THE DYNAMICS OF THE WORLD COCOA MARKET

by

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S.B., Massachusetts Institute of Technology

(1958)

SUBMITTED IN PARTIAL FULFILLMENT

OF THE REQUIREMENTS FOR THE

DEGREE OF DOCTOR OF

PHILOSOPHY

at the

MASSACHUSETTS INSTITUTE OF

TECHNOLOGY

February, 1965

Signature of Author ....

Department of Economics, September 20, 1964

Certified by ....

Thesis Supervisor

Accepted by ....

Chairman, Departmental Committee on Graduate Studies

ERRATA

Page,	Line	Error
iv	11	... I was writing ...
	12	... a confectionery manufacturer ...
	4 from bottom	... contact with ...
28	8	... Dr. Tosta Filho ...
97	footnote 2	... Brennan's article (2a) ...
117	3	... $(P^* - P^F)/h$, $(P^F - P)/h$,
120	last line	... is exhibited in the curve for futures speculation, it reflects saturation in ...
121	13	... for manufacturer
156	equation A-1	... - 0.008700 s ...
162	equation A-13	... = 3.768
175	12	... (May) coefficient on the September ratio, and the final (August) coefficient on the ...
181	4 from bottom	... to be constant, ...
184	equation 20	$\ln \left(\dfrac{P^{* \infty}}{P^*_t h_t} \right) =$
223	new footnote	The cocoa quantities in Table A-1, as well as in all of the remaining tables in this appendix, are in thousands of long tons.
276	Table	Second C column is estimated consumption, $\hat{C}$
282	8 from bottom	... through April of ...
295	3 from bottom	... simulations ...
348	vertical axis label	... $(c_{t+L} - \bar{c})$
371	6 from bottom	... exists no real world counterpart ...

Abstract

The Dynamics of the World Cocoa Market

by

Frank Helmut Weymar

Submitted to the Department of Economics on September 23, 1964, in partial fulfillment of the requirements for the degree of Doctor of Philosophy.

The thesis concentrates on that portion of the world cocoa industry's system structure which determines the dynamic responses of cocoa prices and consumption to changes in cocoa production. In order to set the context for the subsequent statistical research, a play-by-play account of cocoa market events over the 1952-63 interval is given, in the form of monthly excerpts from various market reports and letters.

In order to study cocoa price-consumption dynamics it is necessary to obtain an estimate of the system structure which determines the values of these variables over relatively short time intervals (e.g. one month). The existing economic literature does not treat short term commodity price mechanisms in a manner directly useful for empirical study. In order to satisfy this need, the modern literature on commodity price theory is reviewed and extended, providing a general theoretical price equation format subject to empirical testing.

A model of the system structure of interest is obtained in the form of ordinary and generalized least squares estimates of the equations generating: (a) the monthly average cocoa spot price; (b) quarterly world consumption; and (c) monthly forecasts of calendar year world consumption. In the process of obtaining these estimates the thesis presents the collected and in part constructed monthly data over the 1952-1963 interval for the following variables: world cocoa consumption, cocoa sales by the producing nations, world crop forecasts, and world consumption forecasts.

As a further check beyond conventional hypothesis testing procedures, the response of the estimated price-consumption subsystem to variations in crop expectations and producer sales is simulated. The amplitudes and phase relations of the simulated variables are compared with the corresponding dynamic characteristics of the actual subsystem's behavior. In addition, the simulated and actual crosscorrelation functions between producer sales and consumption are compared.

Acknowledgments

Most of the empirical literature on commodity prices
attempts to explain price movements in terms of variations in
various supply and demand variables, without any explicit
consideration of the general theory of commodity prices. To
the extent that my thesis escapes this indictment, it reflects
the friendly and persuasive cajoling of Professor Paul Cootner.
Moreover, his research in supply of storage theory provides
much of the basis of the theoretical discussion included in
the thesis. Both personally and professionally I am very
much in debt to Professor Cootner.

The entire faculty committee on my thesis, which besides
Professor Cootner included Professors Franklin Fisher, Charles
Kindleberger, and Paul Samuelson, was quite generous with its
time and advice. Despite the fact that he was in the throes
of bringing his already noted cable television study to a
close, Professor Fisher offered detailed comments on the eco-
nometric aspects of the thesis. Professor Kindleberger went
so far in his generosity as to send back comments on part of
the draft while vacationing in France. I am in debt to Professor
Samuelson not only for his suggestions during the writing of the
thesis, but also for his fundamental article on intertemporal
commodity price relationships, which article pointed the direc-
tion for the theoretical discussion in the thesis. I acknowledge
the aid and advice given by each of the committee members,

without wanting to saddle them with any responsibility for such errors as may remain.

The thesis emphasis on studying the dynamic characteristics of the cocoa industry system derives from systems concepts with which I became familiar while a member of Professor Jay Forrester's Industrial Dynamics Research Group. The continuing interest in commodity economics on the part of one of my associates in that group, Professor Willard Fey, had much to do with my own commitment to research in depth in the commodity area.

During the period when I war writing the thesis I was an employee of the James O. Welch Company, a confectionary manufacturer which is now a division of the National Biscuit Company. Well over half of my time during this period was spent on my thesis. While the thesis provides the basis for applications of direct benefit to the company, I owe a major debt of gratitude to Mr. James Welch and Mr. James Welch, Jr. for the risk which they took in initially underwriting my research, and for the friendship and encouragement which they have offered me since that time. My ties with the Welch Company in turn provided the basis for establishing close contack with Mr. T. Patrick Aitken and Mr. John Byers of Gill and Duffus, Inc., and with Mr. Jerry Spielman of Bache and Company. These individuals and their firms have been most helpful in providing me with statistical information and

qualitative background knowledge for the thesis.

The comprehensive services of the MIT Computation Center - - key punching, program consulting, and run processing, with 24 hour access to the last of these - - were indispensable in achieving the quantitative results presented in the thesis.

Finally, while I have always been convinced that I have been lucky in love, this conviction has grown all the more during the writing of my thesis. Not only has my wife, Caroline, provided the inspiration and displayed the patience which every married thesis student knows to be necessary, she typed the entire draft and final copy of the thesis, while meeting her obligations as an Assistant Trust Officer in the New England Merchants National Bank.

F. Helmut Weymar

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Chapter 1

Objectives and Context

1.0 Introduction

My objective in this paper is to describe and explain the nature of the dynamic response of the world cocoa industry to annual fluctuations in world cocoa production. Before elaborating on this objective, I shall briefly sketch the cocoa industry structure, in order to provide a general context for the remainder of the thesis. Then, after more fully defining the thesis objective, I shall lay out the plan of attack to be used in the chapters which follow.

1.1 A Brief Description of the World Cocoa Economy

The discussion which follows regarding the nature and history of the world cocoa economy is in part factual (i.e. based on well documented information) and in part theoretical (i.e. based on what seem to me to be reasonable assumptions). What is fact and what is assumption will be made clear in the more detailed discussions in succeeding chapters.

Figure 1-1 shows a flow graph indicating the way in which the more important industry variables are related to one another. In the paragraphs which follow I shall describe these relationships. Figure 1-2 shows the history of several of the industry variables.

FIGURE I-I FLOW GRAPH OF COCOA INDUSTRY STRUCTURE
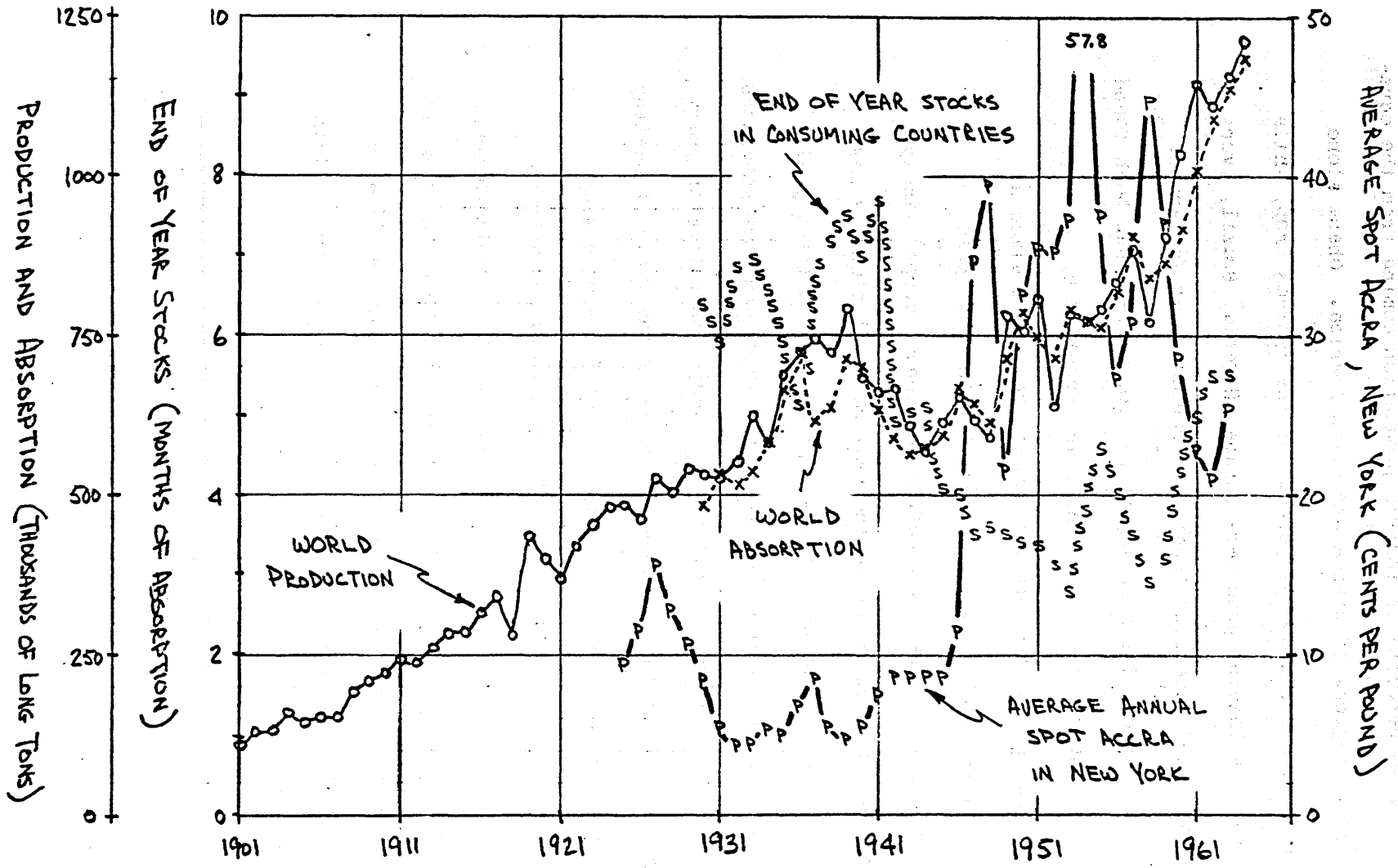
FIGURE 1-2 PAST BEHAVIOR OF SEVERAL COCOA INDUSTRY VARIABLES

(ALL DATA FROM REFERENCES 3 AND 4, GILL AND DUFFUS)

Cocoa beans are harvested from cocoa trees, with most
(over 90 percent) of today's production coming from the equa-
torial regions of Africa and Latin America. Ghana alone
accounted for about 37 percent of the 1962-63 crop, while
the five leading producers (Ghana, Nigeria, Brazil, Ivory
Coast, and Cameroon) together produced about 76 percent
of the crop. The planting of new cocoa trees has been found
to be influenced by the real price received by cocoa pro-
ducers, and by special government incentives aimed at
encouraging planting.[1] In addition the real price of
competitive crops (e.g. coffee, or annual crops) likely
plays a role here, as do the real costs of planting new
cocoa farms. An acre of newly planted cocoa trees yields
little or no cocoa before its fifth year, and then generates
a sharp increase in yield until roughly its fifteenth year.
At this point the continued increase in the yield of healthy
trees begins to be off-set by the incidence of disease
in some of the less vigorous trees. Yield per acre con-
tinues to increase slowly until roughly the twentieth year,
and then levels off and begins a long decline. The time at
which maintenance and harvesting is no longer profitable
at normal prices varies between the thirtieth and fiftieth
year after planting.

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[1]Reference 2, p. 3; Reference 7, p. 32.

While cocoa trees are afflicted by many types of
disease, the worst of these historically have been "witches
broom" (in the West Indies) and "swollen shoot" (in Africa,
and particularly in Ghana). These diseases are both viruses,
for which no cure is currently known. In the case of
swollen shoot, the virus is carried from tree to tree by
insects with the result that the disease can easily spread
from a small pocket of diseased trees to an increasingly
large area. The only way of preventing such spreading
is to cut out and burn diseased trees as soon as the infec-
tion is observed. The main sympton of swollen shoot is
a decline in yield over a period of from two to ten years
until the infected trees yield little or no cocoa.

The yield of an average cocoa tree for any given
season can vary significantly depending on weather and the
amount of attention paid by the cocoa farmer. The farmer
can increase yield in the short run by weeding and spraying
more often and more thoroughly. Spraying can substantially
eliminate the two main natural hazards to cocoa bean pods,
capsid flies and black pod disease. Various writers claim
that the short term crop care efforts of cocoa farmers
are quite sensitive to producer price variations, but to
my knowledge no thorough study has been made on this point.

The plateau in world cocoa production (see Figure 1-2)
which took place from 1938 through 1957 has to some degree

been attributed to the increase of swollen shoot disease,
especially in Ghana (formerly the Gold Coast). During the
early and middle 1950's the governments of both Ghana and
Nigeria undertook major programs aimed at arresting the
spread of swollen shoot. These efforts involved not only
the cutting out of a substantial number of infected trees,
but also the planting of new trees of the high-yield
varieties developed since the war. In addition, the Ghanaian
and Nigerian governments offered direct subsidies to farmers
along with educational programs in order to increase the
use of sprays combatting capsid flies and black pod disease.
These various governmental efforts, aided and perhaps in
part caused by the high prices during the late 1940's and
early 1950's, are generally credited for the rapid increase
in cocoa production over the 1958-1961 interval. The pro-
grams were financed by the marketing boards in the two
countries, which in turn derived (and still derive) their
revenues by paying the cocoa farmers (who by law must sell
to the boards) less than the farm equivalent of open market
prices. To some degree the marketing boards have stabilized
farmer prices, in that they have tended to keep a substan-
tially higher portion of the world price during intervals
of high prices than during intervals of low prices, and at
times of rapid price decline have sometimes paid the farmers
more than the farm equivalent of the world price.

As the cocoa is harvested (from October through February in the key African nations) it is generally sold and exported fairly rapidly (some forward sales take place) to the major northern hemisphere consuming areas (E.E.C., U.K., and U.S.), since cocoa beans tend to deteriorate if stored for long periods in producing regions. Early harvesting figures (or more accurately, early purchasing figures on the part of the marketing boards) form the primary basis for initial estimates of the entire crop. In addition, reports regarding weather and disease conditions coupled with a minor amount of statistical sampling are used for crop forecasting purposes. Such forecasts are issued by private sources (primarily Gill and Duffus Ltd., an international cocoa dealer) along with the Food and Agricultural Organization of the United Nations.

The same sources generally begin to issue world consumption forecasts for the coming calendar year sometime during the fourth quarter. These forecasts are based on past consumption trends, and judgements about the influences of exogenous factors and recent prices on future consumption. The evolving crop and consumption forecasts, and estimates of current and future world cocoa inventories all go together to provide the primary basis for changes in the world price of cocoa. If current stocks plus expected bean production are small relative to expected bean grindings, then the bean

price will tend to be high relative to "normal" price expectations, and vice-versa. Normal price expectations reflect aggregate notions regarding the markets long term equilibrium price level (i.e. the price level at which the long term growth rate in production equals the long term growth rate in consumption), and are based primarily on past price behavior. In the short run cocoa prices are also influenced by technical factors relating to speculative activity in the London and New York cocoa futures markets.

In commercial use cocoa beans are first cleaned, roasted, and shelled, and then ground into a liquid mass called chocolate liquor. The liquor is then either used directly in the manufacture of chocolate confectionaries and biscuits, or pressed to yield two separate products, cocoa powder and cocoa butter. Cocoa butter is combined with chocolate liquor in the manufacture of the lighter (milk) varieties of chocolate. Cocoa powder is used in producing cocoa drinks. In recent years powder has been a surplus product, and at times has been discarded as waste.

Total cocoa grindings can be broken into two categories, grindings for chocolate liquor to be used directly in making chocolate, and grindings for cocoa products (butter and powder) to be used (or sold) separately. This

is a distinction in intent only. Both types of grinding may go on in the same plant, particularly in the case of those chocolate manufacturers who grind for their own liquor and butter needs, and sell or discard the excess powder.

The decision to grind for chocolate liquor is based directly on the decision to produce chocolate, which in turn closely reflects recent sales of chocolate, since finished chocolate inventories are generally held at low levels and do not fluctuate widely. Thus the chocolate manufacturing rate is determined by the price of chocolate and other demand influencing variables (population, incomes, tastes, competitive prices, etc.). The price of chocolate, in turn, is determined by ingredient costs (i.e. primarily the prices of cocoa beans, cocoa butter, sugar, and milk powder), along with grinding and manufacturing costs.

The decision to grind for cocoa products is deter-mined primarily by the profitability of such grinding, namely the grinding margin (the value of the products minus the cost of the beans) minus grinding costs. The prices of powder and butter reflect the inventory levels for these products relative to their respective usage rates. If either product inventory level is low relative to usage, the corresponding product price will tend to rise, and vice-versa. In the case of butter, the usage rate is determined almost completely by the chocolate manu-

facturing rate. Powder, however, is consumed as a separate
product, so that its usage rate is determined directly
by its price along with other demand influencing factors
(population, etc.).

As is indicated in Figure 1-1, this rather complicated
decision mechanism for the cocoa grinding (consumption)
rate can be treated, at least conceptually, as a straight-
forward demand mechanism, with cocoa consumption deter-
mined by lagged cocoa prices and various exogenous influ-
ences (e.g. populations, national incomes, etc.). This
is based on the fact that the prices of the three cocoa
products - liquor, butter, and powder - all reflect the
price of cocoa beans, so that in the final analysis it is
the bean price which determines product (and therefore bean)
consumption. The lag in the price effect on consumption
reflects a lag in the response of product prices to changes
in bean prices, coupled with a lag in the adjustment of
product usage to changes in product prices.

So much for the general structure of the cocoa economy.
We move now to a discussion of the specific objective of
the thesis.

1.2 Objective and Outline

Cocoa price movements can usefully be separated into
three categories: long term, intermediate term, and short

term. Each of the three classes of price fluctuations can be identified with its own causal mechanism.

Long term cocoa price fluctuations are generated by the feedback loop linking cocoa prices with the rate of new planting, planting with production, production with inventories, and, finally closing the loop, inventories with prices. The dynamics generated by this loop follow conventional cobweb lines: (1) a period of low prices, such as the 1930's and early 1940's, causes a decline in new planting; (2) after the substantial delay required to clear the pipeline of maturing trees, production begins to level off, and perhaps decline (e.g. the production plateau lasting from 1939 to 1955); (3) with normal growth, consumption begins to outpace production, causing inventories to fall; (4) cocoa prices climb (e.g. the late '40's and most of the '50's), bringing a revival in new planting, and starting the second half of the cobweb cycle. The length of the period between successive peaks and troughs in these long term fluctuations is in large measure determined by the average length of the delay between the time of planting and the time of peak production of a cocoa tree.

At the opposite extreme, short term month-to-month price fluctuations in part reflect alternating tides of bullish and bearish speculative enthusiasm in the world's

cocoa markets. The speculative element in the market tends
to focus its attention for prolonged intervals on one or
two background developments which may have an important
effect on future cocoa prices. Trends in the influence
of natural hazards on production, or the recent increased
desire on the part of the cocoa producing nations for a
production and/or marketing control agreement provide
examples of such background developments. Some particular
event, such as an impending meeting among the cocoa pro-
ducers, will be judged by the hard core of the cocoa trade
to have special potential (say) bullish significance.
First a few members of the trade will act on this judge-
ment by extending their cocoa positions. The resulting
price firmness tends to lend credence to the original
judgement, and soon all of the cocoa market media begin
to enthuse over the bullish implications of the event under
focus. Eventually anyone who is willing to buy cocoa
given the most optimistic general interpretation of the
situation has already bought, and the event becomes
"fully discounted". The whole process up to this point
may take anywhere from a day or two to a month.

As the developments in question unfold, they are
likely to fall short of the extreme bullish potential which
could be visualized ex ante. The early birds take their
profits, and the price begins to fall. With events having

fallen short of hopes, disillusion sets in. The skeptics of the original bullish rationale, silent or at least unheard during the price climb, now press their bearish cases as the market heads toward the opposite extreme.

In between the long and short modes of behavior lie the intermediate-term movements in cocoa prices, consumption, and inventories. These fluctuations, which will provide the subject of the thesis, represent the response of the cocoa industry system to annual variations in world cocoa production. Recent examples are provided by the 1953-54 price rise, the subsequent decline into 1957, the doubling in the price level culminating in 1958, and the long decline into 1962.

The nature (or more properly, a hypothesis regarding the nature) of the subsystem of feedback loops which generates the intermediate-term behavior of the cocoa economy, and which will be called the price-consumption subsystem, is indicated in Figure 1-1. In response to (say) a weather caused crop shortage, inventories and expectations regarding future inventories both fall, causing the price to rise. After adjustment lags, consumption and consumption expectations decline toward a level more in line with the short crop, but not before inventories have been further depleted, and the price forced still higher. With the continued price rise, consumption is reduced below the production

rate, and the inventory decline is reversed. The price now begins to fall, but the consumption rate does not end its decline until after an adjustment lag. By this time the inventory level is well up from its trough and increasing further, causing a continued price decline. Consumption finally begins to climb in response to the lower prices as the second half of the cycle begins.

The degree to which such intermediate term fluctuations are damped is in large measure determined by the nature of the industry's consumption forecasting procedure. If consumption forecasts covering the next 12 months or so accurately reflect the effect of known past prices on future consumption and effectively gauge future price-consumption interactions, then the price overshoot (or undershoot) resulting from an exogenously caused crop variation will be curtailed, and the system's response will be highly damped. If, on the other hand, consumption forecasts are based on past consumption, which in turn is partially determined by past prices, then the total lags around the relevant feedback loops[1] will be long enough to give rise to noticeable intermediate term fluctuations.

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[1] In Figure 1-1, the (price - past prices - consumption - past consumption - consumption expectations - price) and (price - past prices - consumption - past consumption - consumption expectations - inventory expectations - price) feedback loops.

In terms of the above framework, my objective in this paper has two parts: (a) to determine the quantitative nature of the subsystem of equations which generates intermediate term fluctuations in the world price, consumption rate, and inventory level of cocoa in response to exogenous changes in producer sales of cocoa, and in world production forecasts; and (b) to study the dynamic characteristics of that subsystem.

In obtaining estimates of the individual equations I shall use data covering the 11 year interval from September, 1952, through August, 1963, that being the interval for which the full set of necessary data exists or is amenable to reasonably reliable construction. To provide an historical context for the statistical estimates, Chapter 2 consists of a review of the more important events which took place in the cocoa market during the data period, with an emphasis on the way in which these events influenced cocoa prices.

Given the desire to study the dynamic characteristics of the price-consumption subsystem, it will be necessary to estimate the individual equations in such a way that these equations explain their respective dependent variables on a monthly basis. This requirement arises from the fact that a month is the largest practical (in terms of available data) time interval which is still small enough to allow the estimated difference equations to generate behavior closely

approximating the actual continuous cocoa system. The use of a monthly time interval gives rise to problems in estimating the price equation, since there exists no adequate theory for explaining monthly commodity price behavior. In Chapter 3 I develop such a theory after reviewing the general commodity price literature. Chapter 4 describes the statistical estimation procedure for the price equation.

Chapter 5 concludes the statistical research in the thesis with estimates of the equations generating world cocoa consumption and consumption expectations, thus completing the model of the price-consumption subsystem. In Chapter 6 I shall first indicate the degree to which the estimated subsystem generates behavior similar to that observed over the data period when driven by the observed time series for producer sales and crop expectations. I shall then analyze the characteristics of the dynamic behavior generated by the estimated subsystem. Chapter 7 summarizes the thesis.

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Chapter 2

The World Cocoa Market, 1953 - 1963

2.0 Introduction

My objective in this chapter is to review the history of the world cocoa market over the period from 1953 through 1963. The emphasis will be on explaining the major price movements during this period in terms of their apparent immediate causes.

One important source of information for the history has been the series of market reports generally issued monthly during the period under study by Gill and Duffus, Ltd., a London and New York cocoa dealer. These reports have provided and still provide the most important source of cocoa market news and statistics available to the trade. In addition, cocoa market letters issued by Frank Sweeney Co. (formerly Emil Pick Co.), a New York cocoa broker, and Bache and Co., a commission house, were also used as references. The appendix to this chapter consists of a monthly review of the comments made in these three sources from 1953 through 1963, with the primary reference being the Gill and Duffus reports for the months in which they were issued. The comments included in the appendix include not only descriptions of important cocoa market events, but also market opinions where these were clearly stated. Thus a careful

reading of the appendix should provide an indication of the changing tone of the market opinions of at least part of the trade during the period of interest.

Figure 2-1 shows various monthly time series which will be referred to frequently in the remainder of the chapter:

1) Cocoa Price -- The monthly average spot price of Accra cocoa beans in New York.

2) Estimated World Production -- Sometime near the start of each crop year (October 1) Gill and Duffus usually begins to issue monthly forecasts of total world production for that year. This series consists of such forecasts in months when they were made, starting in September of each year. For the months during which Gill and Duffus did not issue new crop forecasts various substitute figures were used. The nature of such substitutes is explained in Chapter 4, which uses this series in a statistical analysis of price movements.

3) Estimated World Absorption -- Gill and Duffus also issues monthly forecasts of world absorption (i.e. grindings) during each calendar year, usually but not always beginning sometime around January of that year. This series, beginning in the September preceding each calendar year, is made up of either the Gill and Duffus forecasts when available, or else various substitute forecasts. Again the exact derivation of the absorption series is explained more fully in Chapter 4.

4) Current Inventory Ratio -- This provides an indication

of the current cocoa supply situation, and is equal to the cur-

rent level of world cocoa inventories divided by total world

grindings over the past 12 months. The details of the deri-

vation of this series are discussed in Chapter 4.

As is evident from Figure 2-1, cocoa prices experienced

four broad moves during the period under study: an uptrend

from February, 1953, through July, 1954; a downtrend from

July, 1954, through March, 1957; an uptrend from March, 1957,

through July, 1958; and finally a downtrend from July, 1958,

through the summer of 1962. The sections which follow review

the market circumstances which prevailed during each of these

major trend periods, as well as during the 1962-63 price re-

covery.

2.1 1953-54 Bull Market

This sharp, 18 month uptrend was unique among recent

bull markets in cocoa in that it found its cause initially

in a rapid shift in demand, rather than supply, conditions.

As we shall see in Chapter 5, world cocoa consumption under

normal circumstances changes only relatively slowly over time,

in response to changes in price, incomes, and population.

