert the Bank on the dangers of disruption that the proposed projects may pose to the world cocoa market, and to the viability of the Agreement. However, since the Agreement does not have a mandate to control or coordinate cocoa production of exporting member countries, the Secretariat’s opinion on Bank’s projects is likely to be only of a general nature, based on the knowledge of the Secretariat about the market for cocoa, and particularly of the first hand information that the Secretariat has on the levels of stocks accumulated by the Organization and by the producing and consuming countries which are members of the Agreement. The Secretariat could also be very helpful in indicating the range within which the Agreement is likely to try to keep world prices. The ICCO obviously cannot be looked to as the final arbiter on whether a Bank project would have "a significant effect on world supplies or prices". It is unlikely that the ICCO will provide substantive answers to such questions, either formally or informally. The responsibility for this assessment will have to remain with Bank staff. To make such an evaluation it will be necessary, therefore, to project, with the help of the ICCO, the intervention price range likely to be adopted and to pass judgements on the effectiveness of the ICCO Buffer Stock scheme, taking into account forecasts of future supplies, demand and stocks.

59. As shown in Figure 12, the intervention price ranges adopted in the past tended to shift in the same direction as the prevailing prices. This is a reflection of the fact that commodity agreements cannot change the fundamental economics of the market in a significant way, but must adapt to them. Thus, given the large amount of stocks held currently and the expectation of increasing cocoa supplies in the next few years, the intervention price range can be expected to remain the same in nominal terms and to decline in real terms. The simulation results in the previous chapter showed that if the present floor price is kept unchanged in nominal terms until 1989, Buffer Stock operations are likely to succeed in maintaining world cocoa prices within the range. It is clear that if world cocoa production grows considerably faster than the expected growth of world demand, it will make the Agreement ineffective and in the long-run prices will decline even further.

1/ By January 1982, the Buffer Stock Manager has accumulated about 70,000 tons of cocoa without succeeding in maintaining the price at 110c/lb. Discussion among the Agreement members are underway aimed at raising cash to enable the Buffer Stock Manager to buy more cocoa.
60. The econometric model was used to evaluate the rate at which long range cocoa demand will grow due to income and population growth. The resulting rate was shown to be about 2% per annum. This suggests that to maintain the floor price of 110¢/lb in 1981 real prices in the long run, the growth rate of world production should be about the same.
ANNEX I

STRUCTURE AND ESTIMATED EQUATIONS OF THE NEW ECONOMETRIC MODEL OF THE WORLD COCOA ECONOMY

I. Demand Equations

North America: 1961 - 1978

Cochrane-Orcutt

\[
\ln CCNA_t = 1.912 - 0.1204 \ln \left( \frac{P_t}{DFNA_t} \right) -0.1066 \ln \left( \frac{P_{t-1}}{DFNA_{t-1}} \right) + 0.3416 \ln GDPNAC_t
\]

\[
R^2 = 0.916 \quad \text{S.E.E.} = 0.0332 \quad \text{D.W.} = 2.09 \quad \text{Rho} = -0.3625
\]

where:

CCNA = Per capita apparent consumption of cocoa in North America.

Pt = U.S. import unit value of cocoa.

DFNA = Price deflator for North America.

GDPNAC = Per capita real GDP index for North America.

PS = World price of sugar.

Western Europe: 1961 - 1978

\[
\ln CCWE_t = -1.268 - 0.1352 \ln \left( \frac{P_t}{DFWE_t} \right) -0.075 \ln \left( \frac{P_{t-1}}{DFWE_{t-1}} \right) + 0.3535 \ln GDPWEC_t
\]

\[
R^2 = 0.916 \quad \text{S.E.E.} = 0.0332 \quad \text{D.W.} = 2.09 \quad \text{Rho} = -0.3625
\]

\[1/ \] This model was constructed by T. Akiyama and K. Mehta. It will be shortly published in full as a World Bank Staff Commodity Working Paper.

\[2/ \] Figures in brackets are t-statistics.
\[-0.041 \ln \left( \frac{P_{St-1}}{DFWE_{t-1}} \right) \]
\[\text{(3.66)}\]

\[R^2 = 0.883 \quad \text{S.E.E.} = 0.0253 \quad \text{P.W.} = 2.03\]

where:

CCWE = Per capita apparent consumption of cocoa in Western Europe

DFWE = Weighted price deflator for Western Europe.