But in 1953, consumption in the United Kingdom, which during

the previous year had accounted for almost 15 percent of

world net imports, increased sharply and unexpectedly in

response to the lifting of wartime controls on confectionary
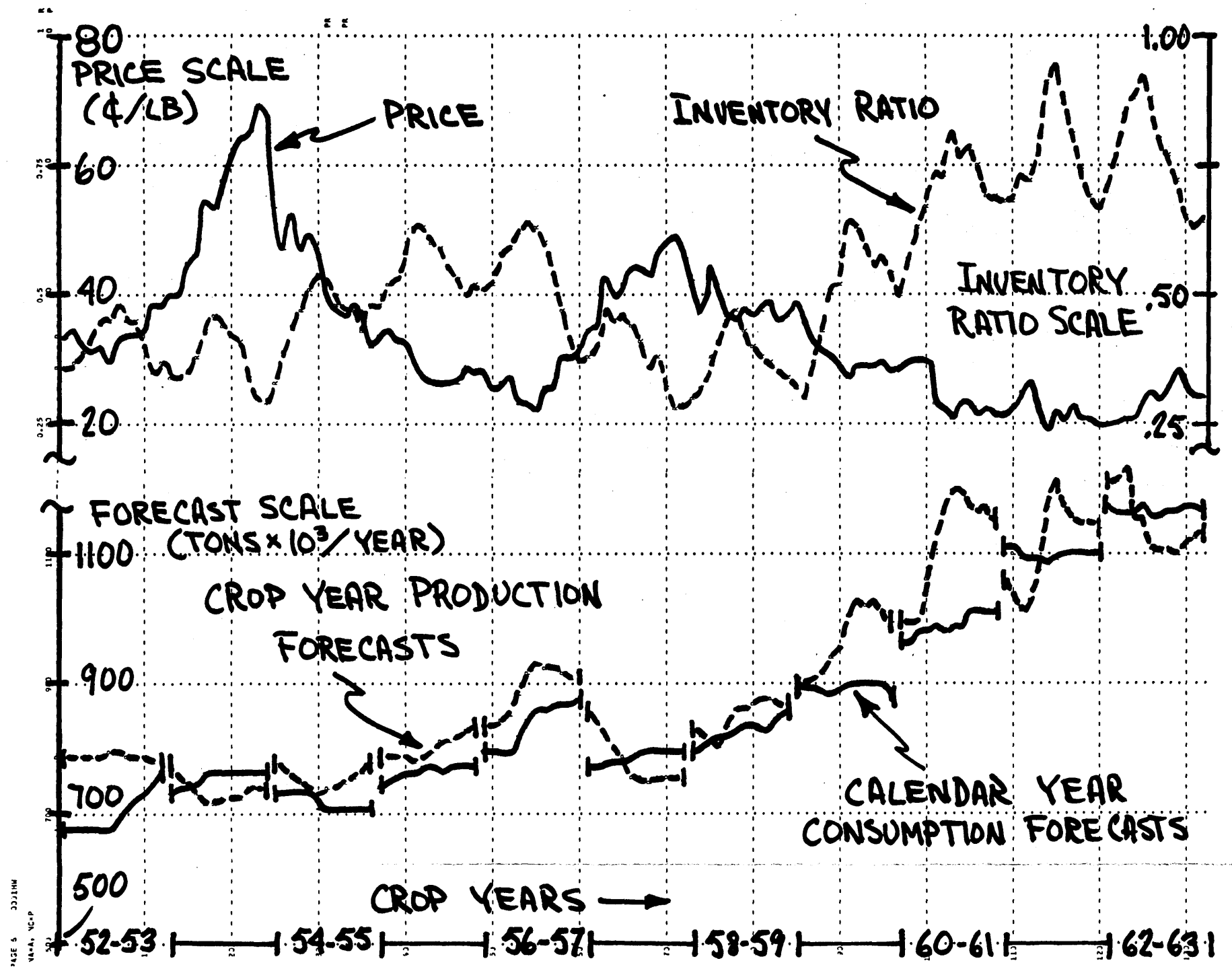
FIGURE 2-1 -- 1952-1963 TIME SERIES
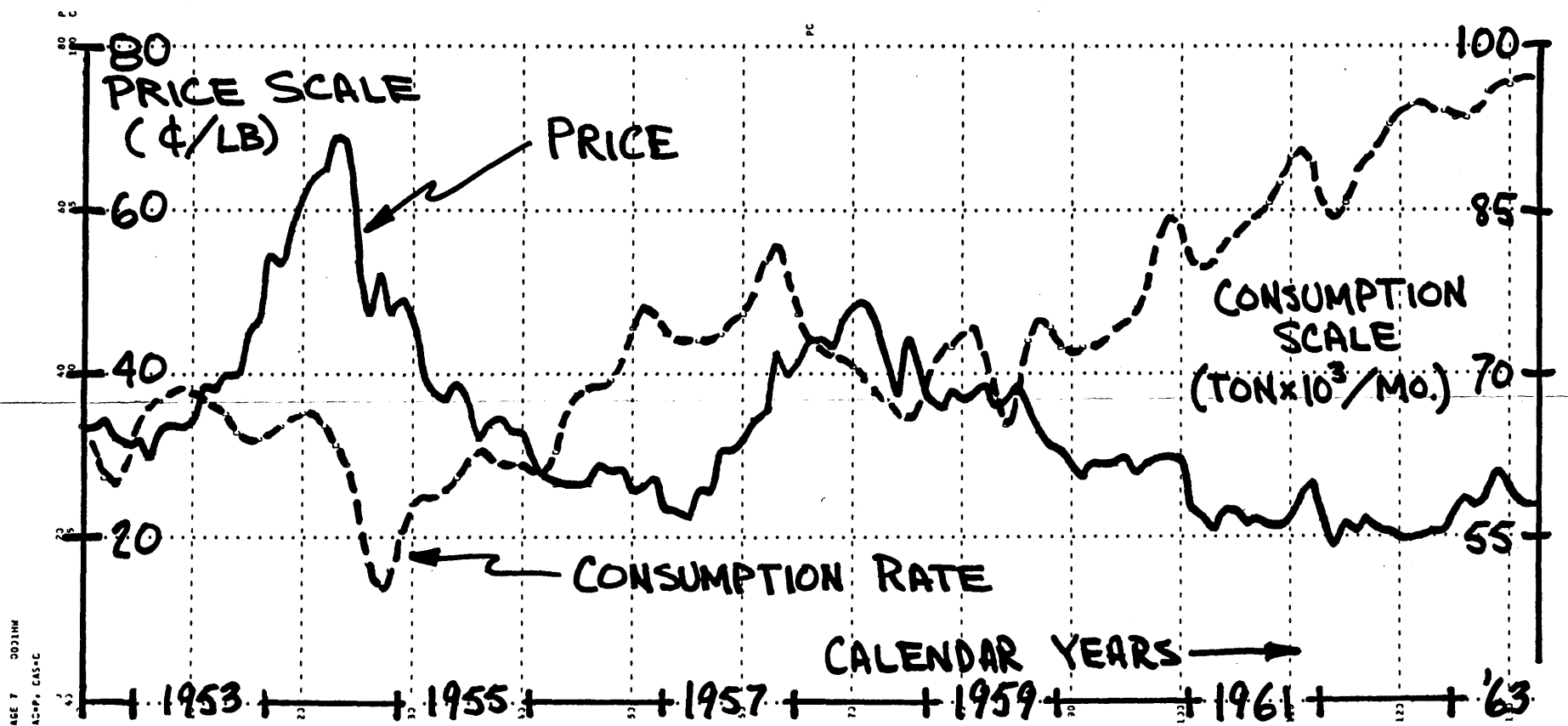
FIGURE 2-2 -- PRICE AND MONTHLY CONSUMPTION

consumption. The following excerpts taken from the appendix

to this chapter show how the events unfolded through the eyes

of Gill and Duffus:

Date	Comment
1/5/53	It is estimated that a further small price increase would cause decontrolled U.K. confectionary consumption to level off at the current rationed rate of six ounces per capita per week... It would be odd indeed if the price were to go into a steep uptrend given that this year's production is almost 10 percent greater than last year's.
2/4/53	Within the past week there was an official announcement that rationing and price control have been ended in the U.K. for chocolate and sugar confectionary... Cocoa prices and world consumption will probably be roughly equal to last year's levels.
3/4/53	With the lifting of controls in the U.K., there is likely to be some adjustment in the prices of particular kinds of confectionary, but any general increase seems unlikely. The initial heavy demand has developed as expected, but there are no signs of hoarding. Manufacturers generally are stepping up production to meet demand. It is too soon to gauge the level at which demand for sweets is likely to settle, but as the rate of buying declines, competition is expected to revive in the trade. The overall increase in U.K. cocoa bean consumption as a result of decontrol will probably be about 5,000 tons (about five percent) or perhaps somewhat more.
4/9/53	Present tentative estimates indicate that U.K. consumption may have increased by 8-10,000 tons per annum (roughly 10 percent) due to decontrol.
5/4/53	Reports regarding U.K. confection demand vary, with some saying that a new level of eight ounces per head per week has been reached and maintained, as opposed to six ounces before decontrol.
6/17/53	During the first four months of 1953, U.K. cocoa bean consumption was up over 10 percent... Some authorities feel that the new level of confection-

ary demand will be nine ounces per head per week.

7/13/53   Informed estimates of free confectionary demand in
          the U.K. now range from 6.1 to 7.75 ounces per
          head per week, versus 7.25 ounces before the war,
          and six ounces under control.

8/5/53   The U.K. supply-demand situation appears to have
          become more normal.

12/11/53 U.K. confectionary production has reached a re-
          cord level of 10 ounces per head per week; manu-
          facturer and distributor stocks have now been
          rebuilt following the decline after derationing...
          U.K. consumption over January-October was over 16
          percent ahead of last year.

2/15/54   Final U.K. consumption for 1953 was roughly eight
          ounces per head per week, an increase of 30 to
          40 percent over the two previous years.

3/1/54   U.K. confectionary distribution over November,
          December, and January was 10.3, 9.3, and 7.9
          ounces per head per week, respectively. Apart
          from a slight reduction in bar size, manufacturers
          have not increased retail prices so far.

6/10/54   U.K. confectionary consumption remains at the high
          level of eight ounces per head per week.

        Using the final adjusted figures, U.K. per capita consump-

tion figures for 1953 and 1954 were 8.5 and 8.9 ounces per week,

versus something less than six ounces during 1952. These fi-

gures cover all confectionary, including non-chocolate con-

fections. 1953 U.K. cocoa bean grindings were up about 19

percent over 1952 grindings.

        As is evident from the above Gill and Duffus comments,

the marked increase in U.K. consumption caught the market

somewhat by surprise. Yet by October, 1953, when the magni-

tude of the demand increase was already fairly evident, spot

Accra in New York had only reached 40.0 cents per pound, 28.9

cents below its eventual high of 68.9 cents reached in July,

1954. The main cause of the continued increase in prices

was a rapid deterioration of the world cocoa production

outlook as the African crops were harvested. Gill and Duffus'

forecast of 1953-54 world production[1] fell from 756,000 tons

in October to 714,000 tons in January. Over the same period

their estimate of 1953 world absorption, which had already

increased over 100,000 tons in eight months, continued to

climb from 783,000 tons in October to 806,000 tons in January.

By January the price had reached 54.2 cents per pound.

The continued and dramatic upward trend from January

through July is more difficult to explain. Some small French

shippers did default on their obligations to ship cocoa,

which did not serve to calm an already nervous market, and

which may have been interpreted bullishly. More important,

demand, especially in Europe, was holding up quite well in

in the face of increased prices. This shows up clearly in

Figure 2-2, which indicates the estimated monthly season-

ally adjusted world grind (derivation given in Chapter 5)

along with spot Accra in New York, over the period of interest.

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[1]With Brazilian production adjusted to conform to the inter-
national crop year.

After falling sharply during the second half of 1953, world grindings actually increased on a seasonally adjusted basis over the first half of 1954. This led to the somewhat perplexed statement by Gill and Duffus in February:

> Despite the great price increase, demand has so far been well sustained. This level cannot be maintained in 1954 given the amount of cocoa available.

On the other hand the outlook for the Brazilian Temporao crop was rapidly improving, with the result that by June Gill and Duffus had raised its world production estimate to 740,000 tons, 26,000 tons greater than the January estimate. Further, in May Gill and Duffus quoted estimates of the decline in U.S. cocoa consumption in 1954 relative to 1953 as ranging between 25,000 and 60,000 tons, or roughly 10 to 25 percent.

2.2 1954-57 Bear Market

As indicated in Figure 2-2, the aggregate seasonally adjusted grind of the five leading consuming nations began to fall off sharply again in June, 1954. This development made the market vulnerable to any bearish break in cocoa news, since it decreased manufacturer support. The break came in the form of a rapid softening of Brazil's marketing policies. After having made substantial forward sales earlier in the year, Brazil found her sales lagging badly during the May-June interval as buyers felt that cruzeiro devaluation, with

resulting lower Brazilian export prices, was imminent. Brazil's first move came in early August, when the minimum export price for September delivery was lowered from 63.25 cents per pound, FOB, to 62 cents. Then within a week the cruzeiro was devalued by allowing 20 percent of cocoa exporters' dollar revenues to be exchanged at the free market exchange rate, rather than at the much lower official exchange rate as had been required earlier. The increase in the internal cocoa price (in cruzeiros) which this brought immediately caused a sharp increase in offers by Brazilian exporters. Simultaneously the minimum export prices for cocoa were eliminated. The result of these steps was a sharp break in Brazilian export prices for immediate shipment from 63.25 cents per pound to 52 cents. At first the British Marketing Board, which had begun its forward sales of the new African crops, lowered its asking price only slightly to a level nine cents above the Bahia sales level (versus the normal premium of about one cent). But within two weeks the British also came down and were making sales at levels competitive with Brazil.

Thus in less than one month cocoa prices had been brought back to their January levels. From there prices entered into a prolonged decline which persisted over some 30 months, ending in March, 1957. The decline found its cause in three straight years of increased world production, coupled with a

relatively long lag in the reaction of world consumption to the decline in raw cocoa prices. As indicated in Figure 2-1, world production increased from 1953-54 to 1954-55 by some 24,000 tons, while world absorption declined from 730,000 tons in 1954 to 720,000 tons in 1955. The decline in absorption took place despite a significant drop in prices coupled with an economic boom in the West, and reflected the fact that the high prices which existed during 1954 strongly influenced consumption in 1955. This is indicated in Figure 2-2. Seasonally adjusted world grindings remained at a broad plateau during 1955, apparently reflecting the price plateau at about 49 cents per pound which lasted through most of the marketing season for the 1954-55 African crops.

As the price continued to decline during 1955 and 1956, world absorption resumed its uptrend, finally catching up with and surpassing the more slowly rising rate of world production in 1957, and thereby setting the stage for the next bull market.

2.3 1957-58 Bull Market

By March, 1957, world cocoa absorption had reached a record level, and cocoa prices were at their lowest levels since 1949. Against this background the Brazilian government announced a new plan for financing farmer and dealer holding of a major portion of the coming Temporao crop in order to

enable the Brazilian cocoa trade to hold out for higher

prices. The plan was announced only after the African pro-

ducers had marketed the major portions of their crops, leav-

ing Brazil as the only major producing area with a substan-

tial amount of cocoa left to sell over the six month interval

before the 1957-58 African crops would become available.

The management of the Brazilian withholding effort was

placed under the direction of Dr. Tosta Filhio, operating

out of the Bank of Brazil. In May Dr. Tosta announced a

minimum export price some four cents per pound over the then

existing market level, thus effecting a complete withdrawal

of Brazil from the world market. The magnitude of the hold-

up relative to the Brazilian marketing pattern which existed

during the previous year is indicated in Figure 2-3. By the

end of August Brazilian sales lagged the previous year by

almost 60,000 tons, or roughly seven percent of the 1956-57

world crop.

As could be expected, the Brazilian withdrawal left the

market in a state of confusion. World production had in-

creased for three years in a row and there was no reason to

expect a reversal in this trend. On the other hand world

absorption had almost equaled production in 1956, and by the

summer of 1957 was once again in an uptrend in response to

the low prices which had existed earlier in the year. More

important, the main source of cocoa for nearby shipment was
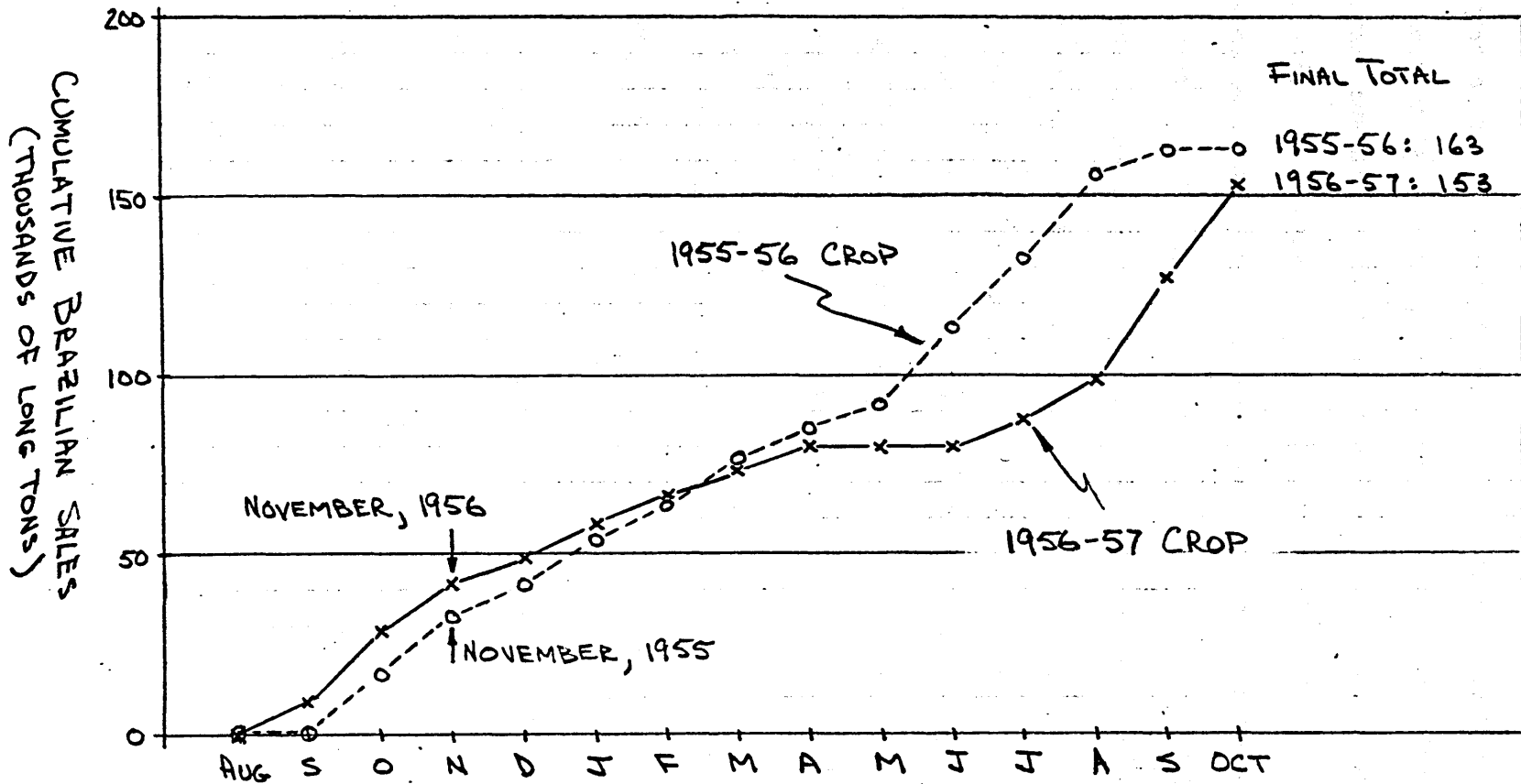
FIGURE 2-3   BRAZILIAN SALES PATTERNS, 1955-56 AND 1956-57

withdrawn from the market. As a result, cocoa prices in June were some eight cents per pound above their March lows.

As developments unfolded regarding the new cocoa crops available to the market, the Brazilian withdrawal took on the aspect of one of the largest and most successful speculations in the history of the world's commodity markets. First it became evident that the Temporao crop itself would be some 6,000 tons smaller than that of the previous year. Then the Ghana mid crop, initially forecast by Gill and Duffus at 12,000 tons, finally totalled only 2,634 tons. But the most important news was yet to come. In September Ghana issued its official forecast of the new main crop at 235,000 tons, down from 262,000 tons for the previous year. Even this proved optimistic, as the crop finally totalled only 195,000 tons. At the same time Nigeria's main crop fell to 74,000 tons from 122,000 tons during the previous year. Total world production in the 1957-58 crop year fell over 14 percent from 893,000 tons to 767,000 tons.

As the magnitude of the crop shortage was slowly becoming evident during the early fall of 1957, world grindings were still climbing at a rapid pace (see Figure 2-2), reaching a peak in November. As a result cocoa prices continued their climb and finally caught up with the Brazilian minimum export price, with the result that in September and October Brazil marketed the bulk of its Temporao crop. With world inven-

tories cut to minimum levels prices continued to climb,
though eratically, through June, 1958.

2.4 1958-62 Bear Market

During the late summer and early fall of 1958 crop
views evolved in a manner essentially opposite to that of
the previous summer. First it became evident that the Tem-
porao crop would be over 15 percent larger than the previous
Temporao crop. Then the Ghana mid crop turned out at 11,851
tons versus 2,634 tons the previous year and an earlier fore-
cast of 4,000 tons. Moreover, the trade generally viewed
the outlook for the African main crops as being very bright,
which opinion was supported by the official Ghanaian forecast
in September at 237,000 tons, over 20 percent greater than the
previous year's 195,000 ton main crop. As a result of these
developments prices in October were some 10 cents below
their August average of 47.4 cents per pound, basis spot
Accra in New York.

The rosy outlook generally held by the cocoa trade re-
garding the size of the African crops reversed sharply and
suddenly in early October, with the result that during the
five week interval from October 7 to November 17 spot Accra
in New York advanced from 36.9 cents per pound to 46.9 cents
per pound. Then, almost as rapidly, the production outlook
became rosy again, causing spot Accra in New York to fall to

35.3 cents per pound on February 6. The events which underlay
cocoa price movements from August, 1958, through February, 1959,
provide an extreme case of the price determining process which
the cocoa market commonly goes through during that season
of the year. For this reason it should be interesting to
go into those events in some detail.

The first noteworthy aspect of the usual process is the
heavy emphasis which published and unpublished market views
place on the expected size of the Ghanaian main crop, the har-
vest of which begins sometime in September or October. This
emphasis finds its origin in three facts: (1) it is easier
to concentrate on estimating the size of one relatively local
crop than it is to try to estimate the crops of several nations
with differing growing conditions; (2) the Ghanaian main
crop generally accounts for some 30 to 40 percent of annual
world production; and (3) more often than not as far as cocoa
crops are concerned, Africa goes as Ghana goes, and all of
Africa normally accounts for about 70 percent of world pro-
duction. In late 1958, the market placed its usual heavy
emphasis on the expected size of the Ghanaian main crop.

Second, before the actual harvest begins, estimates of
the size of the forthcoming Ghanaian main crop are quite sub-
jective, and are vulnerable to extremely large errors. These
two characteristics of early cocoa crop forecasts arise in
turn from two facts: (1) little is known today, at least

in a quantitatively useful form, regarding the way in which
the size of a given crop is determined by nature and the cocoa
economy; and (2) much of the data which one would want to
have in making a forecast or in constructing a reliable
general forecasting procedure is not available. For example
in Ghana only very sketchy information exists regarding the
number of existing cocoa trees, or the age distribution of
the trees, or the planting rate of new trees, or the distri-
bution of various strains having different characteristic
yields. All of these variables have an important effect
on the size of the Ghanaian crops. The data is not avail-
able primarily because of the peasant nature of the Ghanaian
(and, more generally, African) cocoa economy, which makes the
collection of reliable data difficult. As a result rather
subjective estimates of the above variables are coupled with
guesses about the progress of new technology (e.g. the use
of sprays and fertilizers) and about the effects of diseases
and pests, available weather information, the size of the
previous mid crop (an abnormally large mid crop is often
followed by an abnormally large main crop), and any other
variables deemed important to arrive at pre-harvest fore-
casts of the main crop. As observed above, in the late
summer and early fall of 1958 the early forecasts called
for a substantial increase in the size of the Ghanaian main
crop, apparently based on the relatively large mid crop,

coupled with what were generally felt to be good weather con-
ditions for the main crop.

Third, the source material of crop forecasts quickly
shifts from the above subjective information to weekly har-
vesting data, as such data begins to become available in
September and/or October. More accurately, the data which
is used is the weekly purchase rate by the Ghanaian Marketing
Board from the cocoa farmers; this is a lagged version of the
harvesting rate. The purchasing rate data receives its
emphasis primarily because of its quantitative form and its
direct link to the final crop size, which is simply equal to
the sum of all of the weekly marketing board purchases. More-
over, the weekly purchases generally follow a common pattern,
so that after roughly 10 weeks of purchases are known (gene-
rally near the end of November) one can reasonably guess
that a certain percentage of the crop has been harvested,
and can base a forecast of the total crop on that notion.
It was such a transition from the initial subjective fore-
casts to the later forecasts based on purchasing rate data
that underlay the violent price fluctuations in late 1958.

Figure 2-4 shows the pattern of accumulated purchases[1]

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[1] In some years the marketing board has allowed purchases to
accumulate for two or three weeks before announcing the first
"weekly" purchase figure. This shows up in the form of a
first week purchase figure substantially larger than the second
week's figure, a relationship not representative of the actual
harvest pattern. For such seasons I have assumed that the
first announced figures actually represented the first two or
three weeks worth of purchases.
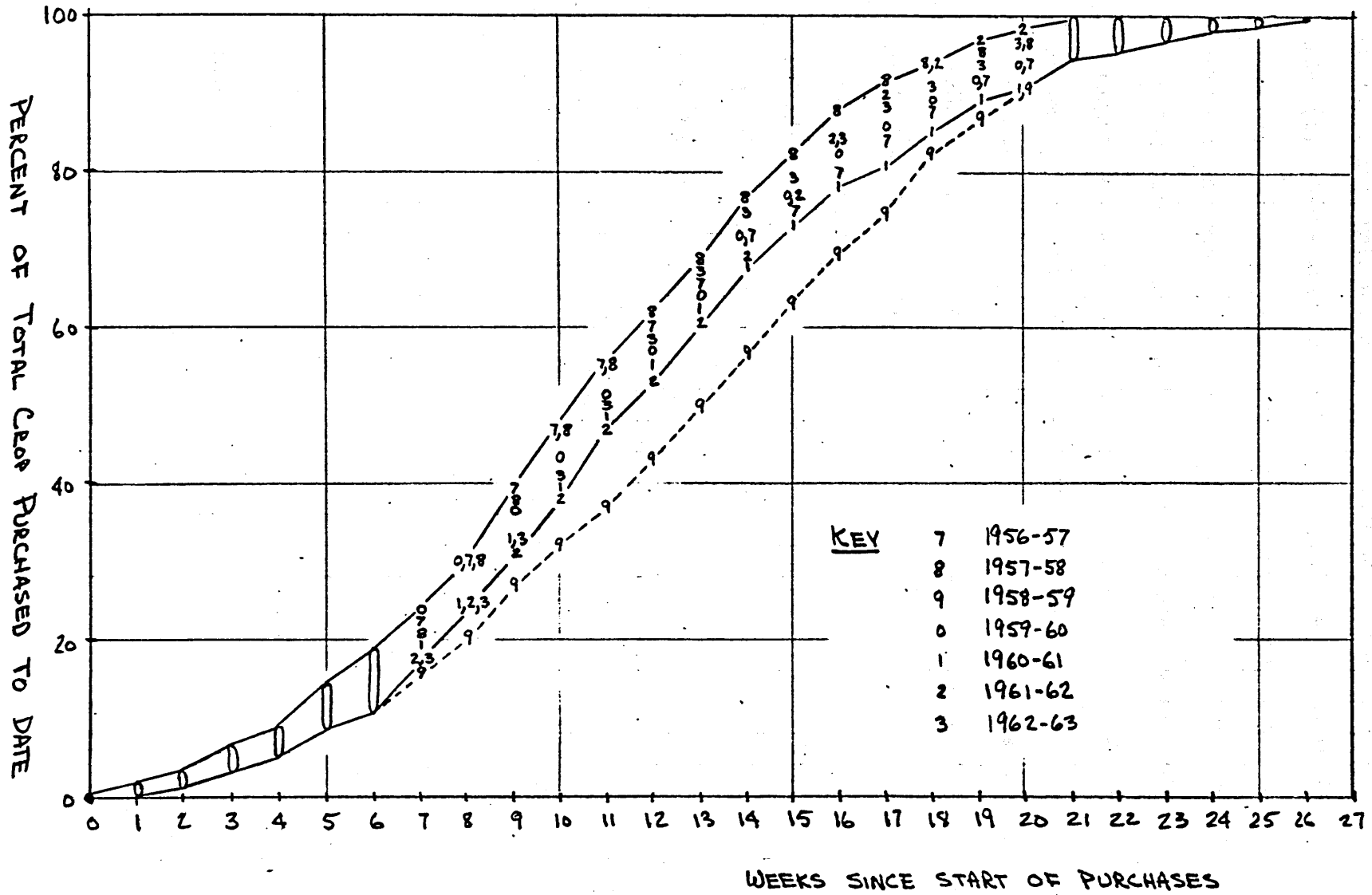
FIGURE 2-4   GHANAIN MAIN CROP PURCHASE PATTERNS

for six consecutive Ghana main crops starting with the 1956-
57 season. Two things are clear from Figure 2-4: (1) all
of the seasons except 1958-59 had rather similar purchase
rate patterns; and (2) in the 1958-59 season the bulk of
the crop was bought much later than usual. Figure 2-5
shows the average pattern of weekly and cumulative purchases
for the six seasons, excluding 1958-59, based on the percen-
tages given in columns (b) and (c) of Table 2-1. Column
(d) in Table 2-1 gives the factor by which one would multi-
ply cumulative purchases to date in order to estimate final
crop size on the assumption that the purchase pattern was
"normal"(i.e. average). For example, at the end of the 11th
week 50 percent of the crop has, on the average, been pur-
chased, so that an estimate of the total crop would be equal
to twice the cumulative purchases through the 11th week.

Figure 2-6 shows the dynamic behavior of actual fore-
casts made of the Ghanaian main crop during the fall and win-
ter of the 1958-59 season, along with a forecast series based
on the assumption that the purchase pattern was normal.
The similarity in pattern between published forecasts
and the forecasts based on cumulative purchases indicates
the degree to which the published forecasts were based
on available purchase data and the assumption that purchases
would follow an approximately normal pattern. Another indi-
cation along the same lines is the fact that the market
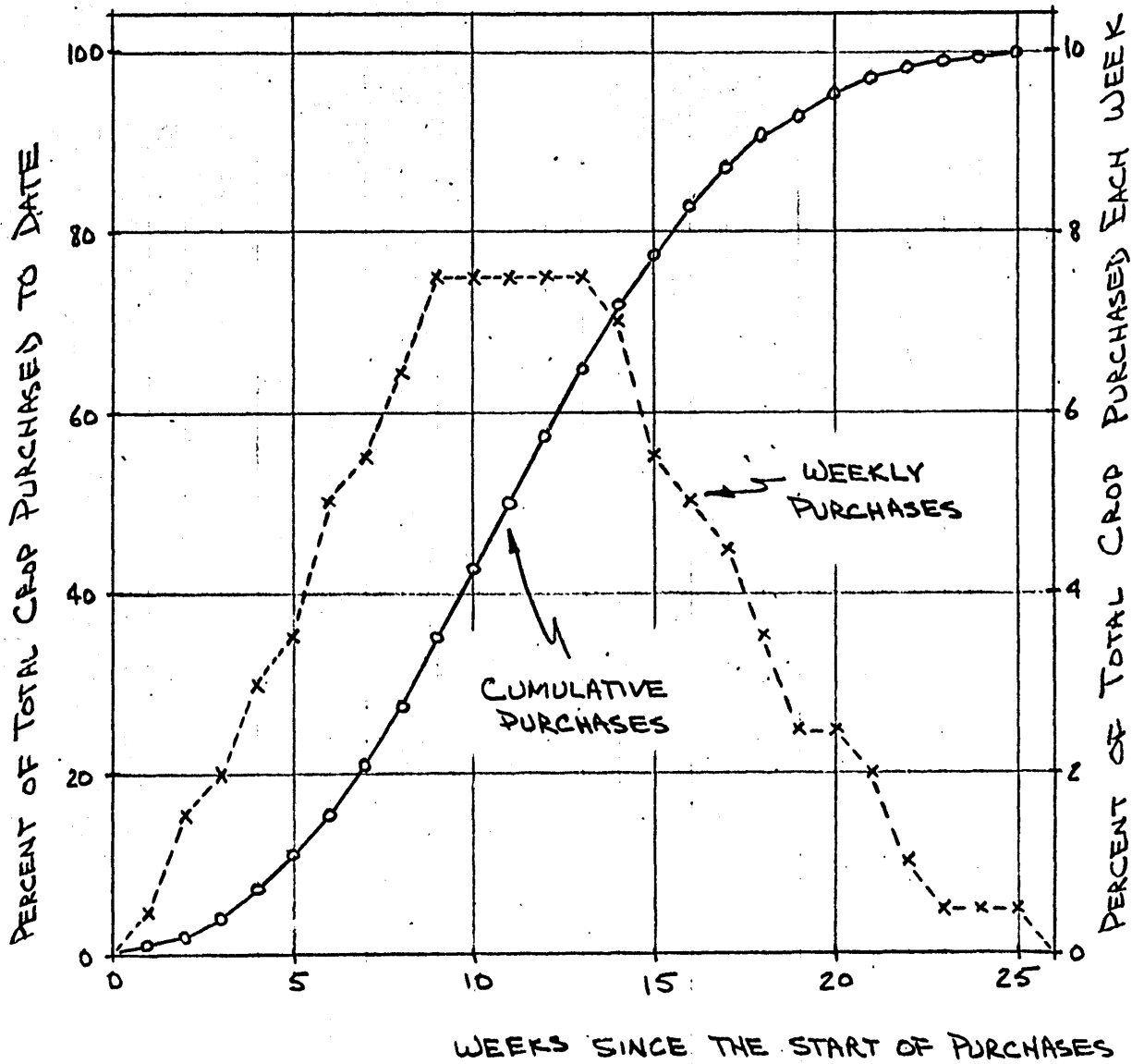
FIGURE 2-5   AVERAGE GHANAIAN MAIN CROP PURCHASE PATTERNS

Table 2-1: Average Ghanaian Main Crop Purchase Percentages

(a)	(b)	(c)	(d)*
Week	Average* % Purchased This Week	Average* % Purchased To Date	Multiplier+
0	-	-	-
1	.5	.5	-
2	1.5	2.0	-
3	2.0	4.0	-
4	3.0	7.0	14.30
5	3.5	10.5	9.52
6	5.0	15.5	6.45
7	5.5	21.C	4.76
8	6.5	27.5	3.63
9	7.5	35.0	2.86
10	7.5	42.5	2.35
11	7.5	50.0	2.00
12	7.5	57.5	1.74
13	7.5	65.0	1.54
14	7.0	72.0	1.39
15	5.5	77.5	1.29
16	5.0	82.5	1.21
17	4.5	87.0	1.15
18	3.5	90.5	1.105
19	2.5	93.0	1.075
20	2.5	95.5	1.045
21	2.0	97.5	1.025
22	1.0	98.5	1.015
23	.5	99.0	
24	.5	99.5	
25	.5	100.0	
26			

* Based on the seasons from 1956-57 thru 1962-63, excluding 1958-59

+ Multiplier = $\dfrac{1}{\text{Fraction Purchased to Date}}$
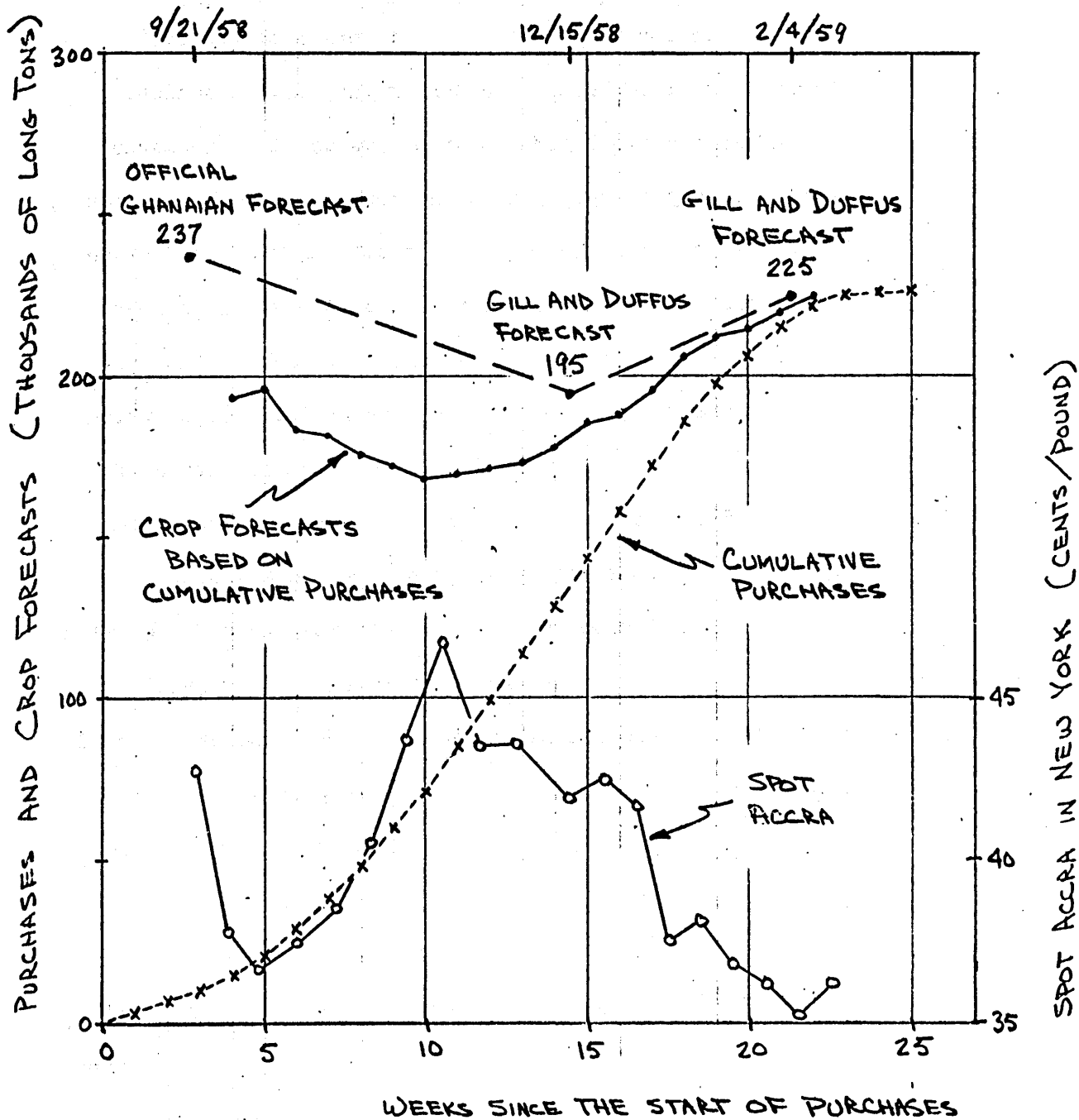
FIGURE 2-6   PERTINENT VARIABLES, 1958-59 SEASON

reached its high at the same time as the forecast series based on cumulative purchases made its low.

So much for the normal price determining process which takes place before and during the harvest season.

After the final African crop news was in, the market settled at a prolonged plateau at roughly 37 cents per pound, basis New York spot Accra, thus completing the first stage of a three stage decline which lasted through the summer of 1961. As is indicated in Figure 2-1, each of the three declines came with the harvest of the African crops, which in each case were substantially larger than the crops of the preceding year, with the sizes of the increases catching the market somewhat by surprise. While grindings increased in response to the price decline, they did so with a substantial lag, as shown in Figure 2-2. As a result, world stocks increased substantially. Over the same period spot Accra fell from 41 to 19 cents per pound.

During the fall and winter of 1961 spot Accra in New York climbed eight cents from 20 cents per pound on September 25, to a high of 28 cents per pound on December 1, and then dropped over eight cents to 19.3 cents per pound on February 13. The circumstances behind these price moves closely paralleled the events which took place during the harvest of the 1958-59 Ghana main crop, described above. As indicated in Figure 2-7, Gill and Duffus dropped its fore-
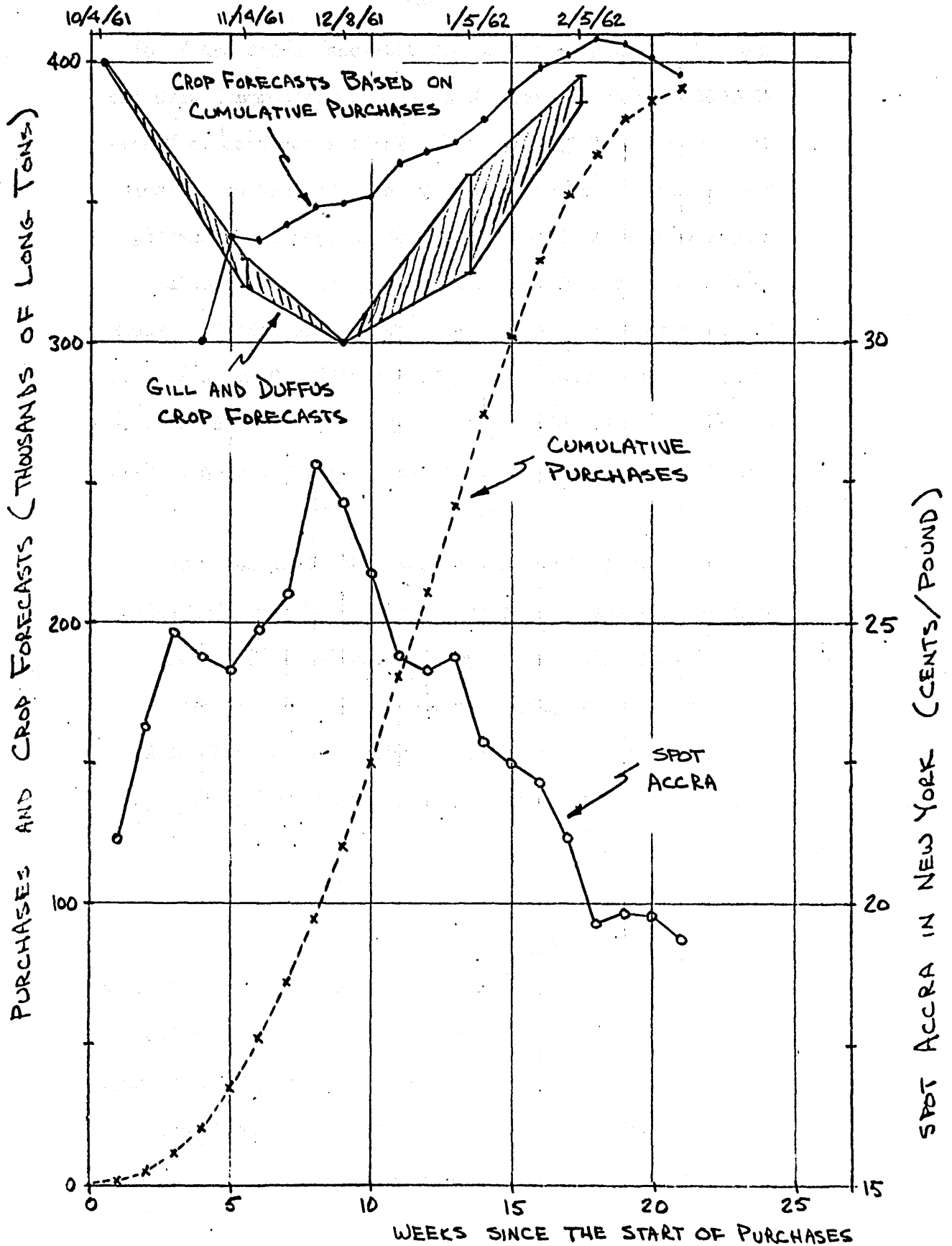
FIGURE 2-7 PERTINENT VARIABLES, 1961-62 SEASON

cast of the main crop from 400,000 tons on October 4 to
300,000 tons on December 8; these figures compare with the
final outturn of 391,000 tons. The low forecast in Decem-
ber reflected the fact not only that the bulk of the pur-
chases came quite late relative to the purchase starting
date, but also that they came even later on a calendar
basis, since the first purchases were made some four weeks
later than is normal. As of November 29, 1961, cumulative
purchases totaled 96,000 tons, versus 232,000 tons at the
same date of the previous year when the total crop equalled
421,000 tons.

While 1961-62 world production was four percent
smaller than that of the previous year, it still exceeded
1962 absorption by almost 30,000 tons, with the result
that world stocks again increased, the inventory ratio
remained high, and spot Accra traded at or around the 21
cent level through November, 1962, after its earlier pre-
cipitous decline.

2.5 1962-63 Price Recovery

With the harvest of the new African main crops in late
1962 and early 1963, the market began to climb from its
plateau at around 21 cents per pound to a new trading range
centered around 26 cents with limits of roughly 24 cents
and 28 cents, and stayed within these limits for the remain-

der of 1963. As in the 1958-59 and 1961-62 seasons, the

harvest period market strength reflected reduced Ghanaian

and world crop prospects; the difference was that this time

the reduced prospects were valid. From November 5, 1962,

to February 4, 1963, Gill and Duffus reduced its world pro-

duction estimate from 1,230,000 tons, over 100,000 tons

greater than the previous year's output, to 1,104,000 tons,

some 20,000 tons less than the previous crop. The three

major producers all contributed importantly to the November-

February decline in estimates: Ghana fell from 430,000

to 390,000 tons, Nigeria from 210,000 to 175,000 tons, and

Brazil from 160,000 to 118,000 tons. An indicated production

surplus of perhaps 60,000 tons was replaced by an estimated

deficit of 63,000 tons. Based on the apparent reduction

in world output, the long term outlook for world production

on the part of the cocoa trade became quite pessimistic.

In its February report Gill and Duffus observed:

> The long term production outlook in Africa is
> obscure due to the spread of spray resistant
> capsid insects and swollen shoot diseases.
> Other things being equal, next year's production
> could well be below even this year's output.
> Destructive weather conditions have prevailed
> in Brazil. On the other hand, the strong up-
> ward trend in consumption is well established,
> and from past experience present prices should
> not put a brake on usage.

The bumper Ghana mid crop of 1963 (40,000 tons versus

the May Gill and Duffus estimate of 15,000 tons) caused a

summer decline from 28 cents to 24 cents, but before the

year was out spot Accra was back to 27 cents in response

primarily to late Ghanaian purchases.

Appendix 2 A

Monthly History of the World Cocoa Market, 1953 - 1963

This appendix presents a monthly review of the impor-
tant developments in the cocoa market, as well as opinions
about the likely market effects of these developments,
over the 1953 - 1963 interval. The sources for the review
are referred to by number in the appendix:

1) Cocoa Market Reports, generally issued monthly by
Gill and Duffus Ltd., world cocoa dealers.

2) Cocoa letters issued weekly or bi-weekly by Bache
and Co., a U.S. commission house.

3) Cocoa letters issued weekly by Frank Sweeney Co.
(formerly Emil Pick Co.), a New York cocoa broker.

The Gill and Duffus reports provided the primary source,
and were always referred to for those months in which they
were issued. For the remaining months the Bache and Sweeney
letters were used. Occasionally, in order to provide con-
tinuity or more complete coverage, two or more of the
sources were used for a single month. Since the specific
comments of interest in the reports and market letters
were often rather wordy, I have at times taken the liberty
of paraphrasing these comments without (hopefully) distorting
their meaning, so that the monthly reviews do not always
represent direct quotations.

The review covers a period of 132 months, and for this

working of the new free exchange market in Brazil...
In the short term, the market is potentially dan-
gerous in either direction.

3/4/53   No..1: When the marketing boards indicated in Febru-
ary that they would sell at prevailing market levels
in London after a prolonged withdrawal, the market
became decidedly weaker. The stalemate between
the West African marketing boards and the U.S.
buyers continues, with neither willing to close the
gap between their respective price notions... With
the lifting of controls in the U.K., there is likely
to be some adjustment in the prices of particular
kinds of confectionary, but any general increase
seems unlikely. The initial heavy demand has
developed as expected, but there are no signs of
hoarding. Manufacturers generally are stepping
up production to meet demand. It is too soon to
gauge the level at which demand for sweets is likely
to settle, but as the rate of buying declines, compe-
tition is expected to revive in the trade. The over-
all increase in U.K. cocoa bean consumption as a
result of decontrol will probably be about 5,000
tons (5 percent) or perhaps somewhat more... Reports
from all areas of Ghana indicate heavy capsid
damage... The effect of the new free exchange market
in Brazil has been a rather sharp fall in Brazilian
cocoa butter prices... Indications are for an
above average Brazilian Temporao crop, so that
there should be adequate supplies this summer...
Providing prices remain stable, consumption will
probably absorb at least most of the available
supplies presently in sight.

4/9/53   No. 1: Activity increased as prices firmed in March
... American manufacturers have been persistent
and heavy buyers of futures contracts this year,
while most African sales of actuals have been made
to U.S. dealers... Present tentative estimates
indicate that U.K. consumption may have increased
by 8 - 10,000 tons per annum (roughly 10 percent)
due to decontrol... The quality of cocoa coatings,
using vegetable oil as a substitute for cocoa butter,
is reported to have been improved in the U.S. to
the point where some candy makers are using these
coatings throughout the year... With prices
below a year ago, demand is gradually being brought
into line with supply, though it is too soon to say
whether current prices will achieve equilibrium...

Increased international tensions in the beginning
of March served to strengthen prices temporarily.

5/4/53   No. 1: Despite the relaxation of tensions in Korea
in April, cocoa prices were slightly firmer in
contrast with most commodities... The Brazilian
domestic cocoa butter industry has been a heavy
buyer of beans, while U.S. Bahia purchases have
been negligible... Reports regarding U.K. confec-
tion demand vary, with some saying that a new level
of eight ounces per head per week has been reached
and maintained, as opposed to six ounces before
decontrol... Cocoa prices have moved in a rather
narrow trading range, and may continue to do so
for the present.

6/17/53   No. 1: Strong demand from Brazilian processors
continues... Trading was quieter during May...
During the first four months of 1953, U.K. cocoa
bean consumption was up over 10 percent. Some
authorities feel that the new level of confectionary
demand will be nine ounces per head per week, versus
six ounces before decontrol... Business generally
has remained at a high level in the U.S. The Tem-
porao crop in Brazil has been later than anticipated
... Latterly the feature of the cocoa market has
been the apparently close overall balance between
world supply and demand, eliminating what earlier
in the year looked like a moderate surplus. The
two factors which lay behind this change were
decontrol in the U.K. and the new free exchange
market in Brazil, leading to a marked increase
in demand by the Brazilian domestic industry...
A new state of price equilibrium appears to have
been reached... The communist peace overtures in
Korea have caused much uncertainty.

7/13/53   No. 1: Trading was again quiet in June... Informed
estimates of free confectionary demand in the U.K.
now range from 6.1 to 7.75 ounces per head per week,
versus 7.25 ounces before the war and six ounces
under control... At present prices supply and demand
appear to be in reasonable equilibrium.

8/5/53   No. 1: Activity picked up considerably in July,
reflecting the increasingly tight old crop supply
position... Manufacturers in some countries covered
their autumn requirements more actively... The
reaction in mid-July was technical... The premium

of nearby months widened appreciably over distant months,
and the London over New York premium remained undi-
minished... The Korean armistice has had no lasting
effect on cocoa prices... Weather in Ghana has been
suitable for the normal development of the crop...
Marketing board forward sales of the 1953-54 crops
are well in advance of last year's sales at this
point... The U.K. supply-demand situation appears
to have become more normal... Government econo-
mists in the U.S. have abandoned views of economic
difficulties in late 1953 and now predict pros-
perity until well into 1954... Current price levels
are high except under conditions of continuing shor-
tage.

9/9/53   No. 1: As the market weakened in August the West
African boards withdrew... Spot supplies in Accra
beans remained tight, in contrast to Bahia beans...
Initial very tentative estimates of the African
main crops place them at about equal to last year's
crops, while demand over the past year has been con-
siderably in excess of the previous year.

10/8/53   No. 1: Fears of a New York dock strike coupled with
the tight spot situation caused the market to ad-
vance in September. The official Ghana main fore-
cast of 236,000 tons was slightly lower than
expectations and also aided the advance... Trading
activity declined somewhat... Manufacturers in
general appear willing to defer purchases in expec-
tation of lower prices for new crop cocoas... The
new world crop should be roughly equal to last
year's crop... Total African cocoa losses due to
diseases and pests were estimated at 200,000 tons
per year at the recent London cocoa conference...
Forecasts of slowing business activity in the U.S.
are becoming quite general... Unless the world pro-
duction forecast is low, or the rate of consumption
declines, no marked relief in the cocoa supply
situation is possible... A modest U.S. recession
could lead to a sharp fall in cocoa consumption.

11/4/53   No. 1: Heavy forward sales by the marketing boards
coupled with low Ghana purchases combined to streng-
then the market in October... The Brazilian exchange
system has been changed so as to give exporters of
cocoa beans the same advantage given earlier to
exporters of cocoa products... While there is little
indication of sufficient cocoa becoming available

to weigh on the market, it must be borne in mind
that a U.S. recession could quickly cut demand.

12/11/53 No. 1: Continued low Ghana purchase figures in
November tended to confirm estimates of a smaller
crop... Trading activity set a record in London
at 3,467 lots, and was the highest in several
years in New York at 6,029 lots... Although spot
London and New York have reached parity, the distant
London contracts retain a significant premium over
the corresponding New York contracts... U.K. con-
fectionary production has reached a record level
of 10 ounces per head per week; manufacturer and
distributor stocks have now been rebuilt follow-
ing the decline after derationing... U.K. con-
sumption over January/October was over 16 percent
ahead of last year... U.S. economists now expect only
a slight easing in the economy in 1954... Consumer
demand is likely to be sharply curtailed when
current cocoa prices are reflected in retail con-
fectionary... The increased use of substitutes
for cocoa butter has already started.

1/6/54 No. 1: The revised official Ghana main forecast
issued on December 21st at 205,000 tons was 31,000
tons below the earlier forecast and considerably
below expectations. Activity remained high.
Some manufacturers seemed to reluctantly accept
the likelihood of continued high prices, and began
to buy more heavily counter to the normal seasonal
pattern... Indications are that the Bahia Temporao
crop, the next major crop to become available to
the market, will be somewhat early and will be a
good crop... The current estimate is for a 1953-54
world crop some five percent below last year...
Nurseries of cocoa seedlings for free distribution
to cocoa farmers in 1954 have been established in
all areas of Ghana... At current high prices manu-
facturers will use thinner coatings, make smaller
bars, and in some cases substitute alternative lines
for ones using cocoa... The principle of momentum
usually means that markets on the upswing often
tend to go higher than is necessarily justified
by the basic factors until a new set of forces come
into play. Cocoa is unlikely to be an exception...
The relative failure of the Ghana crop and some other
crops is disturbing taking the longer view. The
production trend now seems to have turned downward,
which sould seem to call for urgent study.

2/15/54   <u>No. 1:</u> The nervous state of the market in January was heightened by reports that a small cocoa shipper had defaulted and by the temporary withdrawal of primary sellers. Before the mid-month reaction prices had reached the highest levels in cocoa history... Because of the one cent limit on daily price moves in the New York market, New York at times fell to a four cent discount below London during the advance... Manufacturer buying remained low during early January but picked up on the late January reaction... Final U.K. consumption for 1953 was roughly eight ounces per head per week, an increase of 30 to 40 percent over the two previous years; in addition, imports increased by over 200 percent... The total number of trees cut out in the Ghana swollen shoot campaign has now reached 24.6 million, out of a total tree population of some 400 million... Despite the great price increase, demand has so far been well sustained. This level cannot be maintained in 1954 given the amount of cocoa available.

3/1/54   <u>No. 1:</u> Short covering and additional defaults among shippers and merchants aided the continued price advance in February... An unusually large portion of the Brazilian crop has gone to Europe over the past year... U.K. confectionary distribution over November, December, and January was 10.3, 9.3 and 7.9 ounces per head per week respectively. Apart from a slight reduction in bar size, manufacturers have not increased retail chocolate prices so far... A slight recession now appears to exist in the U.S. economy... The French government is reported to have decided to subsidize chocolate on the retail market in an effort to control inflation... Brazilian Temporao crop prospects remain good.