GDPWEC = Weighted real GDP per capita index for Western Europe.

\textbf{Centrally Planned Economies}

\[\ln CCCPE_t = 0.09637 - 0.2044 \ln \left( \frac{P_t}{DFCEP_t} \right)\]
\[\text{(0.65)} \quad \text{(3.60)}\]

-944.0/GDPCPE_t + 0.641 \ln CCCPE_{t-1}
\[\text{(3.36)}\]

\[R^2 = 0.956 \quad \text{S.E.E.} = 0.068 \quad \text{D.W.} = 1.41\]

where:

CCCPE = Per capita apparent consumption of cocoa in centrally planned economies.

DFCEP = Price deflator for centrally planned economies.

GDPCPE = Real per capita GDP in centrally planned economies.

\textbf{Other Industrialized Countries: 1961 - 1978}

\textbf{Polynomial-lag}

\[\ln CCODC_t = -1.498 - 0.235 \ln \left( \frac{P_t}{DFODC_t} \right)\]
\[\text{(4.71)} \quad \text{(5.91)}\]

-0.193 \ln \left( \frac{P_{t-1}}{DFODC_{t-1}} \right) - 0.151 \ln \left( \frac{P_{t-2}}{DFODC_{t-2}} \right)
\[\text{(9.09)} \quad \text{(7.40)}\]
-0.109 \ln \left( \frac{P_{t-3}}{DFODC_{t-3}} \right) + 0.1102 \ln GDPODC_t

\begin{align*}
R^2 &= 0.879 \\
\text{S.E.E.} &= 0.0566 \\
D.W. &= 1.53
\end{align*}

where:

CCODC = Per capita apparent consumption in other 9 industrialized countries.

DFODC = Price deflator for other industrialized countries.

GDPODC = Weighted real GDP per capita index for other industrialized countries.

Latin America: 1961 - 1978

\begin{align*}
\ln CLA_t &= 3.451 - 0.1048 \ln \left( \frac{P_t}{IPI_t} \right) \\
&\quad (14.3) (2.84) \\
&\quad -0.2286 \ln GDPLA_t \\
&\quad (5.44)
\end{align*}

\begin{align*}
R^2 &= 0.685 \\
\text{S.E.E.} &= 0.0375 \\
D.W. &= 1.87
\end{align*}

where:

CLA = Apparent consumption in Latin America.

IPI = Bank's IPI.

GDPLA = Real GDP of Latin America.

Other Developing Countries: 1961 - 1978

\begin{align*}
\ln CCOLDC_t &= -12.94 - 0.3335 \ln \left( \frac{P_t}{IPI_t} \right) \\
&\quad (11.42) (2.57) \\
&\quad -0.1975 \ln \left( \frac{P_{t-1}}{IPI_{t-1}} \right) + 1.536 \ln GDPCOLDC_t \\
&\quad (1.60) (7.45) \\
&\quad -0.07512 \ln \left( \frac{PS_t}{IPI_t} \right)
\end{align*}
R² = 0.829  S.E.E. = 0.103  D.W. = 1.96

where:

CCOLDC = Per capita consumption in other developing countries
GDPCOLDC = Real GDP per capita in other developing countries.

II. Supply Equations

Area for Ivory Coast: 1969 - 1980

\[
\ln AIV_t = 0.7405 + 0.0885 \ln \left( \frac{PPIV_{t-3}}{CPIIV_{t-3}} \right) \\
+ 0.063 \ln \left( \frac{PPIV_{t-4}}{CPIIV_{t-4}} \right) + 0.0415 \ln \left( \frac{PPIV_{t-5}}{CPIIV_{t-5}} \right) \\
+ 0.40097 \ln AIV_{t-1} + 0.5243 \ln AIV_{t-2} \\
+ 0.135 \left[ \ln \left( \frac{PWLF_{t-3}}{PPIV_{t-3}} \right) - \ln \left( \frac{PWLF_{t-4}}{PPIV_{t-4}} \right) \right] \\
- 0.0013 AIV_{t-30} + 0.0938 \ln PLIV_{t-3}
\]

(1.58)  (1.68)  (1.49)  (1.02)  (3.02)  (4.12)  (0.56)  (2.19)  (1.41)

R² = 0.971  S.E.E. = 0.0282  D.W. = 2.15

where:

AIV = Area harvested in Ivory Coast.

PPIV = Producer price in Ivory Coast.

CPIIV = Consumer price index in Ivory Coast.

PWLF = 3 months' future price.

PLIV = New planting areas in Ivory Coast.
Area for Cameroon: 1969 - 1980

\[
\ln AC_{t} = 0.5774 + 0.0885 \ln \left( \frac{PPC_{t-3}}{CPI_{t-3}} \right) \\
\text{(1.21) (1.68)}
\]

\[
+0.063 \ln \left( \frac{PPC_{t-4}}{CPI_{t-4}} \right) + 0.0415 \ln \left( \frac{PPC_{t-5}}{CPI_{t-5}} \right) \\
\text{(1.49) (1.02)}
\]

\[
+0.40097 \ln AC_{t-1} = 0.5243 \ln AC_{t-2} \\
\text{(3.02) (4.12)}
\]

\[
+0.135 \left[ \ln \left( \frac{PWCF_{t-3}}{PPC_{t-3}} \right) - \ln \left( \frac{PWLF_{t-4}}{PPC_{t-4}} \right) \right] \\
\text{(0.56)}
\]

\[
-0.0013 AC_{t-30}
\]

\[R^2 = 0.913 \quad \text{S.E.E.} = 0.028 \quad \text{D.W.} = 0.8\]

where:

ACM = Area harvested in Cameroon.

PPCM = Producer price in Cameroon.

CPICM = Consumer price index in Cameroon.

Area for Brazil: 1969 - 1980

\[
\ln AB_{t} = 0.7538 + 0.058 \ln \left( \frac{PPB_{t-2}}{CPIB_{t-2}} \right) \\
\text{(7.24) (20.0)}
\]

\[
-0.0294 \ln \left( \frac{PPB_{t-3}}{CPIB_{t-3}} \right) + 0.0616 \ln \left( \frac{PPB_{t-4}}{CPIB_{t-4}} \right) \\
\text{(8.35) (21.1)}
\]

\[
+0.0107 \ln \left( \frac{PPB_{t-5}}{CPIB_{t-5}} \right) + 1.1708 \ln AB_{t-1} \\
\text{(3.63) (40.3)}
\]

\[
-0.2855 \ln AB_{t-2} - 0.00047AB_{t-30} \\
\text{(9.40) (11.6)}
\]
\[ R^2 = 0.920 \quad \text{S.E.E.} = 0.0049 \quad \text{D.W.} = 2.18 \]

where:

\[ ABZ = \text{Area harvested in Brazil.} \]
\[ PPMZ = \text{Producer price in Brazil.} \]
\[ CPIBZ = \text{Consumer price index in Brazil.} \]

**Area for Ecuador: 1969 - 1980**

\[
\ln AED_t = 0.436 + 0.058 \ln \left( \frac{PPED_{t-2}}{CPIED_{t-2}} \right) \\
(5.02) (20.0) \\
-0.0294 \ln \left( \frac{PPED_{t-3}}{CPIED_{t-3}} \right) + 0.0616 \ln \left( \frac{PPED_{t-4}}{CPIED_{t-4}} \right) \\
(8.35) (21.1) \\
+0.0107 \ln \left( \frac{PPED_{t-5}}{CPIED_{t-5}} \right) + 1.1708 \ln AED_{t-1} \\
(3.36) (40.3) \\
-0.2855 \ln AED_{t-2} - 0.0047 AED_{t-30} \\
(9.40) (11.6) \\
\]

\[ R^2 = 0.91 \quad \text{S.E.E.} = 0.036 \quad \text{D.W.} = 2.37 \]

where:

\[ AED = \text{Area harvested in Ecuador.} \]
\[ PPED = \text{Producer price in Ecuador.} \]
\[ CPIED = \text{Consumer price index in Ecuador.} \]