3/12/54   <u>No. 2:</u> The sharp decline in futures over the past two weeks was led by London, as was the subsequent recovery with continental manufacturers doing much of the buying... The longer term outlook holds higher prices in prospect.

4/2/54   <u>No. 2:</u> Recent market strength reflects revived manufacturer interest, which in turn reflects the tight spot position. There is little room for the usual spring inventory liquidation on the part of manufacturers this year... Until there are indications

that the financial difficulties of European dealers have ended, we anticipate no reversal of the upward trend.

4/30/54   No. 2:   The premiums of the nearby months over the distant months have continued to widen... The Bahia Temporao crop and the Sanchez crop are both reported to be in excellent condition. The latter crop is still primarily uncommitted, and can be expected to exert pressure on the market, especially since we are entering the slow summer period. We expect a seasonal price decline to develop during the late spring and early summer.

5/14/54   No. 1:   There is no indication at present of any forthcoming cocoa price decline... Bahia sales continue to go largely to Europe... Bahia Temporao prospects are now for a crop 50 percent above the recent average. Forward sales of this crop are far ahead of any recent year at this point... First quarter U.K. grindings were slightly ahead of last year... A Ghana survey of new plantings indicates that production will at least maintain its present level during the next 10 years and may gradually increase during that period... European manufacturers are resisting the use of cocoa butter substitutes, in contrast with their U.S. counterparts... Estimates of the decline in U.S. cocoa bean consumption range from 25,000 tons to 60,000 tons (roughly 10 to 25 percent)... The excellent Temporao prospects appear to have been discounted in the present market.

6/10/54   No. 1:   Temporao crop prospects continue to improve ... U.S. manufacturers' inventories appear to be quite low... U.K. confectionary consumption remains at the high level of over eight ounces per head per week... Some U.S. manufacturers have begun to market dime bars more aggressively. Should the dime bar eventually replace the nickel bar, the long range downward trend in U.S. per capita cocoa consumption may be arrested... Current cocoa prices are far from being reflected at the retail level.

7/26/54   No. 1:   The temporary weakness at the end of May proved to be technical... Ghana and Nigeria have begun to sell new crop cocoa forward, causing some weakness... The trend for the spread between nearby

and distant positions to widen has been reversed...
The wide London premiums over New York remain...
Some large U.S. manufacturers are believed to have
been buying for inventory purposes, in contrast
to their hand-to-mouth buying earlier in the year...
U.K. cocoa consumption has declined seasonally...
A leading U.S. chocolate authority has been quoted
as saying, "The five cent chocolate bar will go
the way of the five cent bus ride and the good
five cent cigar"... U.S. business in general con-
tinues the improvement which began in March... The
U.S.S.R. is reported to be planning an expansion of
its chocolate industry... The good Ivory Coast
production in the past year is said to be a response
to the high price level, in that cocoa beans were
gathered from nearly all of the existing trees,
including trees normally left unpicked... Evidence
is accumulating that record prices are stimulating
cocoa production in many countries... European
consumption during the first half of this year
declined marginally if at all, reflecting the fact
that retail prices haveyet to reflect cocoa bean
prices. Retail prices will have to increase over the
second half, and coupled with manufacturer efforts
to curtail cocoa use this should lead to a drop in
consumption... U.S. consumption has dropped, but
the trend toward substitution for cocoa butter now
seems to be reversing, probably reflecting manu-
facturing difficulties... The present market situ-
ation is one of uneasy balance.

7/16/54   No. 2: Volume on recent declines has been light,
with very little follow-through selling. The de-
clines were caused by sales of new crop Accras,
largely to the U.S. market, which were earlier
than usual and somewhat below the market. The
fact that the offers found a ready market in the
U.S. at historically high prices is an indication
that U.S. manufacturers are still not well covered.
We believe that a backlog of demand exists for the
fourth quarter.

8/13/54   No. 2: After making new highs cocoa futures
reacted sharply over the past week based on reports
that the Brazilian minimum export price has been
reduced from 63.25 cents to 62 cents per pound
for September shipment. This was taken as an
indication that Brazil still has a considerable
quantity of unsold cocoa on hand, which in turn

- has led to the belief that the Temporao crop is some 150,000 bags larger than the official esti-mate-of 1,400,000 bags... In view of the level of the selling price and the need for additional supplies in the U.S., we expect renewed buying to firm the market.

8/27/54 No. 2: Cocoa futures continued their sharp break as a result of: (1) a cruzeiro devaluation which led to a sharp increase in offers; and (2) the elimination of Brazilian minimum export prices, resulting in sales for immediate shipment down to 52 cents per pound... The heavy grinding season has arrived and with inventories still low we would not wish to be short the near months at this time.

9/14/54 No. 1: August weakness stemmed from the 20 per-cent devaluation in the cruzeiro, resulting in an immediate markdown in Bahia bean prices from over 60 cents to 51 cents per pound. This had a demora-lizing effect on the market, which was basically firm but drifting... The African marketing boards have withdrawn... The premium on spot deliveries has virtually disappeared... Bahia sales to the U.S. have picked up sharply... Speculative selling in New York has been heavy in recent weeks, reflecting optimistic forecasts for the new crops... Private forecasts call for a Ghana main some 10 percent above last year... The Temporao crop is now esti-mated as being some 85 percent greater than the recent average... U.S. cocoa bean imports during the first eight months of 1954 were down over 16 percent from the previous year... In recent years a three to five month lag has been observed between changes in cocoa prices and changes in finished chocolate prices... The Ghana farmer price will remain at its past level despite strong farm pressures for an increase to partially reflect world prices... There is no prospect for any sub-stantial increase in cocoa supplies during the coming year; on the other hand, consumption continues at an encouraging level.

9/24/54 No. 2: Cocoa futures continued to react sharply over the past two weeks. The market attempted to rally once the Bahia price stabilized in the 43 to 45 cent range, having fallen from 63 cents before devaluation, but renewed African offerings depressed

the market... In toto, the main crops in the pri-
mary producing areas should show an increase of some
45 - 60,000 tons, which may be ample to supply
grinding needs since U.S. consumption now is down from
last year, and European consumption now seems to
be leveling off... We believe only technical
rallies are probable.

10/8/54   No. 2:   Indications are that the African crops will
be large. In addition, private sources estimate
the Bahia main crop at 1,350,000 bags compared
with the semi-official Brazilian estimate of 850,000
bags... Both the French and Brazilians have been
offering heavily, such that the quote for nearby
Bahias has fallen five cents in two weeks...
U.S. imports have recently been running well ahead
of last year, and with primary producers pressing
the market and indicated crop sizes heavy, we
believe the downtrend will continue.

10/29/54   No. 2: Cocoa futures advanced sharply over the past
week as Russia bought substantial amounts in
Brazil and was reported negotiating for 5,000 tons
of Accra beans. Of course they have ordinarily
been absorbing 20,000 tons of Accras per season,
but the timing has added to the renewed strength
of the market... Brazil has sold some 2 million
bags of its 1954-55 crop, which is certainly
more than two-thirds of their total crop...
While recent U.S. imports have been running well
ahead of last year, imports since January 1 are
still some 600,000 bags, or 15 percent behind last
year. It would seem that the open-to-buy position
is once again fairly large... At present we believe
the trend has turned upward.

11/12/54   No. 2: The four cent rise in cocoa futures over
the past week was caused by substantial short
covering and hedge lifting as well as new buying
by dealers who failed to purchase near the lows and
who fear being caught again, as last year, in a
rising price spiral... We expect continued firmness,
though in view of the size of the recent advance,
the market is entitled to at least a technical
correction.

11/26/54   No. 2:   Both the African and Brazilian crops now
look smaller than earlier private estimates...
With Brazil very well sold, the probability of

tight supplies later in the season is once again indicated... The near term situation seems to indicate no lack of supplies, however, as the demand for spot cocoa is quite slow. Industry reports indicate consumption is still running below a year ago.

12/8/54   No. 1: The September - October break was caused largely by heavy speculative short selling, which in turn set the stage for the October - November advance... Private reports now indicate a Ghana main of 210 - 215,000 tons, versus the September official forecast of 225,000 tons. Nigerian forecasts have also dropped... The new world crop is currently estimated as being about equal to last year at roughly 750,000 tons... While total U.K. confectionary sales have been increasing while chocolate confectionary sales have been declining... Unit sales of chocolate bars in the U.S. have been well maintained, but a severe reduction in weight has taken place... U.S.S.R. consumption is steadily rising... If 1955 world absorption remains at the 1954 level of some 767,000 tons, cocoa stocks will continue to decline.

1/7/55   No. 1: The premium on the nearer months in London was virtually eliminated in December... Manufacturer sentiment in New York changed from being bearish in early December to showing interest in purchasing around the middle of the month... Ghana purchases are disappointing, and the Nigerian crop is now not expected to reach last year's low level ... Reports suggest a surplus of low priced chocolate-type candies in the U.S. market, and a shortage of high priced, high quality chocolates ... The world new crop forecast has been lowered to 736,000 tons, while world absorption seems to have settled at the 750,000 ton level, indicating a further reduction in world stocks.

2/14/55   No. 1: January strength was aided by political tensions in the Far East, and generally unfavorable crop reports from Africa. Also, via a new cruzeiro exchange system, domestic Brazilian processors can again afford to pay more for cocoa than can exporters, so that Bahia is exporting less cocoa... Manufacturers showed considerable interest in actuals in New York... A survey of U.S. manufacturers indicates that 1954 U.S. grindings were 196,000 tons, down from private estimates of 220,000 tons, and

1953 grindings of 240,000 tons. Fourth quarter
grindings were 35 percent below the previous year...
The Ghanaian political situation is unsettled,
with the National Liberation Movement, which favors
higher prices to cocoa farmers, seriously threaten-
ing Dr. Nkrumah's Convention People's Party... The
first large scale plantations are being started
in Ghana, with yields of 1,000 pounds per acre
expected, versus current normal yields of
200 - 300 pounds per acre... The market is probably
in fairly good equilibrium at current prices.

3/25/55. No. 1: The marketing boards have followed the
decline in February and early March, but manu-
facturer buying interest has been slight... The
distant months have now gone to a premium over the
nearby positions in both London and New York... A
measure of the weakness in spot cocoa is the re-ten-
dering of stopped cocoa in New York, mainly by
speculative groups... The forthcoming Temporao
crop is estimated as being substantially below
last year's record crop, but above the recent
average... U.S. grindings remain low... New plan-
tings continue at a high rate in Ghana... The main
factor behind the recent price decline has been a
sharp reduction in European consumption, where retail
prices were only increased toward the end of last
year. World consumption will probably not show a
marked recovery until next fall... The price of
cocoa is less vulnerable to further declines at
current levels, and deserves serious manufacturer
attention. It is difficult to see any further sub-
stantial decline.

3/18/55 No. 2: It is the general lack of manufacturer de-
mand during the past two months that has kept cocoa
under pressure. The failure of any appreciable
sales by the British Marketing Board or Bahia sellers
to materialize should act as a deterrent to sustained
price advances... The U.S. Department of Agricul-
ture, in a review of the world cocoa situation, indi-
cates that the trend of production is downward in all
major areas of West Africa. As a result of various
diseases, the elimination of older trees is
greater than new planting. They hold out little
hope for an improvement in the crop next season.

4/15/55 No. 2: The market rallied during the past week as

manufacturer demand increased, short covering be-
came aggressive, and stop loss and chartist buying
took place... Arrivals in the U.S. are heavy and
running well ahead of last year. First quarter
U.S. grindings were 18 percent below last year ...
We believe the current strength is likely to be
temporary, and is primarily due to technical
considerations.

4/29/55   No. 2: It is generally agreed that the Brazilian
crop will be large but a few weeks late. Despite
this, sales of the 1955 - 56 crop have remained
surprisingly small, with only 129,765 bags sold
to date compared with 881,141 bags at this time
last year. This may in part be a result of the
persistent rumors that a cruzeiro devaluation
is imminent, after which Brazilian dealers would
receive more cruzeiros per dollar of export re-
venue. In any case, heavy Brazilian offers are
yet to be made.

5/23/55   No. 1: The general expectation of cruzeiro devalu-
ation has brought sales of Bahia beans to a
standstill... Manufacturers have shown only a
limited interest in the form of scale-down buying
... The premium for distant contracts remains...
Temporao forecasts have been increased slightly...
First quarter U.S. grindings were 17 percent below
the 1954 first quarter... It is increasingly
conceded that current prices are in line with the
supply-demand situation. World supplies seem
unlikely to increase materially over the next
few years... The outlook for the developing
African crops is better than last year.

5/13/55   No. 2: Futures have displayed distinct resistance
to declines despite the well known bearish factors.
The general uncertainty regarding the Brazilian
exchange rate has brought two results. First,
the trade is believed to have fully hedged what-
ever cocoa is held in inventory. Secondly, pur-
chases of actuals have been limited to a hand-to-
mouth basis. Consequently, there is little trade
selling seen, and when actuals business develops,
hedge lifting orders find sellers scarce. The
market is in a strong technical position and
rallies easily.

6/10/55   No. 2: The market has remained in a very narrow

range with futures volume and open interest very
low... We believe a reversal in the downward trend
in grindings will now take place due to the sharp
decline in cocoa prices over the past several
months. With this in mind, U.S. imports to date
must be considered small... We expect the market
to become firmer.

6/24/55   No. 2:   The long awaited cocoa cruzeiro devalu-
ation finally took place, amounting to 16 percent
or roughly five cents per pound at current prices.
Brazilian offerings, which have remained very
small in anticipation of devaluation, will now
increase rapidly. On the other hand manufacturers
have also allowed their inventories to decline
while waiting for devaluation, so that significant
demand should exist.

7/7/55   No. 1:   After a modification of cocoa cruzeiro
exchange rates, the U.S. has become a steady
buyer of Bahia cocoa. The threat of further devalu-
ation has subsided... Trading activity has fallen
substantially... The Ghana mid crop now appears
to be as much as 50 percent greater than the
official forecast of 5,000 tons... World supply
and demand remain in reasonable balance, but a
slow increase in consumption seems likely at
current levels. There are no reasonable grounds
for expecting a material increase in the 1955 -- 56
world supply.

7/22/55   No. 2:   The recent decline on sharply expanded
volume was initiated by lower prices for Bahias
and the beginning of new main crop Accras offered
by the British Marketing Board. Recent Bahia
sales have been substantial, but sales to date
still are roughly only half as large as they were
at this time last year... European dealers and
grinders have not yet begun to cover autumn needs
in any large way. The effect of this demand is yet
to be felt.

8/19/55   No. 2:   The market has drifted steadily lower under
the impetus of substantial sales from both Bahia
and the British Marketing Board... The U.S. Depart-
ment of Agriculture has issued a 1955 -- 56 world
production estimate of 796,000 tons, up 2.2 percent
from last year... At the lower prices currently

prevailing there should be a substantial reduction
in the use of substitutes... Manufacturers are
beginning the new season with inventories that
are believed to be down around minimum needs,
especially in Europe. The key to future price devel-
opments thus lies with the European trade. Any
follow through to recent European buying could lead
to higher prices... Cocoa circles currently
envisage a Ghana main crop of roughly 245,000 tons.
Crop prospects remain excellent in virtually all
production areas.

9/26/55   No. 1: The decline over the past three months has
been caused by African intermediate crops and a
Brazilian Temporao crop considerably larger than
expectations... Manufacturers have shown appre-
ciable interest in scale down buying, and marketing
board forward sales are now at a record level for
this time of year... The London premium over New
York has declined... Open interest in New York
has declined to a very low level... The final Ghana
mid crop reached 13,662 tons versus the initial
official forecast of 5,000 tons... The official
Ghana main forecast is 220,000 tons... U.K. con-
sumption has again fallen below last year, with
grinding to date running nine percent behind
last year... U.S. grindings for the first half
year were 18 percent behind last year... Cocoa may
be in for a period of modest price appreciation
as consumption increases.

9/15/55   No. 2: There exists a substantial overhanging
supply of cocoa available for nearby shipment
from nearly all production areas... Although the
two largest manufacturers in the U.S. and U.K. are
reportedly covered ahead for a considerable period
of time, a backlog of demand still exists from
smaller manufacturers and from other countries.

10/13/55 No. 2: Cocoa futures continued to trade within a
relatively narrow range influenced by uncertainties
with regard to Brazilian cruzeiro devaluation but
also reflecting a little better demand for actuals
both here and in Europe. With a change in govern-
ment impending in Brazil, devaluation is unlikely
in the near future, but its prospect will continue
to overhang the market... Third quarter U.S. grindings
of 89 million pounds were equal to the same 1954

period and were about as expected. The trend in grind-
ings now seems to be upward... There is considerable
dispute regarding the Bahia main crop, with some
estimates now as low as 800,000 bags, fully one-third
below earlier reports.

10/28/55 No. 2: Recent sales to the U.S. market, parti-
cularly from Bahia, have been substantial and have
brought considerable hedge selling to the futures
market... On the demand side, consumption at retail
has expanded, and some factories have returned to
three shift schedules. Fourth quarter grindings are
expected to be well above the levels of both the
third quarter this year and the comparable 1954
period.

11/11/55 No. 2: The market has remained under pressure from
hedge selling... Reports continue to indicate
excellent demand for finished products and increased
levels of grinding... Over the near term the poli-
tical crisis in Brazil could well dominate the
market. The Army coup has not yet been supported
by the Navy and Air Force. While no fighting has
yet developed, the situation is explosive.

12/16/55 No. 3: Ghana purchases to date now total 151,203
tons versus 146,031 tons for the same 1954 period...
The manufacturing business continues extremely
good, especially considering the time of the year.
Also, almost everyone holds high hopes and expec-
tancies for the first quarter of next year. This
is directly opposite from the same periods of
last year... It continues to appear that total
crops may not be quite so large as previously
expected, and consumption might be greater than
previously expected.

1/6/56 No. 1: Ever since August the market has been
extremely stable in the face of a complete absence
of interesting features... Trading has been very
quiet... The current world crop is currently
estimated at 782,000 tons, down from 799,000 tons
last year, but considerably above last year's
absorption of 707,000 tons... European consumption
is steadily improving... World cocoa stocks should
continue at a more comfortable level than for some
years past, which should place limits on any
price rise resulting from increased demand.

2/20/56   <u>No. 1</u>: Trading activity increased sharply in the declining market, reflecting a considerable volume of stop-loss selling coupled with speculative short selling and hedging... African crops are somewhat larger than earlier anticipated... Fourth quarter West German grindings were 40 percent above the previous year... Some further temporary price decline could occur if manufacturers are not willing to increase their stocks despite the fact that current prices will inevitably mean a return to a substantial level of absorption in due course.

2/20/56   <u>No. 2</u>: After a downward trend that has continued for the past 18 months with only moderate interruptions, cocoa prices have now reached five year lows. The basic causal factors have been: (1) the usual lag in the response of grindings to the price decline, with the result that nearby supplies have been adequate; and (2) the pressures induced by cruzeiro devaluation and the continued threat of further devaluation. As a result of the grindings lag, carryover stocks in the U.S. on October 1st were reported to have increased from the previous year by some 40,000 tons. Parallel developments were noted in Europe. The assumption has been made by many that this 40,000 ton increase still overhangs the market. However, the largest U.S. manufacturer, who accounts for some 38 percent of the market, is believed to have increased his inventory on the recent decline by a minimum of four months supply over and beyond his normal coverage, which would account for roughly 31,000 tons in inventory. The next four largest manufacturers, comprising some 22 percent of the industry, are believed to have acted similarly, so that together the Big Five account for more than the 40,000 ton increase. These manufacturers need this relatively low-priced cocoa in order to guarantee that an increase in product size can be maintained for a sufficient length of time to warrent changes in molds, etc. They also will likely extend coverage further on any declines. On the other hand, the above figures indicate that roughly 40 percent of the U.S. industry is running with sub-normal inventories, these manufacturers should provide support to the market over coming months.

3/16/56   <u>No. 2</u>: Continued rumors of cruzeiro devaluation, forced selling against the purported inability of a

French concern to take delivery of actuals, and continued hedge selling all contributed to the continued price decline over the past two weeks. The near term supply picture is still one of plenty. A strong reversal in price trend will depend upon more aggressive demand for actuals... Over the past three weeks open interest in New York has increased some 17 percent from 2,977 lots to 3,534 lots. This has been interpreted as meaning that virtually all warehouse stocks are now hedged. An expansion of open interest after a prolonged price decline often indicates the beginning of strong buying and the approach of a reversal in trend.

4/9/56   No. 1: Current spot Accra prices are the lowest since 1950, reflecting the fact that stocks are still accumulating... Speculative buying in cocoa was revived in February, reflecting itself in a sharp increase in open interest. This buying then turned into stop loss selling during the March decline... Reports persist of a good if not record Temporao crop... World production is now estimated at 810,000 tons, an all-time record if achieved... First quarter U.S. grindings were 20 percent ahead of last year but were considered disappointing in many quarters... It is unlikely that any upward movement in cocoa prices can be sustained for long; indeed, it would seem more likely that prices may revert to their former levels.

5/2/56   No. 1: April trading in New York set a new record as the market fluctuated under heavy speculation... No important changes have taken place in either supply or demand estimates... The Ghana mid is officially forecast to be 7,000 tons... First quarter U.K. grindings were 20 percent below last year... Open interest in New York is now over twice the year ago level... Cocoa stocks remain quite large.

5/25/56   No. 2: The small number (53) of notices issued against the New York May delivery is an indication that the large stocks held in the U.S. are fully hedged and that the owners are not concerned about disposing of these supplies. Nevertheless, the size of recent imports, when added to the sizeable stocks already on hand, does indicate that the backlog of demand for autumn grinding is rapidly being diminished. Arrivals in the U.S. since January 1st total 2,115,672 bags versus 1,530,611 bags last year... Any firming

tendency in the spot price level should be magnified in futures for three reasons: (1) hedge lifting against dealer sales of actuals; (2) speculative hedge lifting by the trade; (3) speculator short covering... Because we are entering the slow summer period, it is still too soon to expect more than temporary price rallies.

6/22/56 No. 2: Cocoa futures advanced out of the broad trading range in which they had moved for over one month. The rise was initiated by the British Marketing Board announcement that old main crop sales have been completed. Trade houses then began to cover their short positions. This led to renewed chart buying and set off stop loss orders. Finally, there were reports of a generally improved demand for actuals in all consuming countries... Brazil has sold steadily at slowly advancing prices, and now has sold 30 to 40 percent of the expected Temporao crop ... Many small manufacturers are still running with minimum inventories; their anxious buying should provide excellent support on any technical setbacks.

7/24/56 No. 1: The market has remained in a remarkably narrow range over the past six months and there is currently no evidence of any definite price trend... Activity declined in New York, though open interest remains high, particularly in the nearby September position... The Brazilian government has made substantial short term loans to farmers to enable them to withhold much of the very large Temporao crop from the market for as long as three months... In the U.K. chocolate confectionary consumption is gaining at the expense of sugar confectionary... The FAO is setting up an international cocoa study group... Recent price stability is probably a reflection of the large level of cushioning stocks.

7/20/56 No. 2: The cocoa market continues to meet active support during periods of price easiness. During periods of strength, hedge selling has taken place, but follow through pressure has been lacking... Private estimates of the Temporao crop range as high as 1.8 million bags, versus the official Bahia estimate of 1.2 million bags. In any case, 0.9 million bags have already been sold, with the result that there will be little market pressure from this quarter... Third quarter U.S. grindings should exceed imports significantly, with the result

that hedge lifting should exceed hedge selling in
New York.

8/17/56 No. 2: Fairly steady demand for actuals has
supported the market in its narrow trading range.

8/31/56 No. 2: We are entering the period of heavy grindings
with available merchantable old crop supplies
limited. However, prospects are for the new world
crop to be as large as, or possibly larger than a
year ago. As we approach the period of heavy new
crop movement, the weight of the crop should force
a lower price structure... The use of chocolate
is on the increase in confectionary production, but
at a disappointing rate. Unless there is an increase
in the size of chocolate bars, a significant
increase in grindings does not seem probable. So
far, we have not seen any tendency towards increasing
bar sizes.

9/10/56 No. 1: The market has remained quite stable despite
the occurence of several normally important events:
the beginning of forward sales by the marketing
boards; the need to liquidate the large New York
September open position; and the willingness of
Brazil to meet current levels after holding back
for some time... The Ghana mid was 10,670 tons
versus the official forecast of 7,000 tons... Condi-
tions for the new crops have in general been very
good... Diet consciousness in the U.S. has caused
a long term gradual decline in per capita confec-
tionary consumption... The Nigerian farmer price
has been reduced by 25 percent for the new crop... Due
to the substantial existent buffer stocks, crop
rumors may have less effect on the market this year
than they have had in the past.

10/17/56 No. 1: Prices have sagged due to light manufacturer
buying interest... Third quarter U.S. grindings were
six percent ahead of last year, far below the 15 per-
cent increase generally expected... Trading volume
in September was very low... World production for
the new crop should be approximately equal to last
year's record 835,000 tons. There is a possibility
that a long term upward trend in production has
started... Farmer price stabilization schemes
are being established in French West Africa similar
to those which have existed in Ghana and Nigeria...
World consumption should reach an annual rate of

roughly 800,000 tons by the end of 1956... In the
short run prices will be under pressure from the new
crops, but in the longer run prices may recover
reflecting increasing demand.

10/26/56 No. 2: Futures recovered sharply this week as
various events worked to increase fears of a dock
strike. With many smaller manufacturers carrying
minimum inventories, the increased likelihood of
a dock strike could cause a scramble for the
available supply held locally... Because of the
apparent oversold condition of the market, a re-
covery of at least technical proportions appears
long overdue.

11/19/56 No. 2: Cocoa futures continued their rally based
on three developments: (1) the Suez crisis; (2)
continued fears of a dock strike; (3) a U.S. De-
partment of Agriculture report saying that the Ghana
crop is likely to fall below normal due to drought
conditions in July and August, and in any case is a
very early crop, with harvesting likely to fall off
sharply after November. This report tends to confirm
the earlier official Ghana forecast, which many in
the trade felt to be far too low... Latest develop-
ments provide hope that the dock strike will be
settled shortly... The market must now be viewed as
a trading affair. Price swings should be wide
reflecting the changing prospects for peace.

11/23/56 No. 2: Continued offerings of Bahia and Sanchez
cocoa to the U.S. market and higher than expected
Ghana purchase figures have caused cocoa prices to
lose practically all of the advance which followed
the outbreak of hostilities in the Middle East.
Continued international tension and the start of the
east coast dock strike in the U.S. have had no major
influence on the market... The U.S. government has
announced its intention to obtain an 80 day injunc-
tion to force the longshoremen back to work...
While the Ghana purchases have been high, it is likely
that this reflects an early crop rather than a large
crop.

12/7/56 No. 1: October - November strength reflected in-
creased tensions in the Mid East and in Eastern
Europe, which triggered a burst of speculative
activity... Movement of cocoa from producing to

consuming nations has been slower than usual this
year... Manufacturer interest was limited during
the recent advance... Ghanaian officials have stated
that the main crop, which is running at a rate far
ahead of the official 205,000 ton forecast, is very
early... The 1956 - 57 crop is now estimated at
853,000 tons against 839,000 tons last year and
estimated 1957 absorption of 793,000 tons; thus a
further increase in stocks will take place... In
the short term the seasonally heavy movement of
cocoa to consuming countries may cause prices to
decline.

12/7/56   No. 2: U.S. interests have recently been far less
aggressive in their demand for actuals than have their
U.K. counterparts. This stems in part, at least,
from the fear of sterling devaluation arising
from the Suez crisis.