**Area for Papua New Guinea: 1969 - 1980**

\[
\ln APG_t = 0.401 + 0.058 \ln \left( \frac{PPPG_{t-2}}{CPIPG_{t-2}} \right) \\
(5.07) (20.0) \\
-0.0294 \ln \left( \frac{PPPG_{t-3}}{CPIPG_{t-3}} \right) + 0.0616 \ln \left( \frac{PPPG_{t-4}}{CPIPG_{t-4}} \right) \\
(8.35) (21.1) \\
\]
ANNEX I

\[ +0.0107 \ln \left( \frac{\text{PPPG}_{t-5}}{\text{CPIPG}_{t-5}} \right) + 1.1708 \ln \text{APG}_{t-1} \]
\[ -0.2855 \ln \text{APG}_{t-2} - 0.00047 \text{APG}_{t-30} \]
\[ R^2 = 0.88 \text{ S.E.E.} = 0.106 \text{ D.W.} = 2.87 \]

where:

\( \text{APG} \) = Area harvested in Papua New Guinea.

\( \text{PPPG} \) = Producer price in Papua New Guinea.

\( \text{CPIPG} \) = Consumer price index in Papua New Guinea.

Production in Ghana: 1965 - 1980

\[ D \ln \text{QGH}_{t-1} = 5.368 + 0.08473 \ln \left( \frac{\text{PPGH}_{t-1}}{\text{CPIGH}_{t-1}} \right) \]
\[ -0.1560 \ln \left( \frac{\text{PPGH}_{t-2}}{\text{CPIGH}_{t-2}} \right) - 0.1677 \text{GHRAIN}_{t-1} \]
\[ +0.3176 \text{DUM 68} - 0.8844 \ln \text{QGH}_{t-1} \]
\[ +0.100 \ln \left( \frac{\text{PPGH}_{t-1}}{\text{CPIGH}_{t-1}} \right) - 0.2443 \ln \left( \frac{\text{PPIV}_{t-1}}{\text{PPGH}_{t-1}} \right) \]
\[ R^2 = 0.88 \text{ S.E.E.} = 0.0546 \text{ D.W.} = 2.55 \]

where:

\( \text{QGH} \) = Production in Ghana.

\( \text{PPGH} \) = Producer price in Ghana.

\( \text{PPIV} \) = Producer price index in Ghana.

1/ "D" denotes first-order difference.
CPIGH = Consumer price index in Ghana.

GHRAIN = Percent deviation of rainfall from 20-year averages.

DUM 68 = During variable (1968 = 1, 0 otherwise).

PPIV = Producer price in Ivory Coast.

Production in Nigeria: 1965 - 1980

\[
D \ln QNG_t = 4.809 - 0.8844 \ln QNG_{t-1} \\
(7.44) (7.39)
\]

\[
+ 0.100 \ln (PPNG_{t-1}/CPING_{t-1}) + 0.3176 \text{ DUM 68} \\
(1.39) (5.37)
\]

\[
-0.2164 \text{ DUM 69} + 0.07735 \text{ NGBP} \\
(1.51) (2.12)
\]

\[
R^2 = 0.65 \quad \text{S.E.E.} = 0.1338 \quad \text{D.W.} = 1.25
\]

where:

QNG = Production in Nigeria.

PPNG = Producer price in Nigeria.

CPING = Consumer price index in Nigeria.

DUM 69 = Dummy variable (1969 = 1, 0 otherwise).

NGBP = Spraying material against Black Pod Disease made available to cocoa farmers.