12/21/56   No. 2: Consistent hedge selling and long liqui-
dation has kept the market under pressure. Manu-
facturers' demand has kept the decline orderly...
Private reports now place the Ghana crop at 225 -
235,000 tons, versus the earlier official forecast
of 205,000 tons. These reports have recently gained
support from the Ghana Department of Agriculture, which
now feels that the normal autumn rainfall may lead
to a substantial harvest during January and February.
It would appear, however, that a 20 - 25,000 ton
increase in the official crop estimate has been
fully discounted by the market... Turning to demand,
U.S. grinding figures, when compared with U.S.
sales of chocolate powder, would indicate that con-
siderable use of fillers and substitutes is still in
effect. With prices now at pre-Korean War levels,
a decline in the use of substitutes and an increase
in bar sizes should now take place.

1/11/57   No. 3: Ghanaian and Nigerian purchases have re-
mained quite large, causing a continued market de-
cline. The fourth quarter U.S. grindings, up
roughly 16 percent over last year, were not enough
to offset the selling... One or two of the larger
manufacturers were active buyers on the scale down,
but at no time was the demand aggressive.

1/18/57   No. 3: Weakness continued spurred by an unofficial
Ghana main crop estimate of 266,000 tons, compared
with the official forecast of 210,000 tons... Manu-

facturers did a substantial amount of buying on a scale down, giving evidence that they are building inventories.

2/22/57 <u>No. 1:</u> An easing of Middle East tensions, coupled with African crops far in excess of earlier forecasts, caused the continuous price decline over the past two months. The producing countries, particularly Brazil, have resisted the decline as much as possible by holding back sales of cocoa... Russian purchases have been running at twice last year's rate of 20,000 tons... The world crop is now forecast at a record 916,000 tons... Ghana main crop purchases are already 260,000 tons versus the official September forecast of 205,000 tons... World demand continues to expand in response to the sharply lower prices.

3/29/57 <u>No. 1:</u> While the West African marketing boards have been sellers on rallies during the past two months, Brazilian exporters have remained largely withdrawn, being reluctant to accept current values. Manufacturers in the main are well supplied, but the slow rate of arrival has led to a comparative shortage of nearby cocoas in the world's markets... Trading activity has declined... Reports from several consuming countries suggest that consumption is running ahead of earlier already high forecasts. An expansion in consumption, once started, gathers momentum, and the prospects are, therefore, for supply and demand to be in close balance next season. The feeling is growing that the long term downward price trend may have come to an end.

4/12/57 <u>No. 3:</u> After easing because of the somewhat disappointing U.S. first quarter grindings report, the market strengthened on buying by speculators and dealers. Except for some price fixing business, manufacturers remained withdrawn... The FAO increased its world production forecast by 54,000 metric tons from its January estimate to a new total of 924,000 tons; it simultaneously increased its world grindings forecast 66,000 tons to a new total of 881,000 tons. These forecasts caused a sharp advance... We feel that the market needs general factory buying or some unforeseen development to sustain the advance at this time.

4/26/57   **No. 3:** The market was extremely weak early in the past week due to speculative liquidation... The Brazilians have announced a plan to finance a large portion of the coming Temporao crop, enabling Brazilian growers and dealers to hold out for higher prices. The management of the plan, which also involves the continued use of minimum export prices, is in the full charge of Dr. Tosta of the foreign trade department of the Bank of Brazil... Three factors lead us to believe that the market is in a position to advance: (1) the new Brazilian plan; (2) the fact that Ghana only has a limited amount of cocoa remaining to be sold; and (3) the improved technical position of the market after the huge shakeout early this week.

5/10/57   **No. 3:** Everyone has adopted a watchful waiting policy until the Brazilian government's plan of farmer financing becomes definitely known. Rumors of low floor prices and entire abandonment of any support scheme have been denied.

5/24/57   **No. 3:** Prices have climbed some four cents over the past three weeks. It appears that Brazil has to a fair degree accomplished her aim without yet operating on the proposed plan. It is rumored that Brazil will take the first 300 - 400,000 bags of the Temporao crop off of the market... Most of the demand has been from speculators and dealers as prices got away too fast for most manufacturers to operate.

5/31/57   **No. 3:** Brazil has announced a minimum export price which would get Bahia cocoa to New York at 34.25 cents , ex dock; this compares with the current New York Bahia spot price of 30.13 cents, and the New York Accra spot price of 29.63 cents, which also pertains to forward shipments for the October-January period. The Brazilians will have trouble, we think, in disposing of their cocoa at the prices which they are asking.

6/7/57   **No. 3:** The market has continued its climb, gaining some three cents over the past two weeks... It appears that we now have two markets, one nearby controlled by Brazil, the other far off, which is the world market... Generally speaking the demand for actual cocoas recently has been slim.

6/21/57   <u>No. 3</u>: Long liquidation by speculators has caused the recent sharp decline... The French have been sellers, on strength, of new crop cocoas for October-December shipment. As yet Ghana has shown no desire to begin selling their new crop.

7/5/57   <u>No. 1</u>: Reviewing the past three months the main feature has been the withdrawal of Brazil as a seller of cocoa beans and products. A new scheme has been devised whereby the Bank of Brazil (Cacex) has become the sole buyer of beans from the farmers at a specified minimum price, as well as the sole seller to outside channels of both beans and products, also at a set minimum price. With the minimum selling price set considerably above the market, Brazil has been essentially withdrawn. The main effect has been a marked strengthening in prices, with the West Africans disposing of their burdonsome crops on the advance. Another effect has been widespread formula adjustment on the part of U.S. manufacturers to minimize the need for Bahia beans. There has been considerable speculative buying on the advance. The premium for distant months virtually disappeared during the advance... The Ghana mid crop official forecast is 12,000 tons versus last year's 10,772 tons... French first quarter grindings were up over 25 percent from last year... The cocoa outlook is confused and obscure. World production is still in excess of world consumption, and can be expected to remain so at current high levels. On the other hand Brazil, producing some 17 percent of the world crop, remains withdrawn. In the long run price levels will be determined by the forthcoming African crops.

8/1/57   <u>No. 1</u>: Brazil has remained essentially withdrawn, and under this umbrella Ghana and Nigeria have started forward sales of their main crops. The nervous condition of the market has given rise to considerable speculative activity, and the market is now quite unstable... After being at a premium over distant months, the July and September contracts in New York have fallen to a discount in the process of liquidation... Both the Ghana mid crop and the Brazilian Temporao crop appear to be either smaller or later than expected... World absorption remains high... The African main crops appear to be developing

normally... The FAO Cocoa Study Group will meet in
September to discuss a world cocoa stabilization
scheme... The price outlook remains obscure.

8/30/57 **No. 3:** The recent feature of the market has been
U.S. purchases from Brazil at the minimum asking
price of 31.60 cents. There were also sales made
of all other grades, primarily to the larger manu-
facturers... People are asking whether manufacturers
will go back to substitutes on any further price
advances.

9/27/57 **No. 3:** Prices have declined three cents from their
recent highs, primarily due to speculative selling
... One or two of the larger U.S. manufacturers
bought rather heavily on the way down... Up to
this time neither Ghana nor Brazil have lowered
their asking prices, despite the recent decline...
Ghana issued an official crop forecast of 235,000
tons, comparing with last year's 262,000 tons... Recent
weakness in the various stock and commodity markets
as well as the mixed up monetary situation throughout
the world seemed to influence speculative selling...
The situation at present is very confusing, and is
made more so by the possibility that some sort of
cocoa price stabilization plan will be established
among producing countries.

10/11/57 **No. 3:** The market has been firm, supported by quite
low Ghanaian and Nigerian purchase figures, and by
the announcement that U.S. third quarter grindings
were up over 10 percent from last year.

10/25/57 **No. 3:** The shortage of nearby cocoas persists...
The continued relatively high prices are encouraging
increased use of compound coatings... Bahias are
being shipped now in quantity, and it is a fair
guess that at some near future date they may be-
come the cheapest premium cocoa rather than the
highest. These receipts will help relieve the situ-
ation, although it may take a few weeks.

11/8/57 **No. 3:** In exceptionally heavy trading the New York
futures market advanced the one cent daily trading
limit every day during the past week... Continued
low African purchase figures, new reports of short
crops, and indications that Brazil has very little
cocoa left for sale all added fuel to the fire... The
move is playing havoc with the chocolate business

and everyone is stunned and flabbergasted. While
the panic is on, all bearish reports and factors
are ignored.

11/22/57 No. 3: As the market reached a broad plateau over
the past two weeks, some of the larger manufacturers,
both in the U.S. and the U.K., made rather substan-
tial purchases.

12/13/57 No. 3: Waves of speculative and trade liquidation
caused the two cent decline over the past week...
At times there was a fair degree of U.K. and Con-
tinental manufacturer buying on weakness, as well
as buying by Russia... It is rumored that an unof-
ficial report estimates the Ghana crop at 200,000
tons.

1/10/58 No. 1: Reviewing the period since August, the major
uptrend can be attributed to a deterioration of the
African crop outlook. As the market advanced Brazil
was finally able to sell at its minimum asking price
and even higher. Very good manufacturer demand
became evident in late August... The Ghana mid crop
was 2,634 tons versus the official forecast of
12,000 tons... Private forecasts initially placed
the Ghana main crop at close to last year's 262,000
tons. The September official estimate of 235,000
tons was subsequently dropped to 210,000 tons
in December, with a still lower figure now seeming
likely... Consumption remains high at a level well
above production, and stocks have therefore declined.
To date the high cocoa prices have not been reflected
at the retail level.

2/6/58 No. 1: Manufacturers were in the main cautious
during the January advance... New York open interest
is high, reflecting heavy speculative participation
... World production is now placed at 756,000
tons versus 884,000 tons last year, and last year's
absorption of 888,000 tons... The Brazilian Tem-
porao crop is tentatively forecast at 1,400,000
bags, which is the average of the past four years...
Reports suggest a major change in the Brazilian
foreign exchange system... Demand remains high,
but a sharp decline seems inevitable since world
stocks are insufficient to act as a buffer.

2/28/58 No. 2: Brazil has established a new minimum export
price of 40.50 cents, up from the old minimum of

31.70 cents. The new minimum applies to the Temporao crop, which was not available for export until the new plan was announced. Brazilian exporters immediately sold, thereby depressing the market... As African cocoas become increasingly scarce, Brazil will virtually be a monopoly supplier and will probably gradually raise its minimum export price. Hence, for the longer term, we forecast higher cocoa prices, especially if the expected upturn in general business conditions materializes.

3/28/58   No. 2: The stalemate between the primary producers and consumers continues to exist, with Brazilian support of the market a primary influence. Brazil has now instituted a policy whereby her excess cocoa will be consumed by her own industry. While this is certainly no substitute for sales to the outside market, it is still a means of absorbing supplies when overseas demand is slow... U.S. inventories are low, and additional substantial imports will be necessary to meet requirements unless demand falls more sharply than we now anticipate.

4/18/58   No. 1: The recent price trend has been downward and there are some indications that this will continue. There is some evidence of a downtrend in consumption... Due to a high minimum price Brazilian sales are again lagging... New York trade purchases have been lagging. The recent Ghana main crop at 195,000 tons was the lowest since the 1946-47 season... The initial official Ghana mid forecast is 4,000 tons versus 2,634 tons last year... U.K. confectionary industry television advertising expenditures for the pre-Christmas season in 1957 were almost 200 percent above the previous year... U.S. first quarter grindings were some seven percent below last year... The declining trend in world consumption is expected to gather momentum.

4/11/58   No. 2: U.S. first quarter grindings were off over 6.5 percent from last year. This represented a smaller reduction than was expected, and caused a rally in London. With the exception of last year, the grind compares quite favorably with the figures of the previous four years. Moreover, U.S. absorption at the retail level is holding up even better, as is absorption in countries other than the U.S. ... All things considered, it still appears likely that consumers will have to pay the Brazilian minimum to obtain needed supplies.

5/23/58   No. 2: Aggressive dealer and manufacturer demand
has caused cocoa prices to make new highs for the
recent move. Speculative short covering was also
a factor, as evidenced by the fact that New York open
interest declined by over 200 contracts on the most
recent phase of the advance... Based on reports
to date, the African crops are progressing normally.
Moreover an unofficial survey of the U.S. trade
indicates expectations that 1958 grindings will
trail 1957 by 9.5 percent, with the greatest lag
coming in the fourth quarter, just when African
cocoa will become available. These reports cloud
the long term picture.

6/12/58   No. 1: A further increase in the Brazilian minimum
asking price, coupled with reports of substantial
Brazilian sales to Russia, triggered the advance
in May... Manufacturers have in general continued
to run down their stocks, while dealers have taken
longer positions... During the advance, Ghana and
Nigeria sold most of their remaining cocoa... Open
interest in New York declined sharply during the
price rise... The FAO discussions regarding a
cocoa stabilization scheme yielded no concrete
results... The period of shortage is slowly passing
and will be ended given average or above-average
African main crops.

6/20/58   No. 2: Futures prices have recently moved over a
wide range, influenced by both a tight immediate
supply picture and a report of a bumper crop in the
making. The trade as well as the speculative
element was on both sides in erratic action in a
seemingly confused market.

7/18/58   No. 3: The recent rally was caused by the Middle
East crisis... Generally speaking demand from manu-
facturers has been conspicuous in its absence...
The Brazilian crop outlook is excellent, and the
crops may exceed the published estimates. Private
reports have indicated that weather has been per-
fect for the Nigerian crop, and that at least a
normal crop is expected. No adverse news has been
received concerning the Ghana main crop, so that
one can probably assume that that crop will also be
normal... Should warfare break out in the Middle
East, it is probable that price controls would be
put into effect immediately in the U.S. on most
commodities, including cocoa.

8/1/58   No. 1: Manufacturers for the most part have been buying hand-to-mouth... Substantial Brazilian sales have been made to Europe, while the Africans have sold virtually all of their cocoa... Ghana mid crop purchases have already exceeded the official forecast... The new main crops appear to be developing satisfactorily... The crop situation in Brazil remains obscure given the somewhat unreliable nature of the official reports... While Brazilian butter exports are going well, cocoa cake exports are substantially behind last year; this reflects the special exchange rate benefit given cocoa butter... U.S. second quarter grindings were down 15 percent from last year... A substantial tonnage of last year's Brazilian cocoa products withheld from the market are reported to be still unsold. How this will work out for Brazil if African crops revert to normal remains to be seen... In the short run prices could move upward due to short manufacturer stocks; in the longer run, demand is slowly falling and the crop outlook is promising.

9/18/58   No. 1: The market weakened in August despite three bullish factors: marketing board sales at levels above the actuals market; evidence that the Temporao crop is well sold; and widespread concern that the large open position in the retiring September contract in New York portended a squeeze on the shorts... The London premium over New York narrowed substantially... The Ghana mid crop was 11,851 tons versus the forecast of 4,000 tons... The long awaited squeeze on early fall positions has not developed... The Ghana main is officially estimated at 237,000 tons, somewhat higher than most market expectations... The current market appears weak, but there is a considerable amount of pent up buying interest.

9/26/58   No. 2: The market has remained weak lately as the African crop outlook has remained bright. It now appears that the 1958 - 59 African crop may exceed last year's crop by about 15 percent... New crop offers from Africa have been down to 35 cents, c.i.f., while Brazil has stuck by a minimum export price of 44 cents, f.o.b. ... This discrepancy appears great enough to force a re-adjustment in the Brazilian selling price. This may well be accomplished via devaluation of the cocoa export cruzeiro.

10/13/58 No. 2: After declining roughly nine cents since
mid July, cocoa prices have now discounted to some
extent the anticipated increase in African pro-
duction... Third quarter U.S. grindings were off
7.3 percent from last year, but some had been
forecasting a decline of as much as 14 percent...
Open interest in New York has been steadily de-
clining but is still large. However there has been
recent evidence that much of the long position
has been transferred from weak speculative hands
to strong trade hands. We do not expect that the
liquidation of the December position will be as
disruptive as was the September liquidation...
Brazil has maintained her 44 cent minimum export
price, and as a consequence has sold very little
cocoa.

10/28/58 No. 2: The three cent rally in futures over the past
two weeks was technically overdue, but was pri-
marily caused by disappointing Ghanaian purchase
figures... Ghana crop estimates still call for a
substantial increase over last year, but initial
production estimates have in the past been notori-
ously unreliable; hence the importance of the weekly
Ghana purchase figures.

11/25/58 No. 2: The March futures in New York recently
reached a high of 40 cents, up eight cents from
the October low. This rise has reflected continued
disappointing purchase figures in Ghana... Some
traders still feel that the Ghanaian crop is late
due to the heavy rains in October. An officer in
the Ghana Department of Agriculture has given some
support to this theory... Nigerian purchases are
running at the expected rate, well ahead of last
year... Manufacturers were counting on large
African crops this season to replenish inventories.
However, with Ghana purchase figures running well
below last year, a very tight supply situation has
developed and manufacturers have turned aggressive
buyers of whatever actual cocoa is available...
Although she has not officially abandoned the 44
cent minimum price, Brazil has sold to U.S. dealers
below the minimum and has apparently succeeded in
selling a major portion of her 1958 - 59 crop.

12/15/58 No. 1: Over the past three months the market has
responded primarily to changing notions regarding the
size of the Ghana crop. After an initial official
forecast higher than expectations caused a decline,

a series of low weekly purchase figures by the market-
ing boards led to considerable strength... Heavy
rains in October and November have been partially
responsible for slow Ghana purchases. The main
crop is now estimated at about 195,000 tons, down
from the official forecast in September of 237,000
tons... A new program is being started in Ghana
whereby the major portion of cocoa acreage will be
sprayed for capsid flies twice each year. Capsid
losses this year have been estimated at 25 percent
of the crop... New crop world production is forecast
at 807,000 tons, comparing with 1958 absorption
of 842,000 tons... It seems extremely unlikely
that there can be any serious decline in cocoa
prices in the foreseeable future.

1/6/59 No. 2: In a little over three weeks futures have
declined over three cents due to: (1) heavy
Brazilian sales at levels well below the official
minimum; and (2) an improvement in the trend of weekly
Ghana purchases... While world production esti-
mates have increased markedly over the past few
weeks, the recent high price level and sharply
reduced inventories have had an adverse effect
upon consumption. Fourth quarter grinding esti-
mates for the major consuming countries range any-
where from nine to 12 percent below 1957, as against
an average decline for the whole year of about
seven to eight percent.

2/4/59 No. 1: As it became evident during the past two
months that the Ghana main was late rather than
small, the market declined sharply. In addition,
consumption continued to fall. The world crop
forecast is now 862,000 tons, versus a 1959 con-
sumption forecast of 827,000 tons. What appeared to
be a shortage situation now appears to be a surplus
situation... The Brazilian exchange rate system has
again been modified, which coupled with the revised
minimum selling prices has again resulted in a virtu-
al Brazilian withdrawal... During much of the past
two months nearby cocoas have remained in relative
short supply, with the result that they sold at a
substantial premium over the distant months.

3/2/59 No. 1: The rally in mid-February was largely tech-
nical, as a large portion of the speculative short
position was closed out. In addition the relative
shortage of spot cocoas persists... Brazil remains

largely withdrawn... Current prices are generally
felt to be reasonable under the existing circum-
stances.

3/24/59   No. 2: With the exception of the U.S. and perhaps
Germany, all major free world consumers are now well
covered. On the other hand there still appears
to be a substantial quantity of cocoa to be sold
by both the Africans and the Latin Americans other
than Brazil... Consumption in the U.S. and Europe
is not expected to improve before the third quarter.

4/24/59   No. 2: The recent rally of futures through their
recent highs was prompted by the widespread belief
that the May delivery period in New York would find
the short interest on the defensive... Although world
production appears to be considerably in excess
of world consumption, the tight spot situation
persists. This reflects the lateness of the Ghanaian
crop, which in turn has caused Ghanaian exports
to be late... World consumption continues to
decline, with first quarter grinding estimates
of the five major consuming countries down three
to 21 percent from last year; a reversal of this
trend is not foreseeable given the current price
level... The unsold portion of the Brazilian main
crop is believed to be at least 10,000 bags, whereas
a few weeks ago it was thought to be all sold.

5/8/59   No. 1: The market has remained stable due to the
continuing relative shortage of spot cocoas, which
in turn reflects the late African crops. Export
figures indicate that a substantial amount of
African cocoas should be coming to market over the
next few months... Brazilian sales at the minimum
price have been increasing... The Ghana mid crop
is officially forecast at 15,000 tons... First
quarter U.K. grindings were 21 percent below last
year, while U.S. grindings were down three percent
... The Department of Commerce has reported that
U.S. confectionary consumption was virtually unaf-
fected by the 1958 recession... Under the new Ghana
five year plan, the producer price has been reduced
from 72 shillings per head load to 60 shillings.
Plans for an even larger anti-capsid campaign than
earlier envisioned have been announced. The govern-
ment will subsidize sprays and sprayers... The rate
of consumption decline is slowing considerably, and
there is a chance of a small revival at current
prices.

6/8/59   No. 2: Futures have declined sharply after the announcement of enormous Ghana mid crop purchases, which in the first three weeks have totaled 16,093 tons, already above the previous record for the total mid crop. These large purchases could conceivably be a forerunner to a larger 1959-60 main crop.

6/23/59   No. 2: If manufacturers show aggressive demand for Brazilian cocoa, the only large crop currently on the market, it is not difficult to visualize higher prices until, at the earliest, next year's African crops are available in sizable quantities.

7/8/59   No. 2: Futures posted declines of over two cents as the estimates of African mid crops remained high, and rumors of a reduction in Brazil's minimum export price persisted. This reduction finally occurred, and the minimum price is now expected to be more flexible than it has been in the past due to Brazil's defensive position vis-a-vis the large African mid crops... A significant upturn in world absorption has apparently not taken place yet.

8/10/59   No. 1: The Ghana mid crop now appears to be close to 30,000 tons versus the initial forecast of 15,000 tons... Recent strength in New York reflects the possibility of a dock strike at the end of September... Weather conditions for the new African crops have been favorable... Ghana is now subsidizing farmers to replant cocoa in areas where trees having swollen shoot were cut out... A small improvement in the world stocks outlook has taken place, but stocks are still well below normal.

9/8/59   No. 2: Futures will apparently remain quiet until the official estimate of the Ghana main crop is released, and we know when and if there will be a dock strike on the U.S. east coast... Arrivals of both beans and products have picked up recently in the U.S. as a safeguard against the possibility of a dock strike... Just about all private views point to a high Ghana main crop. The weather has been good and plantings made four or five years ago are coming of age.

9/24/59   No. 2: The market moved sharply lower under the influence of: (1) continued high estimates of the

the African crops; (2) heavy recent arrivals
in the U.S. in anticipation of a possible strike;
and (3) the general lack of interest in nearby
cocoa, which is being offered at a substantial
premium over prices for forward shipment...
European consumption during the past several months
has been disappointing, owing to the extremely
hot weather recorded this summer.

10/7/59   <u>No. 1</u>: The market has weakened somewhat in the
face of probable larger African crops... Brazil
remains largely withdrawn... The U.S. dock strike
has had a negligible effect on prices since manu-
facturers had increased stocks in anticipation of
the strike... The Ghana main is officially fore-
cast at 247,000 tons, in line with expectations.
All the signs point to an above average crop, though
we would draw attention to the 1957 - 58 season,
when the initial forecast was 235,000 tons and the
final crop was 195,000 tons... New crop world
production is forecast at 900,000 tons, versus
last year's crop of 874,000 tons, and 1959 ab-
sorption of 837,000 tons... The outlook is for some
further modest price declines.

10/21/59 <u>No. 2</u>: Brazil has temporarily suspended all further
sales of cocoa. This may put her in a difficult
position, as almost half of the current Temporao
crop is believed unsold, and the upcoming Bahia
crop will by all early estimates be quite large
... Third quarter U.S. and U.K. grindings were
quite disappointing: down six percent in the U.S.
and 28 percent in the U.K. To some extent, but
not completely, these figures are offset by increased
imports of products.

11/6/59 <u>No. 2</u>: The tight supply situation in the U.S.
caused futures to rally nearly three cents in two
weeks. Brazil remained effectively withdrawn
by raising her minimum export price... In Ghana,
purchases to date are running some 40 percent ahead
of last year... A close supply-demand balance over
the next year is conceivable but not likely.

11/19/59 <u>No. 2</u>: Large scale arrivals of African cocoas
and declining fears of a dock strike have led to a
continued decline in futures... There are uncon-
firmed reports that Brazil has resumed selling
cocoa at prices below her minimum... Ghana pur-

chases are now running 50 percent ahead of last
year, when the crop was very late.

12/3/59   No. 1:   The full impact of the West African crops
has not yet been felt on the market, so that manu-
facturer demand has held prices steady... Bra-
zilian actions have been confusing. First all sales
were suspended even at minimum levels. Then the
minimum level was reported to be increased. Then
reports circulated that substantial sales were made
at below the old minimum price. As far as we know
Brazil is currently withdrawn... The revised
official figure for the Temporao crop was consider-
ably larger than expectations... The outlook is for
some further decline in prices.

1/5/60   No. 1:   As the market declined in December rumors
circulated that Brazil had made substantial sales
below their announced minimum price... The world
crop forecast has been raised to 941,000 tons,
led by the further improved prospects in Ghana for
a record crop... Major producing nations are
expected to resist any further declines by with-
drawing from the market at least partially.

2/2/60   No. 1:   The market became firmer in January during
the meeting of the leading cocoa authorities of
Brazil, Ghana, and Nigeria... Rumors persist
of substantial Brazilian sales as much as five
cents per pound below the official minimum...
World production is now estimated at 958,000 tons
and could well be higher. Even if consumption in-
creases by 10 percent, which is optimistic, there
would be a sizable increase in stocks... In the
absence of stockpiling by the larger manufacturers,
it would seem that the cocoa market will continue
to ease.

3/1/60   No. 1:   Both the African main crops and the Bra-
zilian Temporao crop have grown ever larger in
prospect, with the result that world production
is now forecast at 1,002,000 tons, versus a 1960
consumption forecast of 896,000 tons... The market
has not slumped badly due to the firm selling
policies of all of the major producers... Some
experiments in Ghana have indicated a threefold
increase in cocoa yield in response to proper
shade control and fertilization... In the short run
prices may decline further.

4/1/60 No. 1: The market remained stable in March despite
the fact that both the Africans and Brazil made
very substantial sales, the latter openly below
the official minimum... The Bahia main crop just
completed set a post war record. The coming Tem-
porao crop is expected to be early and well above
average... Brazil has now sold all of her old
crop beans and products... World production is
now forecast at 1,024,000 tons up from the October
forecast of 900,000 tons... Manufacturers have
increased stocks considerably in response to lower
prices... Consumption has begun to gradually expand.

5/3/60 No. 1: The market strengthened in April following
reports of substantial Russian purchases coupled
with a block purchase of 15,000 tons of African
cocoa by a major U.S. manufacturer... First
quarter U.K. grindings were up five percent...
A substantial volume of the new higher yielding
cocoa plants have been distributed in Ghana, but
farmer demand is still in excess of supply...
No Temporao sales have yet been announced...
Prices are likely to remain stable.

6/1/60 No. 1: It is now clear that the April-May strength
was largely caused by speculative interests in
New York; the market lost all of these gains in
the middle of May... Ghana and Nigeria have sold
the balance of their main crops... Brazil made
substantial sales of the Temporao crop just as the
market reached its peak. Excessive rains have
cut the size of the Temporao crop... World con-
sumption is only making a gradual recovery...
The surplus this year has been taken up in part
by manufacturers and in part by European dealers
as speculative stocks... The outlook seems to be
for a further downward drift in prices.

7/5/60 No. 1: The Ghana mid crop has been disappointing
to date... A devaluation of the cocoa cruzeiro
had little market effect... A large portion of the
New York open position is in the nearby September
contract... The farmer demand for capsid sprayers
in Ghana is running far ahead of supply... The
market likely will continue at about current levels.

8/3/60 No. 1: The market has continued its remarkable
stability... Continued slow demand has dampened
bullish enthusiasm... The Temporao crop is sub-

stantially below earlier expectations... 1959-60
world production is now estimated at 995,000 tons,
down 29,000 tons from the April estimate.

9/2/60   No. 1: August weakness resulted from tired long
liquidation by both dealers and commission houses
in New York, coupled with larger Ghana mid crop
purchases than were expected. In addition the
marketing boards were reported to have come down
in their asking prices... The new Ghana main
should be between 290,000 and 300,000 tons, or
roughly equal to last year's record crop... The
coming Brazilian main crop is reported to be small
... Indications are that an expansion in absorp-
tion is definitely underway... The market should
remain quiet with a tendency to drift downward.

10/4/60   No. 1: The market has remained firm in response
to firm African asking prices, and growing evidence
of a short Brazilian main crop due to drought
conditions... Brazil has been withdrawn from the
market... Reports indicate that a 10 percent
increase over last year's record Ghana main is
possible... The U.S. Candy, Chocolate, and Con-
fectioners Institute is launching a major pro-
motional campaign aimed at increasing U.S. per
capita candy consumption by over 40 percent over the
next three years... World production may well be
of the same order as last year... Prices may
remain stable or tend to increase slightly;
some major producing countries feel that current
prices are too low, and they may therefore withdraw
from time to time.

11/3/60   No. 1: Adverse African weather reports, coupled
with a meeting on stabilization by the Cocoa
Study Group tended to strengthen the market in
October. Nothing concrete came from the meeting
and prices weakened somewhat... The marketing
boards made substantial sales on the advance...
Private Ghana main forecasts indicate 320,000
tons or more... World new crop production is fore-
cast at 996,000 tons, versus a 1960 absorption
estimate of 898,000 tons... Consumption is now show-
ing an encouraging upward trend.

12/2/60   No. 1: In the face of record African marketing
board purchases, coupled with aggressive selling by
French shippers, the market broke sharply in

November... The Ghana main crop is estimated at
350,000 tons, but could be as high as 400,000 tons;
world production is now forecast at 1,057,000 tons.

1/6/61   No. 1: With African record crops virtually assured,
the market continued to decline steadily during De-
cember, with French shippers being the most aggressive
sellers. The Ghanaian and Nigerian marketing boards
first attempted to resist the decline, but then
met market prices and made substantial sales.
Brazil remained withdrawn for the fourth successive
month... World production is now forecast at 1,109,000
tons versus a 996,000 ton estimate two months ago...
U.K. per capita cocoa bean consumption has been in
a long term downtrend: 4.94 pounds in 1957, 4.49
pounds in 1958, and 3.96 pounds in 1959... World absorp-
tion should increase substantially at current prices
... Nigeria has recently withdrawn as a seller.

2/3/61   No. 1: The Nigerian withdrawal early in January
was short lived but gave rise to a brief rally at
which time Ghana made substantial sales... January
trading activity was up sharply in both New York
and London; in New York open interest increased more
than 40 percent to the highest level since 1941...
Brazil remains withdrawn... The Brazilian main crop
was down 50 percent from last year... Theproducer
price in Nigeria has been cut by 30 percent... The
world crop is now forecast at 1,166,000 tons... The
price outlook is obscure due to the forthcoming
FAO meeting on price stabilization.

3/2/61   No. 1: Prices broke sharply in February with the
announcement from the FAO meeting that the only
practicable stabilization scheme would involve
export quotas. Apparently this disappointed the
very substantial speculative long position in New
York... Brazil continued withdrawn though there
were rumors of a substantial private deal with the
U.S. market... The large open interest in New York
increased further... The outlook for the Temporao
crop appears favorable... Experiments in Ghana have
shown cocoa yields of up to 10 times the national
average...
World cocoa consumption is growing more rapidly,
and is now forecast at 987,000 tons for 1961,
versus 909,000 tons in 1960, and a current pro-
duction forecast of 1,194,000 tons.

4/5/61   **No. 1:** After making new lows early in March the market recovered, with support coming from news of drought conditions affecting the Temporao crop, uneasiness about the coming FAO discussions of stabilization, and the Laos crisis... Ghana and Nigeria remained withdrawn except for certain privately negotiated deals... Brazil is believed to have sold all of her remaining beans and products... During the first quarter the volume of trading in New York was up over 60 percent from last year; open interest continued to climb rapidly... Brazil has officially forecast the drought damaged Temporao crop at 800-850,000 tons versus 1,400,000 tons last year. Most private sources feel that this is unrealistic, and a 1,100,000 to 1,300,000 range is generally accepted. It is normal for the initial Brazilian official forecast to be exceeded ... Ghana and Nigeria have stopped issuing figures for the weekly purchases and sales of the marketing boards; the market will now use private estimates of these figures... Consumption is improving more rapidly than was forecast.

5/2/61   **No. 1:** April strength was caused primarily by leakage of news from the FAO meeting on stabilization... The cocoa cruzeiro was again devalued, and Brazil announced a new selling policy whereby the official minimum price would fluctuate in line with the market price, thus essentially restoring a free market for Bahia beans... All of the major producers made substantial sales in the advancing market... The FAO meeting was concluded with an agreement to draw up a draft stabilization plan based on export quotas... There is little doubt that a strong upward trend in world production is taking place. Ghana crops of 500,000 to 600,000 tons (versus 420,000 tons) are mentioned as possible in coming years... African shipments will increase over the next few months. It would seem likely that somewhat lower prices are in prospect... The U.S. and U.K. grindings figures released in early May were generally considered to be disappointing, but they had little effect on the market.

6/2/61   **No. 1:** The principle reason for the sharp break in the market during May was a general realization that a cocoa stabilization agreement is a long way off. This touched off substantial speculative long liquidation, as evidenced by the 10 percent decline

in open interest from the all time record of 10,107
lots reached in early May... Again all three major
producers made substantial sales... As expected,
Brazil has increased the official Temporao crop
forecast, but most observers feel it is still too
low... Exports from Africa are picking up as
expected... Latest reports indicate that the forth-
coming African main crops should be as good as or
better than last year.

7/3/61 No. 1: For 80 percent of consuming countries, first
quarter grindings were up 13 percent over a year ago...
The expansion of existing chocolate factories and
building of new ones are distinctly encouraging
features in the longer term... Over the first
half of this year bean arrivals in the U.S. have
totalled 3,388,429 bags versus 2,132,922 over the
first half of last year... The strike by officers
and seamen of the U.S. Merchant Marine which started
in the middle of June appears to be settled... The
outlook for cocoa prices is somewhat obscure.

8/4/61 No. 1: The Kuwait and Berlin crises and the increase
in the U.K. bank rate had only momentary effects
on cocoa prices in July. During early July the U.K.
and U.S. second quarter grindings became known, and
both were regarded as disappointing; here again,
they did not have any significant effect on the
market... Present indications are that the very
large West African crops of last season will not
be repeated this year; rainfall has been excep-
tionally heavy, and it has been cold. Current
Ghana main crop estimates range between 350,000
and 375,000 tons, versus 410,000 tons last year.
If current indications materialize, next year's
world production will be about equal to this year's
... Consumption continues to develop well, with first
half grindings 12.5 percent above last year.

9/4/61 No. 1: Ghana and Nigeria have made moderate sales
of the new crop... The very large September open
position in New York was liquidated in an orderly
manner... It is generally accepted that the Ghana
main crop, estimated at between 350,000 and 400,000
long tons, will be later than usual... Among
British industries, the largest percentage increase
in advertising in 1960 over 1959 came in the con-
fectionary industry... Japan's first half grindings
were 50 percent ahead of last year... The world crop

outlook improved markedly in August, and a further
increase to record levels may be in prospect...
At the end of this year consuming countries are
expected to hold stocks equal to five months of
current consumption; this sizable buffer stock is
likely to prevent any sharp price increase... The
immediate outlook suggests that prices may tend to
decline.

10/4/61   No. 1:   Ghana and Nigeria were withdrawn during most
of September, but sold fair amounts toward the end of
the month... Estimated Ghana main at 400,000 tons...
Estimate Nigeria at about equal to last year's
190,000 tons... Estimate Brazilian main crop at
1.5 million bags versus 0.8 last year... Scientists
at the 1961 Cocoa Conference held in September in
London agreed that the long run swollen shoot and
capsid fly battles had been won, and that only
a steady preventative effort was now needed.
Emphasis was placed on recent efforts at increasing
yields; experiments have shown that yields could
fairly easily be increased to 1,000 pounds per acre,
from the current West African average of 200 to 300
pounds per acre, via the use of fertilizers, higher
yielding strains, etc... Nigerian farmers do not have
enough money at current prices to buy cocoa seedlings
... The West African crop outlook has seen a further
improvement; it looks as if prices could drift some-
what lower... The FAO Cocoa Study Group Executive
Committee meets this month to hear government views
on the proposed cocoa stabilization scheme.

11/14/61 No. 1:   Initial purchase figures have been low...
Ghana and Nigeria have sold heavily on the price
increase; their end-of-October sales position is
believed better than in any previous year... The
West African crops are unusually difficult to fore-
cast this year; some feel they are four to five
weeks late, others feel they were permanently damaged
by the early drought followed by wet, cold weather.
The best Ghana main estimate is probably the FAO
forecast of 320,000 - 330,000 tons, although the mar-
ket consensus puts the figure lower... Third quarter
U.S. grindings were 17.8 percent above last year...
The Soviet-Ghanaian long term trade agreement signed
recently is reported to have Russia buying 35,000 tons
during the first year, up to 60,000 tons or more in
the fifth year... The market outlook is obscure.

12/8/61   **No. 1:** The continued market strength in November was attributed to: (1) continued low West African purchase figures; (2) a Bahia Cocoa Trade Commission announcement that their main crop was liable to turn out 13 percent below earlier estimates, and that they were well sold; (3) the well sold positions of Ghana and Nigeria; and (4) the 25 percent increase in the New York open interest from mid-October to mid-November, reflecting substantial speculative participation... It now seems most unlikely that the Ghana main crop will exceed 300,000 tons. It is generally recognized that weather damage to West African crops does not exceed 15 percent, yet the current Ghana estimate is 30 percent below last year's crop. Reports suggest that a definite decline in capsid spraying explains this discrepancy... Estimate a 15 percent decline in world cocoa production this year, and a 10 percent increase in consumption, with world stocks declining 65,000 tons. Such a decline has not occured since 1958, but the large, though not evenly distributed, world inventory should prevent any very sharp price increase.

1/5/62   **No. 1:** Improved West African purchases caused the December market decline, during which Ghana and Nigeria remained withdrawn as sellers... Ghana main now expected at between 325,000 and 360,000 tons... Fourth quarter U.S. grindings up 11.6 percent over a year ago ... Estimated 1961 U.S. net imports totalled 335,000 tons, implying an inventory build up of some 94,000 tons... World stocks are quite adequate and there is unlikely to be any shortage in 1962... 1962 supply and demand should be broadly in balance, with perhaps a slight tendency to a short fall... Cocoa prices may be stable for a time.

2/5/62   **No. 1:** It gradually became apparent during January that there will be a surplus of production this year, conservatively estimated at some 90,000 tons, or 8.5 percent of estimated production... The Ghanaian and Nigerian marketing companies became sellers at prevailing levels during January... Ghana main estimated at between 380,000 and 420,000 tons... Total sales of capsid sprays to Ghana farmers during 1961 is provisionally estimated to have been 32 percent below the 1960 figure... At a meeting in Abidjan during January, the major African producers and Brazil decided to form an alliance for the purpose of regulating cocoa marketing... As a consequence of

the 400,000 ton build up in world stocks over the
past three seasons and the current season, pressure
on public warehouse accomodations in consuming
countries is becoming a noticeable feature... At
the lows of 1961 quoted prices were in part
supported by major private sales below the market for
stockpiling and other special purposes, which served
to take a quantity of cocoa off of the market...
There is a question as to whether such support would
be forthcoming a second time.

3/6/62   No. 1: Ghana and Nigeria sold some 170,000 tons
during February, or 37 percent of their total sales
to date this season. Brazil and the Ivory Coast
withdrew as sellers, but this had little effect
on the market as both were known to be well sold...
The rather large open March position in New York
was liquidated in an orderly fashion... Estimate
Ghana main at 400,000 tons... There have been reports
of further capsid damage all over Ghana... U.S. per
capita consumption in 1961 rose to 3.8 pounds of
cocoa beans from 3.5 pounds in 1960... It seems
unlikely that cocoa prices will reach their 1961
low in the near future.

4/3/62   No. 1: The New York open position reached a record
high at the end of March... Speculative buying
during the second half of March was based on sub-
stantial West African sales coupled with reports
of a poor Temporao crop in Bahia - some of these
reports are in our view greatly exaggerated, calling
for 400,000 bags versus 1,000,000 bags last year...
1961 Japanese grindings were up 52 percent over 1960
... Ghana and Nigeria have now sold 85 to 90 percent
of their crops, versus 75 percent at this time last
year... The final Ghana main was 396,000 tons versus
421,000 last year... Cocoa prices at current levels
remain extremely attractive to manufacturers, who
are unlikely to reduce their stocks.

5/7/62   No. 1: The large May open position in New York
was liquidated without trouble... Ghana and Nigeria
continued to sell in April... Ghana mid crop fore-
casts range from 12,000 tons to 30,000... First
quarter U.S. bean consumption was up only 2.75
percent from last year... The market has passed
through a quiet period, and these conditions may
well continue during the between-crops season...
A full meeting of the FAO Cocoa Study Group will be
held in May to discuss the proposed export quota and
sales quota schemes.

6/7/62   No. 1:   The market was strongly influenced in May by
the FAO meeting, first rising in anticipation of
successful negotiations for a stabilization scheme,
then fluctuating with rumors about the possible
stabilization price levels. No final conclusions
were in fact reached, and the market considered
this disappointing. This event coincided with the
plunge on the New York Stock Exchange, which spilled
over into the cocoa market, reflecting the heavy
speculative interest in cocoa... The Bank of Brazil
increased the foreign exchange rate of the cocoa
dollar to 350 cruzeiros per dollar from the previous
310. Reports state that this will hardly offset
the rise in production costs... The cocoa market
will probably remain quiet until some news regarding
the forthcoming main crops becomes available.

7/9/62   No. 1:   The market remained quiet in June... Pros-
pects for the developing main crops in Africa and
Brazil are very good... First half U.S. grindings
were up 6.3 percent over last year... The govern-
ments of Ghana, Nigeria, Brazil, the Ivory Coast,
and the Cameroon Republic have formally ratified
the establishment of the Alliance of Cocoa Pro-
ducing Countries... Rumors in Accra suggest that
the government will stop paying subsidies for the
cutting out of trees damaged by swollen shoot...
We are in the "in-between" season in cocoa, and
there seems little apparent reason for any price
change.

8/13/62   No. 1:   Lower offers from Bahia weakened the mar-
ket somewhat in mid-July... The Ghana mid crop is
now estimated at 13 - 14,000 tons... First half
U.K. grindings, taking into account net trade in
cocoa butter, were up 12 percent over last year;
first half U.S. grindings stated on the same net
basis were up only 0.5 percent. First half grindings
of the five major consuming countries combined
were up over eight percent over last year. This
compares with an FAO forecast of a nine percent in-
crease for the whole year... Ghana and Nigeria have
not yet begun their new crop sales.

9/6/62   No. 1:   The September future was liquidated in an
orderly fashion in New York, but it was noticeable
that speculative longs did not switch into more
distant positions... Initial private forecasts of
the Ghana main crop range from 400,000 to 500,000
tons, compared to 396,000 tons last year; the other

African producers are expected to do equally well...
Brazilian forecasts have recently turned lower...
A 15 percent purchase tax on confectionaries has been
instituted in the U.K.

10/2/62   No. 1:   After reaching a post-war low in mid-September,
prices recovered somewhat, reflecting manufacturer
covering and uncertainty regarding the political
situation in Ghana... Ghana and Nigeria made substan-
tial sales in September, after starting late...
The African crop outlook remains very good, with
expectations generally pointing toward crops exceeding
the record 1960 - 61 levels... The Bahia Temporao
crop at 600,000 bags fell far short of earlier
expectations... It looks as if supply and demand
could be in approximate balance during the coming
season. The market is currently digesting the recent
heavy sales by Ghana and Nigeria. In the longer
term, manufacturers may consider that current price
levels for cocoa are particularly attractive.

11/5/62   No. 1:   Prices remained quite stable during October,
despite the Cuban crisis... The Ghana main crop
is estimated at 410 - 420,000 tons, while Nigeria
is expected to produce a record 210,000 tons, up
eight percent from last year. The Brazilian outlook
has continued to deteriorate. World production
is forecast at a record 1,230,000 tons, up nine per-
cent from last year, and 13 percent greater than 1962
absorption... African sales have been running at a
record pace to date... At present prices, consump-
tion is likely to steadily expand.

12/2/62   No. 1:   Prices strengthened in November in response
to: (1) the FAO forecast of a slight cocoa deficit
in the coming year; (2) reports of the evolution of
new African capsid insect strains immune to the
standard insecticides; and (3) the impounding of a
large quantity of cocoa in Philadelphia due to in-
festation... The crop outlook in Ghana and Nigeria
have become less optimistic due to abnormally heavy
rains, while drought continues to lower Brazilian
forecasts... The FAO Cocoa Study Group will meet in
February to prepare a final draft of an international
cocoa agreement aimed at stabilization... The long
term price outlook is strong, with world production
seemingly having leveled off, and world absorption
continuing in an uptrend.

1/3/63   No. 1: The market drifted in December in response
to heavy Ghana purchases, and in the face of the com-
plete withdrawal of Brazil, and diminished selling
pressure came from the French West Africans...
A small production deficit of 29,000 tons is now fore-
cast for the current season.

2/4/63   No. 1: The extremely well sold position of the Afri-
cans, increasing evidence of smaller Ghanaian and
Nigerian crops than were expected, coupled with
substantial speculative buying, all combined to
generate a spectacular price increase in January...
Trading volume set new records in both London and
New York, as did New York open interest, up almost
50 percent in two months... World production is now
forecast at 1,104,000 tons, down from 1,230,000 tons
forecast in November. A 63,000 ton deficit is now
expected... The long term production outlook in
Africa is obscure due to the spread of spray resis-
tant capsid insects and swollen shoot diseases.
Other things being equal, next year's production
could well be below even this year's output. Des-
tructive weather conditions have prevailed in Brazil.
On the other hand, the strong upward trend in con-
sumption is well established, and from past experience
present prices should not put a brake on usage.

3/5/63   No. 1: Prices levelled off in February as some
smaller speculators took profits. Manufacturers
showed good interest on declines. There was a
sustained bear attack on the market... Ghana has
opened what its officials call a "total war" against
capsids and swollen shoot... Some manufacturers
have slightly increased chocolate prices or reduced
bar sizes... Stocks in consuming countries declined
sharply during the fourth quarter of 1962.

4/5/63   No. 1: Speculative selling dropped the market
during early March, but then there was a fresh
wave of speculative buying, mainly brought about
by speculators shifting their attention from sugar,
in which they have recently been successful, to
cocoa... Brazilian cocoa bean and products exchange
regulations were changed such that exports were again
resumed... A Ghana mid crop of 10 - 15,000 tons is
expected... The FAO conference agreed to proceed to
a formal negotiation meeting to adopt an international
cocoa agreement, despite the existence of a substan-
tial disagreement between producing and consuming

countries as to a "proper" price level for cocoa...
Present indications are that the trend of prices
will be upward, with fluctuations from time to time
due to the large speculative interest.

5/6/63   No. 1: The hectic conditions which existed during
the rapid price advance during the second half of
April were reminiscent of the 1953-54 and 1957-58
bull markets. The reasons for the advance were:
(1) higher than expected first quarter grindings;
(2) growing fears of a short Temporao crop; (3)
confirmation of earlier reports that certain French
shippers were having trouble covering their commit-
ments; (4) further speculative buying... By the end
of April Ghana was virtually sold out of cocoa...
The Ghana mid crop is forecast at 15,000 tons... The
Ghanaian Minister of Agriculture has reported that
of the some 97,000 trees marked for cutting out in
the Eastern Region due to swollen shoot, only 1,699
have been cut out, while in the other regions virtu-
ally none of the marked trees have been cut out.
These figures compare with an average of over 10,000,000
trees cut out per year during the 1954-1960 period.
After the British relinquished control of the De-
partment of Agriculture in Ghana in 1961, much of
the government support for the swollen shoot
campaign was dropped.

6/10/63   No. 1: Trading activity and open interest in New
York reached a new record level in May as the market
fluctuated sharply... The break in the sugar market
near the end of May undoubtedly caused some weakness
in the cocoa market via links in speculative holdings
... Ghana is reported to have made a sizable private
sale of mid crop cocoa to Russia... Ghana mid fore-
casts now range from 15,000 to 30,000 tons... Japanese
1963 grindings are forecast at 28,000 tons, up from
an average of 5,000 tons during the 1954-59 interval
... The increase in world sugar prices may temporarily
restrain consumption in Japan. The overall influence
of high sugar prices on world cocoa consumption is
difficult to determine. While chocolate prices
will be forced higher, the prices of sugar con-
fections will be affected even more, with the result
that chocolate consumption lost due to higher prices
may be regained via switching from sugar confections.

7/3/63   No. 1: The June decline resulted from three main
factors: (1) the Ghana mid crop is larger than
expected earlier; (2) the weather for the developing

main crops has been quite favorable; (3) the sub-
stantial speculative interest in cocoa has continued
to overhang the market... Ghana mid estimates now
range from 25,000 to 40,000 tons... Brazil has
reduced its exchange retention quota on exports of
cocoa and cocoa products.

8/6/63   No. 1: Despite generally satisfactory grindings, the
market continued to decline in July under the weight
of speculative liquidation.... The Ghana mid crop
should reach at least 35,000 tons, exceeding the old
record by some 6,000 tons. It should be noted
that large mid crops have tended in the past to be
followed by large main crops. The weather for the de-
veloping main crops remains quite favorable... The
Temporao crop is now estimated at 700,000 bags, up
slightly from last year but down 50 percent from
1960... Some of the larger consuming countries have
been running down their inventories, but it seems
unlikely that inventories will be further depleted.

9/4/63   No. 1: Prices marked time during August as the
market appeared content to await new crop develop-
ments... Rumors were circulating that the Ghanaian
Marketing Company had negotiated special deals with
certain large dealers, even before the company announced
that it was officially open to negotiation last week.
This the Company denied. It is certain, however, that
substantial sales of new main crop cocoa have now
been made. The Ghana mid crop totalled 39,671 tons
versus earlier forecasts of 15,000 tons. Because
of unusually heavy rains in August, the main
crop outlook is not now as favorable as it was a
month ago. Current estimates point toward a main
crop of about 380,000 to 400,000 tons... The FAO nego-
tiating conference for an international cocoa agree-
ment starts in three weeks. The primary dispute
which must be resolved before an agreement can be
reached concerns the stabilization price range,
particularly the minimum price. Earlier it was unof-
ficially reported that the consuming countries' idea
of a minimum was 18 cents per pound, while producers
favored 25 cents or higher. A compromise may be very
difficult to achieve. The U.S. cocoa trade - manu-
facturers, dealers, and merchants - are unanimous in
opposing an agreement on the grounds that there is no
economic need for a scheme and they fear that an
agreement would artificially raise cocoa prices.

10/9/63   No. 1: The generally firmer trend in prices in

September mainly reflected continued reports of
unfavorable weather in West Africa... While it is
true that the rainfall in both July and August was
two-thirds greater than average, nevertheless it
is also true that the temperature and duration of
sunshine in all the important cocoa growing areas
were also above average... The U.N. Cocoa Con-
ference began as scheduled. So far, public state-
ments indicate that a rather wide difference on
minimum prices exists; this seems to be due largely
to a difference in approach between producing and
consuming countries. The former are looking towards
a reasonably high support price, which will enable
them to develop their economies, whereas the latter
tend to regard the scheme as insurance against
disastrously low prices to producers. Very broadly
the proposed scheme, if it is approved, will work
on a system of basic sales quotas which will be
negotiable at the start of any agreement period and
will be re-negotiable during the course of a period.
An International Cocoa Council will be set up to
run the scheme, and will have the power to either
increase or decrease the basic sales quotas depen-
ding on the movement of the market during the course
of each season. It is the price levels at which
various actions would be taken by the Council
that are providing the main point of controversy at
the current negotiating conference. Such surplus
stocks as are above the basic quotas will be placed
under the control of the Council, but will still be
owned by the individual producing nations concerned.
In times of shortage the Council will release
such stocks, while in times of acute surplus the
Council will have the authority substantially to
curtail marketable cocoa supplies.

11/15/63 No. 1: Continuing uncertainty over the state of the
new main crops in Africa caused a generally firmer
market during October. The breakdown of the U.N.
negotiating conference had virtually no impact on
prices as the market had obviously discounted any
likelihood of the talks succeeding. A number of
generally favorable third quarter grindings figures
for the major consuming countries became known in
October. These, coupled with fresh speculative buying,
added to the general market strength... Of the 628,000
trees marked for cutting out through August of this
year due to swollen shoot in Ghana, only 94,000 have
been removed. During the last comparable period (1961)

when the program was under direct government supervision, 5.3 million trees were cut out... 1963-64 world cocoa production seems likely to be much the same as last year's level. Consumption continues to do well, although the rate of expansion is tending to slow down somewhat, as was anticipated. The long term future for cocoa seems bright, with no burdonsome surplus in prospect.

12/16/63 No. 1: Continued uncertainty regarding the size of the African crops caused several price fluctuations during November. Because of the unexpectedly low rate of purchasing in Ghana to date, there are rising doubts as to whether the main crop will reach last year's level of 382,000 tons; a number of estimates have been circulating in the market in the region of 340,000 to 350,000 tons... The Cocoa Producers' Alliance met in early November; the communique issued at the end of their meeting merely stated that they had studied developments in the international market following the failure of the U.N. negotiating conference... The price has stood up well to the peak level of seasonal purchases in Africa and the increasing rate of shipments. Values having fallen from higher levels, manufacturers may consider that cocoa at present prices is likely to prove attractive in the long term.

Chapter 3

Commodity Price Theory

3.0 Introduction

In this chapter I suggest a theoretical framework use-
ful for explaining the dynamic behavior of commodity spot
prices in general, and the monthly average spot price of cocoa
in particular.

In constructing the general framework I review por-
tions of the literature on commodity prices, emphasizing
and expanding upon those contributions which seem most
relevant. While I draw heavily upon the literature in devel-
oping the theory, it is interesting to note that the result,
a functional relationship between the spot price and current
and expected inventory levels, has not been put forth per se
in previous theoretical discussions,[1] and has not been
used at all as a theoretical construct for earlier empirical
studies of commodity price behavior.[2] As will become evident,
the explanation for the latter event probably lies in the fact

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[1]Though I should stress that the price-inventory relationship
developed in this chapter is only a special case of a more
general theory put forth by Samuelson (15).

[2]Though again, Brennan's article on seasonal inventory behavior
is based on similar theoretical notions.

that most empirical commodity price studies in the litera-
ture have dealt with data intervals much longer than one
month (e.g. a year).

3.1 The General Commodity Model

In general, any model attempting to explain empiri-
cal price movements for a given commodity must be based on
assumptions (either explicit or implicit) about not only
the structural relationships which determine the price, but
also those which determine the production, consumption, and
inventory level of the commodity. This necessity arises
from the fact that under certain circumstances, the avail-
able data for two or more of the above four variables (inclu-
ding price) may have been generated in part by a simultaneous
equation structure. The nature of the appropriate econo-
metric model used for estimation depends critically on whether
or not such simultaneity exists.

The general model for any given commodity may be
written in the following somewhat oversimplified form, invol-
ving three behavioral equations and one identity:

$$C_t = f_C \left(P_t, P_t^L \right) + e_{C_t} \tag{1}$$

$$H_t = f_H \left(P_t, P_t^L \right) + e_{H_t} \tag{2}$$

$$\left(P_t^* - P_t \right) = f_P \left(I_t \right) + e_{P_t} \tag{3}$$

$$I_t = I_{t-1} + H_t - C_t \tag{4}$$

where,

C = Consumption
P = Price
P^L = Lagged Price
H = Production (Harvest)
I = Inventory
P^* = Expected Price

The first two equations, indicating the dependency of consumption and production on current and/or lagged price, reflect traditional micro-economic theory. While other variables may appear in these relationships (e.g. consumer income; government support levels), their exclusion here will not affect the discussion which follows. Equation 3 represents the "supply of storage" curve, to be covered in considerable detail later in this chapter. For the moment, suffice it to say that equation 3 reflects the notion that the amount of a commodity that people are willing to carry in inventory depends on their expectations as to future price behavior. If they feel that the price will increase substantially, they will be willing to carry heavier inventories (supply more storage) than would otherwise be the case. Since the inventory level is in fact

determined by the identity expressed in equation 4, the
supply of storage function can be used to explain the gap
between the current price and price expectations in terms of
the current inventory level.