Production in Ivory Coast: 1965 - 1980

\[
\ln QIV_t = -0.4375 + 0.2530 \ln QIV_{t-1} \\
(0.34) (2.14)
\]

\[
+0.2593 \ln (PPIV_{t-1}/CPIIV_{t-1}) + 0.0269 \ln (PPIV_{t-2}/CPIIV_{t-2}) \\
(0.34) (2.14)
\]

\[
-0.01327 \ln (PPIV_{t-3}/CPIIV_{t-3}) \\
(0.20)
\]
\[ +1.884 \left( \frac{HYBIV_{t-1}}{AIV_{t-1}} \right) + 0.5346 \ln AIV_{t-1} \]
\[ (2.59) \quad (2.65) \]
\[ R^2 = 0.68 \quad \text{S.E.E.} = 0.0962 \quad \text{D.W.} = 1.73 \]

where:

\[ QIV = \text{Production in Ivory Coast}. \]
\[ PPIV = \text{Producer price in Ivory Coast}. \]
\[ CPIIV = \text{Consumer price index in Ivory Coast}. \]
\[ HYBIV = \text{Area planted to hybrid variety in Ivory Coast}. \]

Production in Cameroon: 1965 - 1980

\[ \ln QCM_t = 0.0347 + 0.40047 \ln (PPCM_t / CPICM_t) \]
\[ (0.05) \quad (1.89) \]
\[ -0.3051 \ln (PPCM_{t-1} / CPICM_{t-1}) + 0.8122 \ln QCM_{t-1} \]
\[ (1.48) \quad (3.42) \]
\[ -3.92 \ln QCM_{t-2} + 0.3928 \ln ACM_{t-1} \]
\[ (0.99) \quad (1.78) \]
\[ R^2 = 0.814 \quad \text{S.E.E.} = 0.0962 \quad \text{D.W.} = 1.73 \]

where:

\[ QCM = \text{Production in Cameroon}. \]
\[ PPCM = \text{Producer price in Cameroon}. \]
\[ CPICM = \text{Consumer price index in Cameroon}. \]

Production in Brazil: 1969 - 1980

\[ \ln QBZ_t = 1.494 + 0.241 \ln QBZ_{t-1} + 0.154 \ln QBZ_{t-2} \]
\[ (2.35) \quad (1.86) \quad (1.40) \]
\[ +0.103 \ln (PPBZ_{t-1} / CPIBZ_{t-1}) + 0.1665 \ln (PPBZ_{t-2} / CPIBZ_{t-2}) \]
\[ (1.17) \quad (1.53) \]
-0.1824 \ln \left( \frac{PPBZ_{t-3}}{CPIBZ_{t-3}} \right) + 2.4787 \left( \frac{HYBBZ_{t-1}}{ABZ_{t-1}} \right) + 0.2732 \ln ABZ_{t-1} \\
(1.88) \quad (1.91) \quad (1.63) \\
-0.382 BRAIN_{t-1} \\
(2.37) \\
R^2 = 0.785 \quad \text{S.E.E.} = 0.128 \quad \text{D.W.} = 2.15 \\

where:

Q_{BZ} = \text{Production in Brazil.} \\
PP_{BZ} = \text{Producer price in Brazil.} \\
C{PI}_BZ = \text{Consumer price index in Brazil.} \\
NYBBZ = \text{Area planted to hybrid variety in Brazil.} \\
BRAIN = \text{Percent deviation of rainfall from 20 year average.} \\

Production in Ecuador: 1965 - 1980 \\

\ln Q_{ED_t} = 0.7967 + 0.241 \ln Q_{ED_{t-1}} + 0.154 \ln Q_{ED_{t-2}} \\
(1.26) \quad (1.86) \quad (1.80) \\
+ 0.103 \ln \left( \frac{PPED_{t-1}}{CPIED_{t-1}} \right) + 0.1665 \ln \left( \frac{PPED_{t-2}}{CPIED_{t-2}} \right) \\
(1.17) \quad (1.53) \\
-0.1824 \ln \left( \frac{PPED_{t-3}}{CPIED_{t-3}} \right) + 0.2732 \ln AED_{t-1} \\
(1.88) \quad (1.63) \\
R^2 = 0.523 \quad \text{S.E.E.} = 0.177 \quad \text{D.W.} = 2.31 \\

where:

Q_{ED} = \text{Production in Ecuador.} \\
PP_{ED} = \text{Producer price in Ecuador} \\
C{PI}_ED = \text{Consumer price index in Ecuador.}
Production in Papua New Guinea: 1965 - 1980

\[ \ln Q_{PGt} = 0.579 + 0.241 \ln Q_{PGt-1} + 0.154 \ln Q_{PGt-2} \]
\[ + 0.103 \ln (PPPG_{t-1}/CPIPG_{t-1}) + 0.1665 \ln (PPPG_{t-2}/CPIPG_{t-2}) \]
\[ + 0.103 \ln (PPPG_{t-3}/CPIPG_{t-3}) + 0.2732 \ln APG_{t-1} \]

\[ R^2 = 0.87 \quad \text{S.E.E.} = 0.111 \quad \text{D.W.} = 2.39 \]

where:

- \( Q_{PG} \) = Production in Papua New Guinea.
- \( PPPG \) = Producer price in Papua New Guinea.
- \( CPIPG \) = Consumer price index in Papua New Guinea.

Production in Rest-of-World: 1956 - 1979

Polynomial-lag

\[ \ln Q_{ROWt} = 0.978 + 0.8217 \ln Q_{ROWt-1} \]
\[ + 0.02213 \ln (PWLF_{t-1}/FXPI_{t-1}) \]
\[ + 0.0159 \ln (PWLF_{t-2}/FXPI_{t-2}) + 0.0097 \ln (PWLF_{t-3}/FXPI_{t-3}) \]

\[ R^2 = 0.668 \quad \text{S.E.E.} = 0.0575 \quad \text{D.W.} = 1.99 \]

where:

- \( Q_{ROW} \) = Production in Rest-of-World.
- \( FXPI \) = UN price index for primary food products.
III. Stocks and Price Equations

World Stocks

Identity

\[ \text{STK}_t = \text{STK}_{t-1} + \text{QGH}_t + \text{QNG}_t + \text{QIV}_t + \text{QCM}_t + \text{QBZ}_t + \text{QED}_t + \text{QPG}_t + \text{QROW}_t + \text{CCNA}_t \cdot \text{POPNA}_t - \text{CCWE}_t \cdot \text{POPWE}_t - \text{CCCPE}_t \cdot \text{POPCPE}_t - \text{CCODC}_t \cdot \text{POPODC}_t - \text{CLA}_t - \text{CCOLDC}_t \cdot \text{POPOLDC}_t \]

where:

\( \text{STK} \) = End-of-season world stocks.

\( \text{POPNA} \) = Population in North America.

\( \text{POPWE} \) = Population in Western Europe.

\( \text{POPCPE} \) = Population in centrally planned economies.

\( \text{POPODC} \) = Population in other industrialized countries.

\( \text{POPOLDC} \) = Population in other developing countries.

US Import Unit Value: 1960 - 1980

Cochrane-Orcutt

\[
\ln \left( \frac{P_t}{\text{IPI}_t} \right) = 0.9799 + 0.4751 \ln \left( \frac{P_{t-1}}{\text{IPI}_{t-1}} \right) - 0.8965 \ln \left( \frac{\text{STK}_t}{\text{GRWD}_t} \right)
\]

(5.46) (3.93) (6.46)
\[ R^2 = 0.912 \quad S.E.E. = 0.121 \quad D.W. = 1.30 \quad \text{Rho} = 0.7709 \]

where:

GRWD = World seasonal grindings.

World Seasonal Grindings: 1962 - 1978

\[
\ln GRWD_t = 0.05112 + 0.6806 \ln WD_t + 0.3124 \ln WD_{t-1}
\]

\[(0.42) \quad (9.48) \quad (5.38)\]

\[ R^2 = 0.976 \quad S.E.E. = 0.012 \quad D.W. = 2.33 \]

where:

WD = World demand (sum of demand variables above).
ANNEX II
DATA USED IN ESTIMATING DEMAND ELASTICITIES 1/

1. Period

Annual data, 1961-1978

2. Regional breakdown

Since income and price elasticities of demand are believed to differ among countries, reflecting different income and consumption patterns, the world was broken down into 6 regions:

i) Industrialised North America - U.S., Canada.
ii) Western Europe.
iii) Other developed countries - Japan, Australia, Israel, New Zealand and South Africa.
iv) Centrally planned economies of Eastern Europe and USSR
v) Latin American countries.
vi) Other developing countries.