It is interesting that none of the four equations in
the general model represents the price mechanism per se
(i.e. none explicitly represents the causal mechanism for
price behavior, in the sense that equation 1 represents
the causal mechanism for consumption). Evidently the price
mechanism is implicit in one or more of the three behavioral
equations. The examples which follow indicate the way in
which assumptions about each of the four equations deter-
mine the nature of the price determining mechanism. From
the point of view of statistical estimation, the examples
can be split into two broad classes, depending on whether or
not they involve simultaneity in the equation sets.

Class I: No Simultaneity: the current price level (P)
is determined by any one of the three behavioral equations
alone.

Example (a): Price Determined by Demand Curve --
The above general equations are often modified using the
following assumptions.

Consumption is determined by the current price level:

$$C_t = f_C (P_t) + e_{C_t} \qquad\qquad (1a)$$

Production is determined by past prices:

$$H_t = f_H (P_t^L) + e_{H_t} \qquad\qquad (2a)$$

Consumption during the data interval equals production, so
that the inventory level is constant, and the expected price
level is implicitly assumed to vary in a random manner around
the current price level plus a constant:

$$(P_t^* - P_t) = f_P (\bar{I}) + e_{P_t} \qquad (3a)$$

$$I_t = I_{t-1} = \bar{I} \qquad (4a)$$

If these assumptions are (explicitly or implicitly) made,
and the object is to explain price behavior, then the study
is generally limited to estimation of the single equation:

$$H_t = f_C (P_t) + e_{C_t} \qquad (5)$$

or more commonly:

$$P_t = f_C^{-1} (H_t) + e_t' \qquad (6)$$

An example of this general approach for explaining commodity
price behavior is provided by Breimyer's study of demand and
prices of meat (1; pp. 63-80).[1]

Example (b): Price Determined by the Supply of
Storage Function -- A second set of assumptions for which the
single equation approach is appropriate is the following.
The data interval is short enough to warrent the assumption
that both production and consumption are functions of past
prices:

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[1]Breimyer does consider simultaneity in the demands for
different kinds of meat, but he assumes away simultaneity
in the above four equation model, i.e. simultaneity in the
determination of production, consumption, and/or storage.

$$C_t = f_C \, (P_t^L) + e_{C_t} \tag{1b}$$

$$H_t = f_H \, (P_t^L) + e_{H_t} \tag{2b}$$

The current price is determined by the expected price and the inventory level via the supply of storage function:

$$P_t = P_t^* + f_p \, (I_t) + e_{P_t} \tag{3b}$$

$$I_t = I_{t-1} + H_t - C_t \tag{4b}$$

If the interest is solely in explaining price behavior, then given the above assumptions, statistical estimation can be carried out using single equation least squares on equation 3b alone, providing that data indicative of price expectations is available, or that price expectations are assumed to be constant. The cocoa price model developed by the Cocoa Study Group of the Food and Agriculture Organization of the United Nations (5; pp. 16-18) is of this general form. The FAO model is presented and discussed in detail in Appendix A of this chapter.

Class II: Simultaneity: the current price is determined by the interaction of two or more of the three behavioral equations.

Example (c): Supply-Demand Price Determination --
If example (a), above, is changed so that production is determined by the current price, the model then takes the form:

$$C_t = f_C (P_t) + e_{C_t} \qquad (1c)$$

$$H_t = f_H (P_t) + e_{H_t} \qquad (2c)$$

$$(P_t^* - P_t) = f_P (\bar{I}) + e_{P_t} \qquad (3c)$$

$$I_t = I_{t-1} = \bar{I} \qquad (4c)$$

where, as before, equation 4c implies that $C_t = H_t$.

Given this structure, the price determining mechanism can

no longer be estimated using a single equation in the

original model; the simultaneity between equations 1c and

2c must be taken into account. In fact, in the example as

stated, where there are no exogenous variables serving to

shift either the demand or the supply curves, the price

determining mechanism (i.e. equations 1c and 2c combined)

can not be estimated at all.[1]

Example (d): Demand-Storage Price Determination --

Meinken's wheat model (14; pp. 36-40) is based on a general

structure similar to example (b), above, except that con-

sumption is considered to be determined by the current price:

$$C_t = f_C (P_t) + e_{C_t} \qquad (1d)$$

$$H_t = f_H (P_t^L) + e_{H_t} \qquad (2d)$$

$$P_t = P_t^* + f_P (I_t) - e_{P_t} \qquad (3d)$$

$$I_t = I_{t-1} + H_t - C_t \qquad (4d)$$

---

[1]See Foote and Fox (6; pp. 43-44) for a detailed discussion
of this case.

Here the price serves to establish equilibrium between the pre-determined supply, and the two types of demand, one for consumption, the other for storage into the next period; equations 1d and 3d must therefore be estimated simultaneously. A time series of crop forecasts is used as an indicator of expected price changes.

These examples should make it clear that assumptions which one makes about the four basic equations in the general model critically determine the equation structure appropriate for an empirical study of commodity price behavior. The appropriate assumptions, in turn, depend in large measure on the length of the data interval relative to the important lags (e.g. in the response of production and/or consumption to changes in price) in the system. If the data interval is quite long relative to the consumption and/or production lags, and inventories are allowed to vary significantly (as will generally be the case in a non-perishable commodity), some form of simultaneity in the equation structure seems inevitable. On the other hand, if the data interval is quite short relative to both the consumption and production lags, the general approach indicated in example (b), using the supply of storage function to explain the current price in terms of price expectations and the current inventory level, is appropriate.

Since we are interested in explaining monthly cocoa
spot price behavior, and the lags in response to price changes
of both cocoa production and cocoa consumption appear to be
significantly greater than one month (six months or more
for consumption; several years for production), the use
of the supply of storage function to explain spot price
behavior appears to warrent further study.

3.2 Supply of Storage Theory

There exists a considerable body of literature devel-
oping what has come to be known as "Supply of Storage"
theory, and testing this theory in the markets for
various commodities (references 2,3,4,9,10,11,12,16,18,19,
20, and 21 all relate to supply of storage theory in some
form). The objective of the theory is to explain inter-
temporal price differences, between spot and futures prices,
or between spot and expected future spot prices. The
development of the theory has followed the lines indicated
in the paragraphs which follow.

Consider first a commodity in which there is no futures
trading. As Keynes observed, at least a portion of the total
existing inventory of the commodity generates a yield or
return to the holders of the inventory, just in the process
of being held:

> "Some assets produce a yield... measured in terms
> of themselves, by assisting some process of pro-

duction or supplying services to a consumer."[1]
This yield, later coined by Kaldor[2] as the "marginal con-
venience yield" of stocks, reflects two main services per-
formed by inventories.

First, the processing of primary commodities often
involves a significant amount of capital equipment. If a
processor runs out of the commodity his plant is at least
temporarily idled, and he is not in a position to cover
the overhead expenses associated with his capital equip-
ment and organization. Increased processor inventories
reduce the chances of incurring such costly outages.

Second, owing to various institutional factors
within his industry, the commodity processor may wish to
maintain a relatively stable (as well as competitive)
price level for his finished product, even though his raw
material prices fluctuate significantly. Stability in
this context refers more to the frequency of changes in
finished goods prices than to the amplitude of such changes.
The finished product price which the processor normally
quotes under these circumstances is at or near a level
which will bring a normal return over his processing
costs and the average cost of the raw materials in his
current inventory (i.e. the average price which he paid for

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[1] 11; p. 225.

[2] 10; p. 6.

his inventory). Only if his average inventory cost moves significantly out of line with his finished product price will the processor consider initiating a change in the industry's finished product price structure. If a competitor initiates such a change, then the processor is likely to follow the price change if it is in the direction indicated by his own cost-price gap, or if (in the case of a price decline) he feels that by maintaining his price level he would suffer a significant loss of business. Following these general policies, the processor will find it necessary to initiate a change in finished product prices less often, the longer is his normal level of inventory coverage. On the other hand he will be reluctant to extend his inventory coverage significantly beyond his estimate of his competitors' coverage lest he find himself in a declining market still carrying a large portion of high-priced raw material in his inventory, at a time when the rest of the industry is ready for a decline in finished product prices.[1]

The chocolate industry provides an interesting case

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[1] Kaldor considered the converse of this reasoning to be the main motivation for manufacturer long hedging:

> "The risk of a rise in the price of raw materials
> is a sufficient inducement for (long) hedging,
> even if the manufacturer does not produce under
> contract, so long as he produces for a steady market."
> (9; p. 197)

The more general statement is that processors generally attempt to keep their coverage in line with their estimate of their competitors' coverage, so that they will be in a position to move their prices in line with the rest of the industry.

in point illustrating the institutional factors making

relative stability in finished product prices desirable to

industry members. In the United States a substantial

portion of the chocolate consumed is sold in bars bearing

standard prices (e.g. nickel and dime bars). If cocoa

or sugar prices change substantially, finished chocolate

prices (per unit weight) are changed by varying the weights,

rather than the prices, of the bars. Such weight changes

entail changes in molds, wrappers (which state the weight),

and packaging materials, and as such are quite expensive.

In situations where finished chocolate prices are varied

(as is the case for most chocolate products sold in Europe,

and for some types of bulk chocolate sold in the U.S.),

price changes are accompanied by other complications found

undesirable by manufacturers. Where manufacturers change

prices at all frequently, it soon becomes accepted com-

petitive practice for the manufacturers to offer their

distributors "price protection" on their inventories. For

example, if a chocolate manufacturer lowers his wholesale

price, he will refund to his distributors the difference

between the old price and the new price on all of the

inventory held by the distributors at the time of the price

change. Besides finding it distasteful to have to give such

refunds, the manufacturer is put in the position of either

accepting the distributors' figures regarding the size of

their inventories, or entering into the costly and embarassing

procedure of counting the distributors' inventories himself.

Based on these considerations, the marginal inventory

holding cost incurred by the aggregate of manufacturers has

the general qualitative shape indicated in Figure 3-1. The

marginal holding cost (C) is equal to the marginal cost of

storage (C_S; warehousing costs, etc.), minus the two types

of marginal convenience yield, the one (R_S) reflecting

insurance against stockouts, the other (R_C) reflecting in-

surance against being over or under covered. At low inven-

tory levels marginal holding costs are negative, as a result

of high marginal convenience yields (of both types) from

holding an additional unit of inventory. As the aggregate

inventory level increases, the marginal convenience yields

fall to zero, and the marginal holding cost is equal to the

marginal storage cost. Finally, as the aggregate inventory

level continues to increase, the marginal holding cost also

increases, reflecting a rise in storage costs as warehousing

facilities become saturated, and the tendency for the marginal

coverage convenience yield to become negative as coverage be-

comes excessive.

In deciding how much inventory to carry, then, manufac-

turers determine the difference between the current price

and the price which they expect to exist at some future date.

In the aggregate, they will increase or decrease their inven-
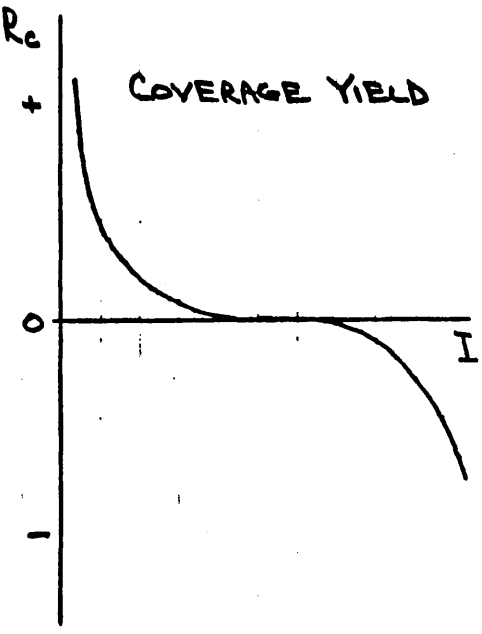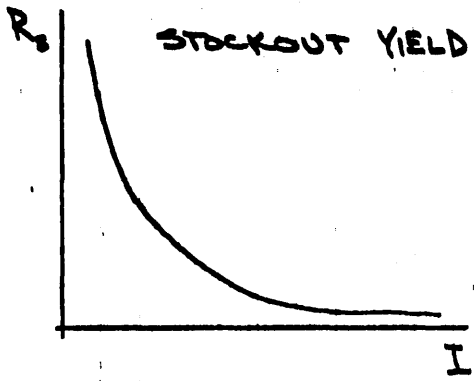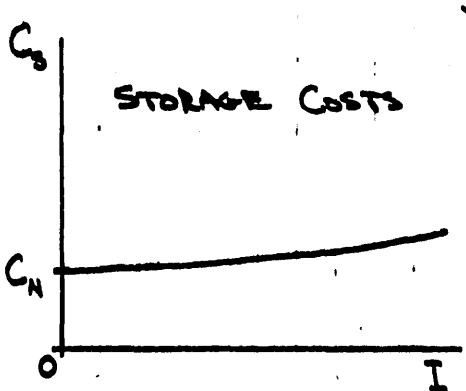
KEY

C = MARGINAL INVENTORY HOLDING COST

C_N = NORMAL STORAGE COST

C_S = STORAGE COSTS

R_S = STOCKOUT YIELD

R_C = COVERAGE YIELD

I = AGGREGATE MANUFACTURER INVENTORIES

STORAGE COSTS

STOCKOUT YIELD

COVERAGE YIELD

MARGINAL INVENTORY HOLDING COST

$$C = C_S - R_S - R_C$$
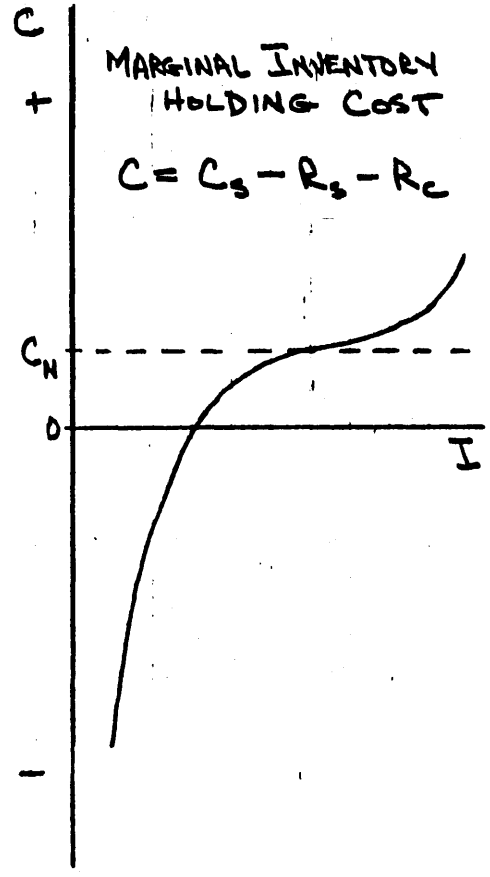
FIGURE 3-1 MARGINAL INVENTORY HOLDING COST
vs MANUFACTURER INVENTORIES

tory level to the point where their marginal inventory holding
cost equals the rate at which they expect the commodity price
to appreciate. Thus the marginal holding cost curve of
Figure 3-1 can be tipped on its side to indicate the manu-
facturers' aggregate demand for inventories as a function of
the expected price rate of change, as shown in Figure 3-2a.
The aggregate expected price[1] used to determine the expected
price rate of change refers to a particular horizon point in
the relatively near[2] future, with the interval between the
current (spot) instant and that horizon point equalling the
horizon time, h.

Processors are not the only holders of inventories in
a commodity market devoid of forward trading. In addition
there will exist speculators (generally in the form of
dealers or producers) willing to carry stocks if they expect
the price to appreciate at a rate fast enough to cover
carrying costs and yield a satisfactory return. As was
observed by Kaldor, it is necessary for the expected rate

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[1]There exists some controversy regarding the usefulness of
the aggregate expected price concept. Rather than interrupt
the discussion of supply of storage theory here, I will come
back to this point later. In the meanwhile, suffice it to
say that the aggregate expected price as it is here used
simply refers to some meaningful aggregation of the price
expectations of all participants in the market for the
commodity in question.

[2]I will come back to discuss the length of the horizon
interval later. For the moment we will simply assume that h
is rather short (e.g. one month).

KEY

I^M = Inventory Held by Manufacturers P^* = Expected Price

I^S = Inventory Held by Speculators P = Spot Price

I^T = Total Inventory h = Horison Interval

C_N = Normal Storage Costs

Figure 3-2a $I^M = f_1\left(\dfrac{P^*-P}{h}\right)$

Figure 3-2b $I^S = f_2\left(\dfrac{P^*-P}{h}\right)$

Figure 3-2c

$$\frac{P^*-P}{h}$$

$$I^T = I^M + I^S$$
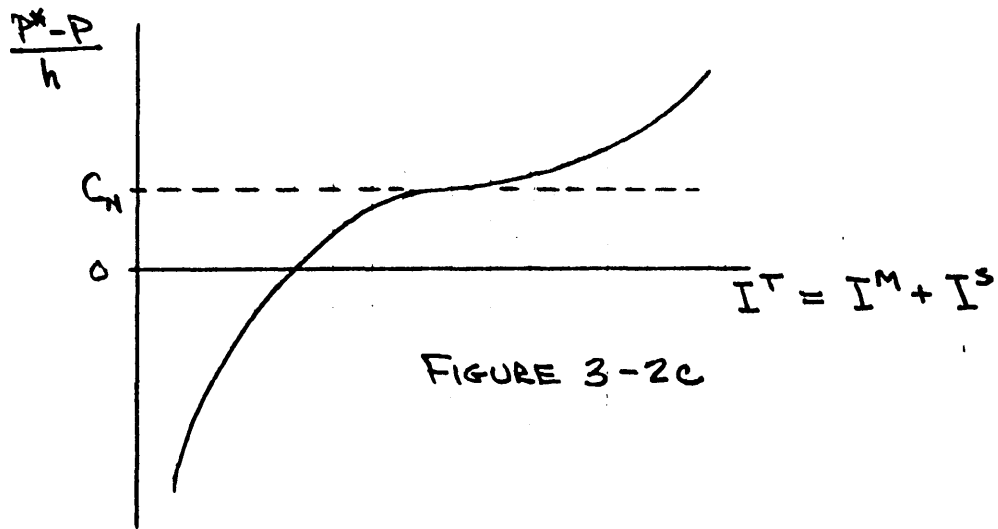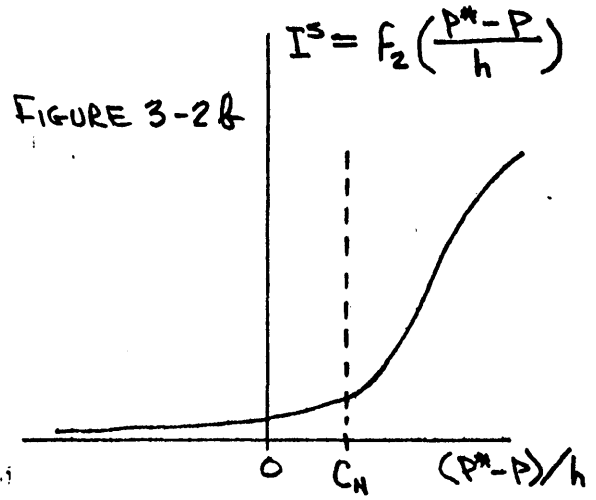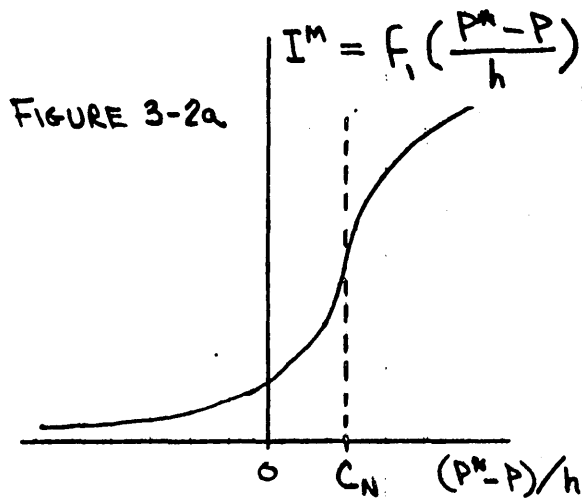
Figure 3-2   Derivation of Supply of Storage Curve, No Futures

of appreciation to increase if speculators are to increase

their holdings:

> "If expectations are uncertain, the difference
> between the expected price and current price must
> cover, in addition (to storage costs), a certain
> risk premium, which will be the greater (i) the
> greater the dispersion of expectations around the
> mean...; (ii) the greater the size of commitments.
> Hence, given the degree of uncertainty, marginal
> risk premium is an increasing function of the size
> of speculative stocks."[1]

Figure 3-2b indicates the qualitative shape of aggregate

speculative holdings as a function of the aggregate ex-

pected price rate of change. There will be some holdings

even when aggregate expectations are for a price decline,

since there will be some individual speculators within that

aggregate who expect a price increase. As the aggregate

expected rate of price appreciation increases above normal

storage costs, an increasing portion of the potential

speculative holders begin to carry inventories, causing the

curve of Figure 3-2b to rise more sharply. Eventually, the

storage facilities and financial capacities of the specu-

lators become strained, causing the speculative inventory

demand curve to begin to saturate.[2]

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[1] 10; p. 5.

[2] Telser (16) has suggested the notion that speculators in
the aggregate may receive a sufficient psychic gain from
gambling to hold inventories without expecting gains, or at
least not significant gains. To the extent that Telser is
right, the whole curve shown in Figure 3-2b would tend to
be shifted to the left, especially for high levels of I^S.

The total demand for inventories, then, for any given
expected rate of price appreciation is equal to the sum of
processor demand and speculator demand. It is conventional
to tip this aggregate demand curve on its side and view it
as a supply of storage curve, as indicated in Figure 3-2c.[1]
Now the level of commodity inventory which exists (and
"demands" storage) at any point in time is determined by
past consumption and production, and is not a variable
subject to direct control (in the sense that the only way
the inventory level can be changed is to change the rates of
production or consumption; i.e. the inventory is the integral
over time of the difference between the controllable variables,
production and consumption). That is, the current inventory
is what it is, and must be stored, so that the supply of
storage curve can be used to derive the expected price
rate of change as a function of the existing inventory level.

The curves shown in Figure 3-2 can be expressed in
equation form:

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[1]Since we are dealing with a market involving no futures
trading, Figure 3-2c is the same as Cootner's "supply curve
of unhedged inventory" (3; p. 175).

$$I_t^M = f_1 \left(\frac{P_t^* - P_t}{h} \right) \qquad (7)$$

$$I_t^S = f_2 \left(\frac{P_t^* - P_t}{h} \right) \qquad (8)$$

$$I_t^T = I_t^M + I_t^S \qquad (9)$$

where,

I^M = Manufacturer inventories

I^S = Speculator inventories

I^T = Total inventories

P^* = Expected price at horizon time

P = Spot price

h = Horizon interval

The three equations can be solved for the three unknowns, I^M, I^S, and $(P^* - P) / h$, in terms of the existing total inventory level, I^T.

If we now introduce futures trading into the market the three equations above are expanded to eight equations:

Figure 3-3 shows the curves for the five functional relationships above. The eight equations can be solved for the eight unknowns, I^{AM}, I^{AS}, I^{AH}, I^{FM}, I^{FS}, I^{FH}, $(P^* - P^F) / h$, in terms of the existing total inventory of the actual commodity, I^{AT}.

The above equations and the corresponding curves shown in Figure 3-3 have the following explanations:

a)

$$I_t^{AM} = f_1(\frac{P_t^* - P_t}{h}, I_t^{FM})$$

As long as a processor has enough actual inventory on hand to make the chances of running out of stock negligible, then any convenience yield contributed by an extra unit of inventory will come primarily in the form of additional cost coverage, and as such the additional yield can be gained as easily by buying futures as by buying actuals. Put another way, the manufacturer, in calculating the current average cost of his inventory, must weigh his futures position equally with his actuals position, since both play equal roles in establishing costs. It follows that the larger the manufacturer's futures position is, the smaller will be the net marginal yield of an additional unit of actual (or futures) inventory. Thus the curve for manufacturer actual inventories (I^{AM}) shown in Figure 3-3a when manufacturer futures inventories (I^{FM}) equal zero is the same as the curve shown in Figure 3-2a; and as I^{FM} increases, the curve for I^{AM} is shifted
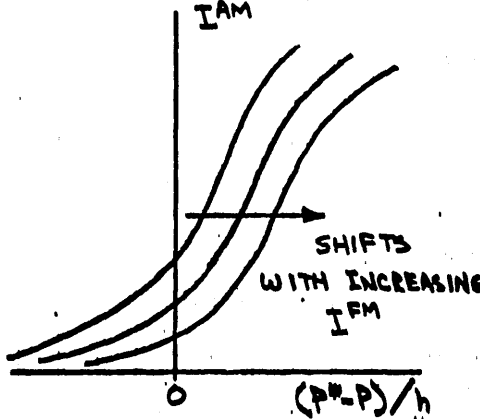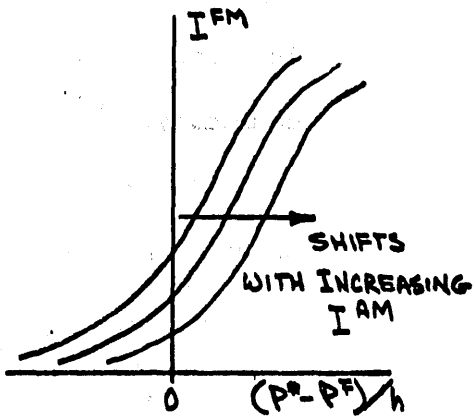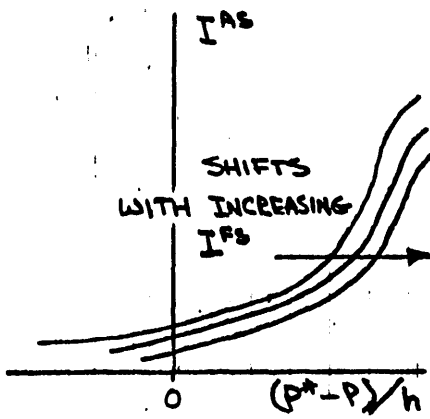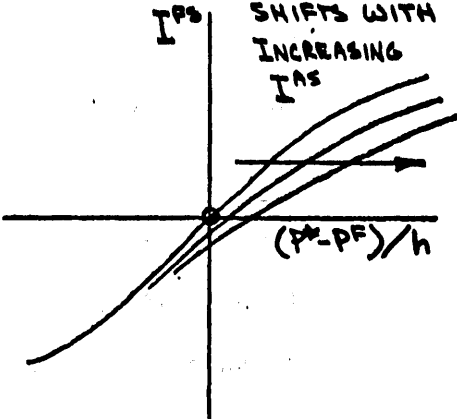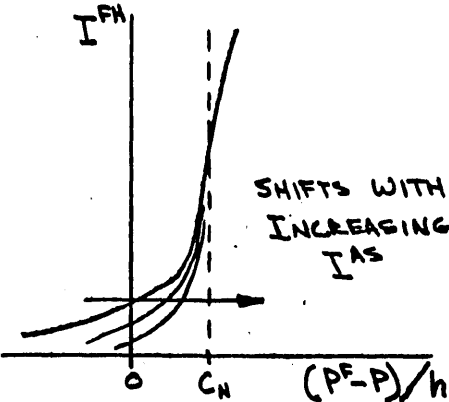
TYPE OF HOLDING	ACTUALS	FUTURES
(IDENTITY)	$I^{AT} = I^{AM} + I^{AS} + I^{AH}$	$I^{FH} = I^{FS} + I^{FM}$
MARGINAL CONVENIENCE YIELD	FIGURE 3-3a 	FIGURE 3-3b
SPECULATION	FIGURE 3-3c 	FIGURE 3-3d
SHORT HEDGING	FIGURE 3-3e $I^{AH} = I^{FH}$	FIGURE 3-3f

FIGURE 3-3 DERIVATION OF SUPPLY OF STORAGE CURVE, WITH FUTURES

to the right, reflecting the decline in the net marginal yield for any given level of I^{AM}. This shift is smallest for low levels of I^{AM}, since in this case a greater portion of the marginal convenience yield takes the form of insurance against outages, which is not affected by the manufacturer's futures position.

b)

$$I_t^{FM} = f_3(\frac{P_t^* - P_t^F}{h}, I_t^{AM})$$

It follows from the above discussion that the curve showing the manufacturer long hedging position in futures (I^{FM}) as a function of the expected rate of price appreciation in the futures contract has the same general shape as the Figure 3-2a curve, except that it does not reflect marginal convenience yield arising from insurance against outages. It also follows that an increase in manufacturer actual inventories (I^{AM}) will cause a shift to the right in the curve for I^{FM}, while a decrease will cause a shift to the left.

c)

$$I_t^{AS} = f_2(\frac{P_t^* - P_t}{h}, I_t^{FS})$$

When the net speculative position in futures (I^{FS}) equals zero, the curve for the speculative position in actuals (I^{AS}; Figure 3-3c) is basically the same as it was in the absence of futures trading (Figure 3-2b). If I^{FS} becomes positive, it is likely that at least a small portion of the traders who are considering

acquiring new speculative positions in actuals, already have speculative long positions in futures, and therefore require a larger risk premium for establishing a new position in the actuals market than would otherwise be the case. Thus, as I^{FS} becomes increasingly positive (i.e. as the expected price (P^*) becomes increasingly greater than the futures price (P^F)), the curve for I^{AS} tends to shift to the right. There is not a corresponding leftward shift in the curve for I^{AS} when there is a net short speculative position in futures, because the persons who are holding speculative inventories in actuals (because they expect an increase in the spot price) cannot be short futures against those actuals or by definition their actuals position would be hedged, not speculative.

d)

$$ I^{FS}_t = f_4(\frac{P^*_t - P^F_t}{h}, I^{AS}_t) $$

The rationale behind the curve for speculative holdings of futures (I^{FS}) is similar to the rationale explaining speculative holdings of actuals (I^{AS}), except that it is possible for the futures speculator to take a short position. For this reason the curve passes close to the origin, since when the aggregate expected futures price rate of change equals zero, the speculative long position in futures will equal the speculative short position.[1] To the extent that saturation is exhibited in

---

[1] If, as is often argued, futures speculators prefer long positions to short positions, the curve in Figure 3-3d would tend to pass above the origin.

the financial capacity of the body of futures speculators.