3. Price

In a number of previous studies on cocoa, including Mr. Yeung's model, 2/ the ICCO average price was used. One drawback of this data is that it is not volume-weighted.

1/ Description of apparent consumption data is given in Section I.

The price series used here to avoid this problem, as in Mr. de Vries' econometric model for coffee, 1/ is the largest single importer.

4. Income and Deflators

GDP's expressed in constant 1975 US dollars and exchange rates were used to derive income elasticities. Within the regions of North America, Western Europe and other developed countries, GDP's of countries in these regions were converted to an index form and given weights reflecting each country's cocoa consumption share in the regions to form weighted regional GDP indexes. 2/

A similar approach was used for price deflators for the three regions mentioned above. Country consumer price indexes were weighted according to the share of cocoa consumption to form the weighted deflators.

1/ See Jos. de Vries The World Coffee Economy: An Econometric Analysis, EPDCE, to be published.

2/ In mathematical form:

\[ \text{GDP} = \sum W_i \text{GDP}_i \]

where \( \text{GDP}_j \) = weighted GDP index for region j.

\( \text{GDP}_i \) = GDP index in constant price and exchange rate of country i which belongs to region j.

\( W_i \) = 1961-78 average market share of cocoa consumption of country i in region j.
ANNEX III

DISTRIBUTION OF VOTES IN THE INTERNATIONAL COCOA COUNCIL

The following is the distribution of votes among Members, using Article 10 of the International Cocoa Agreement, 1980, as a basis.

<table>
<thead>
<tr>
<th>Exporting Members</th>
<th>Votes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brazil</td>
<td>275</td>
</tr>
<tr>
<td>Dominica</td>
<td>6</td>
</tr>
<tr>
<td>Ecuador</td>
<td>6</td>
</tr>
<tr>
<td>Ghana</td>
<td>300</td>
</tr>
<tr>
<td>Haiti</td>
<td>6</td>
</tr>
<tr>
<td>Jamaica</td>
<td>6</td>
</tr>
<tr>
<td>Mexico</td>
<td>18</td>
</tr>
<tr>
<td>Nigeria</td>
<td>233</td>
</tr>
<tr>
<td>Papua New Guinea</td>
<td>6</td>
</tr>
<tr>
<td>Peru</td>
<td>6</td>
</tr>
<tr>
<td>Saint Vincent and the Grenadines</td>
<td>6</td>
</tr>
<tr>
<td>Samoa</td>
<td>6</td>
</tr>
<tr>
<td>Trinidad &amp; Tobago</td>
<td>6</td>
</tr>
<tr>
<td>United Republic of Cameroon</td>
<td>114</td>
</tr>
<tr>
<td>Venezuela</td>
<td>6</td>
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<table>
<thead>
<tr>
<th>Importing Members</th>
<th>Votes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Argentina</td>
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</tr>
<tr>
<td>Belgium/Luxembourg</td>
<td>42</td>
</tr>
<tr>
<td>Czechoslovakia</td>
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<td>Denmark</td>
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<td>Finland</td>
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<td>France</td>
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<td>Germany, Federal Republic of</td>
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<td>Greece</td>
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<tr>
<td>United Kingdom</td>
<td>121</td>
</tr>
<tr>
<td>Yugoslavia</td>
<td>21</td>
</tr>
</tbody>
</table>

1,000
ANNEX IV

CONSUMPTION OF COCOA, BY MAJOR REGIONS

(Semi-log scale)

Western Europe

U.S.

CPEs

Developing countries
(Incl. Latin America)

('000 mt)

YEAR

61 63 65 67 69 71 73 75 77
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