Just as an increase in the speculative long position in

futures (i.e. an increase in I^{FS} when I^{FS} is positive)

tends to shift the I^{AS} curve to the right, an increase in

I^{AS} tends to shift the I^{FS} curve to the right.

e)
$$I^{AH}_t = I^{FH}_t$$
This is an identity. The level of

actual inventory that is hedged (I^{AH}) must equal the short

hedging position in futures (I^{FH}).

f)
$$I^{FH}_t = f_5(\frac{P^F_t - P_t}{h} , I^{AS}_t)$$
The short hedging

position consists of short positions in futures held against

long positions in actuals by merchants and/or producers.

The fact that the basic curve for the short hedging position

(I^{FH}; Figure 3-3f) is similar in shape to the curve for manu-

(long hedging) actual inventories (I^{AM}; Figure 3-3a) for low

levels of the respective inventories is not coincidental.

Just as his inventory of actuals insures the manufacturer

against a stock-out, a hedged inventory insures the dealer

against running out of stock. That is, if he carries an

ample hedged inventory he will be in a position to be

readily responsive to bids from his customers at current

market prices, without in the process having to risk losses

from a major price decline. Thus, up to a certain point

an additional unit of hedged actuals inventory provides the

dealer with a positive marginal convenience yield. As the
level of hedged inventories increases, the marginal con-
venience yield falls to zero, but unlike the manufacturer's
case, no negative convenience yield accrues to the dealer
from holding an excessive level of hedged inventory.
Once the dealer has reached the point where further stocks
yield no more convenience, he will still continue to add
stocks as long as the futures market carrying charge
($(P^F - P) / h$) exceeds his own carrying costs. This
accounts for the extended vertical section in the Figure 3-3f
curve for I^{FH}. Eventually the curve begins to bend over as
dealer storage capacity becomes taxed. Insofar as dealer
hedgers often are also speculators in actuals, the size of
the aggregate speculative position in actuals (I^{AS}) influ-
ences the I^{FH} curve. A speculative (unhedged) unit of
actuals inventory provides the dealer with as much con-
venience yield as does a unit of hedged inventory, in terms
of his being able to respond to customer inquiries. Thus,
as I^{AS} increases, the marginal convenience yield of I^{FH}
decreases toward zero, and the I^{FH} curve is shifted to the
right.[1]

---

[1]See Telser (16) and Johnson (8) for discussions of the theory
of hedging. The curves shown in Figure 3-3 are consistent with
their findings, except that neither author considers the role
played by the possibility of delivering actuals against a fu-
tures contract (e.g. in the extreme of full carrying charges
on futures, actuals may be acquired specifically for delivery
against futures, with zero price risk involved).

g)
$$I_t^{AT} = I_t^{AM} + I_t^{AS} + I_t^{AH}$$
This is an identity stating

the total existing actuals inventory (I^{AT}) must either be

held for manufacturer convenience yield purposes (I^{AM}) or

speculative purposes (I^{AS}), or else it must be hedged (I^{AH}).

h)
$$I_t^{FH} = I_t^{FM} + I_t^{FS}$$
This is the third equilibrium

identity stating that the short hedging position in futures

(I^{FH}) must be exactly offset by the long hedging position

(I^{FM}) and the net long speculative position (I^{FS}).

Given equations 10 through 17 we can derive the two

supply of storage relationships:

$$\frac{P_t^* - P_t}{h} = f_h^* (I_t^{AT}) \tag{18}$$

$$\frac{P_t^F - P_t}{h} = f_h^F (I_t^{AT}) \tag{19}$$

where,

P = Spot price
P^* = Expected price at horizon time
P^F = Futures price, for delivery at horizon time
h = Horizon interval
I^{AT}= Total actuals inventory

In the functional equations, 10, 11, 14, 15, and 16, the various

inventories were expressed as the dependent variables because

the functions described the aggregate decision mechanisms

involved in deciding how much of each type of inventory would

be held. Equations 18 and 19 express the fact that the exo-

genous input variable to the earlier system of equations (10 through 17) is I^{AT}, the total inventory level, and that the system can be solved for the expected actuals price rate of change and for the futures - actuals price gap. The resulting solution equations (i.e. 18 and 19) are the actuals market and futures market supply of storage functions. Figure 3-4 shows the general shapes of these curves under certain conditions, to be spelled out below.

In discussing the nature of the two curves I will make the simplifying assumption that speculative holdings of actuals (I^{AS}) and futures (I^{FS}) are not dependent on one another. That is, I am rewriting equations 11 and 15:

$$I_t^{AS} = f_2 \left(\frac{P_t^* - P_t}{h} \right) \qquad (20)$$

$$I_t^{FS} = f_4 \left(\frac{P_t^* - P_t^F}{h} \right) \qquad (21)$$

where,

I^{AS} = Speculator actuals inventories

I^{FS} = Speculator futures inventories (net)

To the extent that speculators in actuals only play a relatively minor role in futures speculation, this assumption is not a significant distortion of the facts. In any case, relaxing the assumption would not change any of the general conclusions reached in the discussion which follows.

First consider the case, where the spot price (P) equals the expected price (P^*). In this case equation 10 reduces to,

KEY

P^* = Expected Price at Horizon Time

P^F = Futures Price, for Delivery at Horizon Time

P = Spot Price

h = Horizon Interval

I^{AT} = Total Actuals Inventory

C_N = Normal Storage Costs
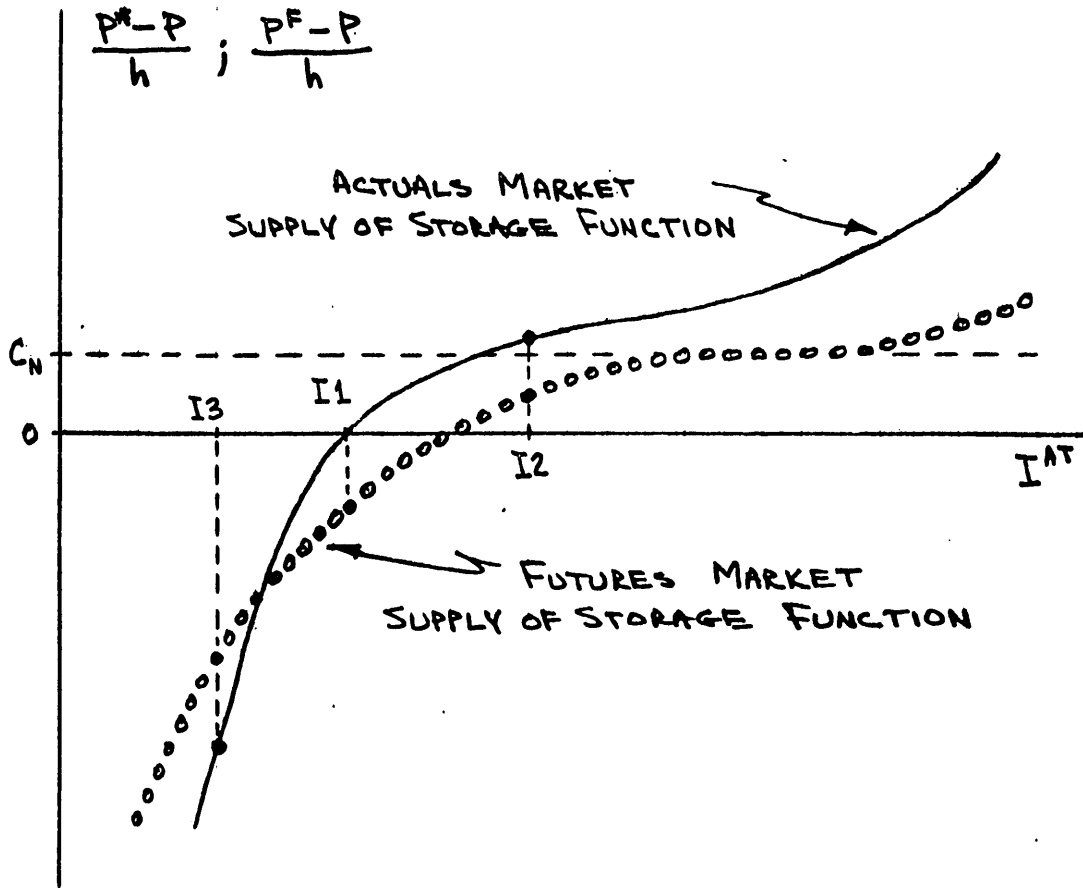
Figure 3-4   Actuals Market and Futures Market
Supply of Storage Functions

$$I_t^{AM} = f_1(0, I_t^{FM})$$
(22)

and can be combined with equation 14 to yield,

$$I_t^{FM} = f_{1,3}\left(\frac{P_t^* - P_t^F}{h}\right)$$
(23)

or,

$$I_t^{FM} = f_{1,3}\left(\frac{P_t - P_t^F}{h}\right)$$
(24)

since $P^* = P$. Similarly, equation 20 becomes,

$$I_t^{AS} = f_2(0)$$
(25)

and can be combined with equation 17 to yield,

$$I_t^{FH} = f_{2,5}\left(\frac{P_t^F - P_t}{h}\right)$$
(26)

Now substituting equations 21 (with P^* replaced by P^S), 24,

and 26 into the futures market clearing identity, equation 17

(repeated here for convenience), we have,

$$I_t^{FH} = I_t^{FM} + I_t^{FS}$$
(17)

$$f_{2,5}\left(\frac{P_t^F - P_t}{h}\right) = f_{1,3}\left(\frac{P_t - P_t^F}{h}\right) + f_4\left(\frac{P_t - P_t^F}{h}\right)$$
(27)

Figure 3-5 depicts this equilibrium graphically, where the

three functions are similar in shape to the corresponding

curves in Figure 3-3 (i.e. the curves for I^{FH}, I^{FM}, and I^{FS}).

As drawn, Figure 3-5 illustrates Keynes' "normal

backwardation", where $P = P^* > P^F$:

> "If supply and demand are balanced, the spot price
> must exceed the forward price by the amount which
> the producer is ready to sacrifice in order to
> "hedge" himself, i.e. to avoid the risk of price
> fluctuations during his production period. Thus

KEY

P = SPOT PRICE

P^F = FUTURES PRICE, FOR DELIVERY AT HORIZON TIME

h = HORIZON INTERVAL

I^{FH} = SHORT HEDGING FUTURES POSITION

I^{FM} = MANUFACTURER FUTURES INVENTORIES

I^{FS} = SPECULATOR FUTURES INVENTORIES

C_N = NORMAL STORAGE COSTS
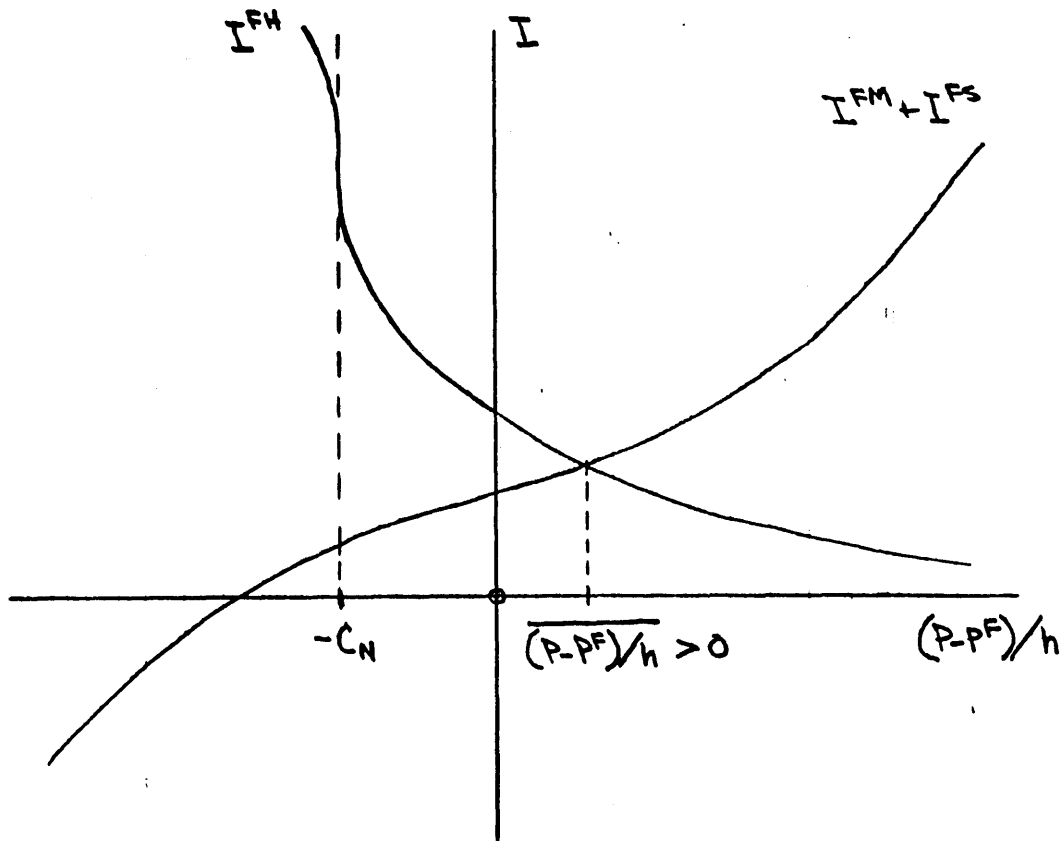
FIGURE 3-5. FUTURES MARKET EQUILIBRIUM

in normal conditions the spot price exceeds the
forward price, i.e. there is backwardation". [1]

The necessary and sufficient condition[2] for the existence of

normal backwardation is that when aggregate expectations

point toward no change in the spot price (i.e. $P^* = P$), the

short hedged position in futures (I^{FH}) be greater than the

long hedged position (I^{FM}); in this case futures speculators

must be net long, and therefore the futures price must lie

below the expected (and spot) price. Whether or not this

condition will in fact be "normal" (i.e. usual) depends on

various characteristics of the particular commodity industry

in question, such as seasonality, the influence of the struc-

ture of trade channels on the desirability of short hedging,

and the influence of the processing industry structure on

the desirability of long hedging.

If the opposite of the above condition holds (i.e. long

hedging greater than short hedging when no price change is

expected) then speculators would be net short, and the fu-

tures price would be at a premium over the expected (and

spot) price.[3]

---

[1] 12; p. 143.

[2] Providing that speculators in the aggregate expect a return
on their commodity holdings.

[3] The same observation was made by Kaldor (10; pp. 6-7) and
Cootner (4; p. 400); the qualification given in the previous
footnote holds here as well.

The total inventory of actuals which must exist if the spot price is to equal the expected price (i.e. I_1 in Figure 3-4) can be determined by solving equations 10 through 17 for I^{AT}, given that $P^* - P = 0$. Now if I^{AT} increases to a level greater than I_1, say I_2, then based on the foregoing discussion, the spot price must fall relative to the expected price (i.e. $(P^* - P) > 0$, as shown in Figure 3-4). This can be shown as follows:

1) The extra actual inventory must either be held by manufacturers (I^{AM}) or speculators (I^{AS}), or it must be hedged.

2) To be held by manufacturers or speculators an increase in $P^* - P$ above zero would be required.

3) Alternatively it could be short hedged in futures, in which case an increase in $P^F - P$ would be required, as would an increase in the long hedged futures position (I^{FM}) and/or the net long speculative position (I^{FS}). But an increase in either of the long positions requires an increase in $P^* - P^F$, which coupled with the increase in $P^F - P$ implies an increase in $P^* - P$.

Given the curve shapes as shown in Figure 3-3, the increase in actual inventories would cause an increase in $P^* - P$, $P^F - P$, and $P^* - P^F$ (see Figure 3-4), so that all of the six sub-classes of inventory (I^{AM}, I^{AS}, I^{AH}, I^{FM}, I^{FS}, and I^{FH}) would

increase somewhat. The increase in the premium of the futures price over the spot price will be limited to carrying charges by short hedging (see Figure 3-3f). Keynes noted this relative price behavior:

> "... the existence of surplus stocks must cause the forward price to rise <u>above</u> the spot price (by an amount) equal to the cost of the warehouse, depreciation, and interest charges of carrying stocks. ...the quoted forward price, though above the present spot price, must fall below the anticipated future spot price by at least the amount of the normal backwardation."[1]

The tendencies for the $P^* - P$ and $P^F - P$ curves in Figure 3-4 to begin to bend upward for large levels of inventory (I^{AT}) reflect saturation in speculative holding and hedged storage capacity, respectively.

Using exactly the same reasoning (with opposite signs) as was used above for the case of an increase in actual inventories from I1 to I2, it can be shown that a decrease from I1 to, say, I3 will cause decreases in $P^* - P$, $P^F - P$, and $P^* - P^F$, as indicated in Figure 3-4. Under the conditions shown in Figure 3-4, speculators are net short (i.e. $P^* < P^F$) and are thereby providing manufacturers with part of their

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[1] 12; p. 144.

inventory position.[1]

So much for the rationale behind the supply of storage curves represented by equations 18 and 19 and shown in Figure 3-4. One of the more important implications of these curves has been stressed by Working,

> "The results from all lines of investigation concur in indicating that prices quoted at one time in a futures market, for two dates of delivery, stand in a relation which in general <u>does not</u> reflect expectations regarding events that may occur between the two delivery dates."[2]

or, "... expectations which deserve to influence the price of the most distant future quoted should always bear equally on spot prices, unless a period intervenes when stocks from both past and future production are expected to be non-existent."[3]

---

[1] The critical role of the marginal convenience yield concept as an explanation of large inverse carrying charges (i.e. $P^F \ll P$) has been emphasized repeatedly in the literature. In the process there has been a tendency to make something of a straw man out of Keynes and his "normal backwardation" concept. Working (20; p. 8) and Brennan (2; p. 71) have both suggested (a) that Keynes offerred the existence of risk premia as the sole explanation of inverse carrying charges, and (b) , by implication, that Keynes was unaware of the role which marginal convenience yield could play as a cause of inverse carrying charges. These unwarranted suggestions perhaps derive from Keynes' assertion that "normal backwardation" was in fact normal. None the less, Keynes clearly indicated his awareness of the existence of the marginal convenience yield concept and its effect on price spreads:
> "If there is a shortage of supply capable of being remedied in six months but not at once, then the spot price can rise above the forward price to an extent which is only limited by the unwillingness of the buyer to pay the higher spot price rather than postpone the date of his purchase." (12; p. 143)

[2] 21; p. 1255.

[3] 20; p. 15.

Stated positively, Working's point is that intertemporal price spreads are in general determined by the existing inventory level alone, and not by events expected to occur in the future (e.g. harvests, shifts in consumption, etc.). This conclusion is not only important (it has formed the basis for several empirical investigations by Working and others)[1], it is also subject to serious question on both theoretical and empirical grounds.[2]

First, the hypothesis involves something of a logical inconsistency. Consider the general supply of storage function, equation 18, written for horizon intervals (h) of one month and two months:

$$\frac{P_t^{*1} - P_t}{1} = f_1^* (I_t) \tag{28}$$

and,

$$\frac{P_t^{*2} - P_t}{2} = f_2^* (I_t) \tag{29}$$

where,

P^{*i} = Expected spot price i months in the future
P^- = Spot price
I = Current actual inventory

Now it is logical to expect that if equation 28 serves to determine the spread between P^{*1} and P, then the spread

_____

[1]See References 2, 16, 18, and 19.

[2]Though as will be shown, Working's conclusion is approximately valid much of the time, which accounts for the large degree of empirical support it has received in the literature.

between P^{*2} and P^{*1} should be determined similarly:

$$\frac{P_t^{*2} - P_t^{*1}}{1} = f_1^* (I_t^{*1}) \tag{30}$$

where,

I^{*1} = Inventory expected to exist one month in the future

Equation 30 simply involves the substitution into equation 28

of current expectations about the variables one month in

the future for the corresponding spot variables (i.e.

P^{*2} replaces P^{*1}; P^{*1} replaces P; and I^{*1} replaces I).[1]

Adding both sides of equations 28 and 30, and dividing the

result by 2, we have,

$$\frac{P_t^{*2} - P_t}{2} = \frac{1}{2} \left[f_1^*(I_t) + f_1^*(I_t^{*1}) \right] \tag{31}$$

which contradicts equation 29 and Working's hypothesis,

in that it says that intertemporal price spreads are

affected by events (i.e. variations in inventory) expected

to occur during the spread time interval.

This contradiction is illustrated by the following

example. Say that the one month supply of storage curve

(equation 28) is as shown in Figure 3-6a, and that the inven-

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[1]This is logical in the sense that it postulates that if
equation 28 holds now, it will also hold one month from
now. This is akin to Muth's "rational expectations" hypo-
thesis:

"... expectations, since they are informal pre-
dictions of future events, are essentially the
same as the predictions of the relevant economic
theory." (14; p. 316).

$$\frac{P^* - P}{h}, \quad h = 1$$
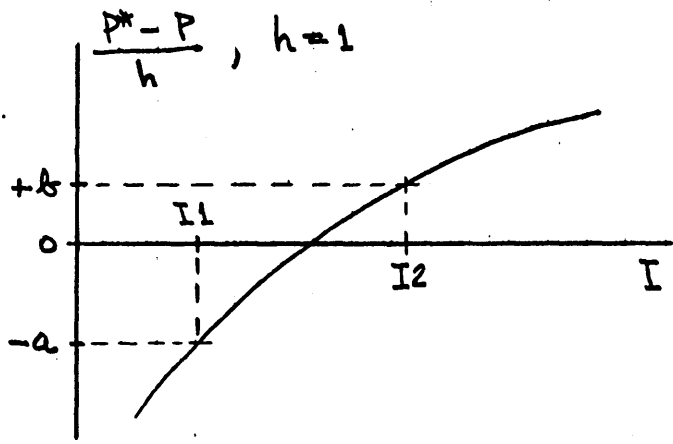
FIGURE 3-6a

SUPPLY OF STORAGE CURVE
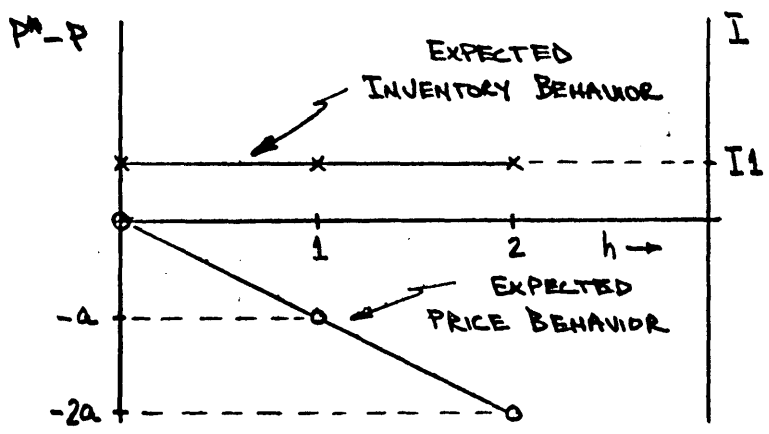
FIGURE 3-6b

INVENTORY EXPECTED TO REMAIN CONSTANT
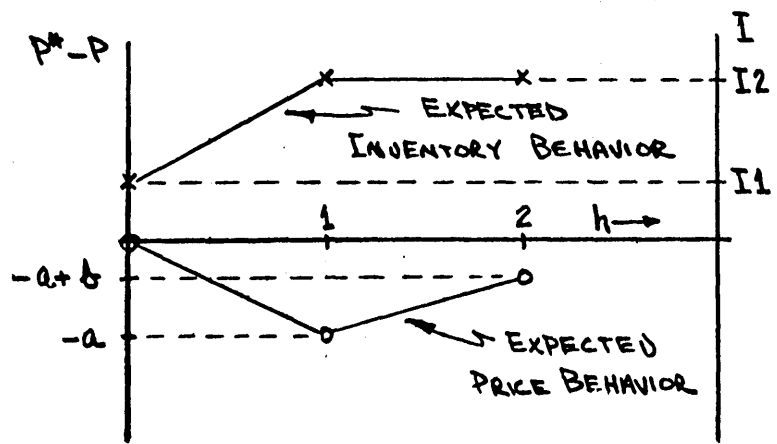
FIGURE 3-6c

INVENTORY EXPECTED TO INCREASE

FIGURE 3-6   THEORETICAL EXAMPLE OF

FORWARD PRICE DETERMINATION

tory is expected to remain constant at its current level,

Il, as shown in Figure 3-6b. Since at this level there

is a shortage, the price expected one month in the future

is at a discount to the spot price (i.e. there is an inverse

carrying charge), and the price expected in two months is

at a discount to the price expected in one month (also

indicated in Figure 3-6b), where the size of the monthly

discount is given by the supply of storage curve in Figure 3-6a.

Now suddenly expectations about future inventory behavior

change, so that the inventory level in one month is expected

to increase from Il to I? (as shown in Figure 3-6c), where

I^2 represents a surplus inventory level, which will only

be carried if the storer expects a price increase. The

result is a change in the pattern of price expectations to

that shown in Figure 3-6c, where the supply of storage

curve gives the premium of the price expected in two months

over the price expected in one month. It is this shift in

the pattern of price expectations that contradicts Working's

hypothesis that the spread between the spot price and the

expected price in two months (or at any future time) is

not influenced by events expected to transpire in the interim.

Figure 3-7 shows an actual case in the cocoa market

similar to the above example, where futures prices are

used instead of expected spot prices. During the 1959-

1960 autumn and winter period market estimates of the size
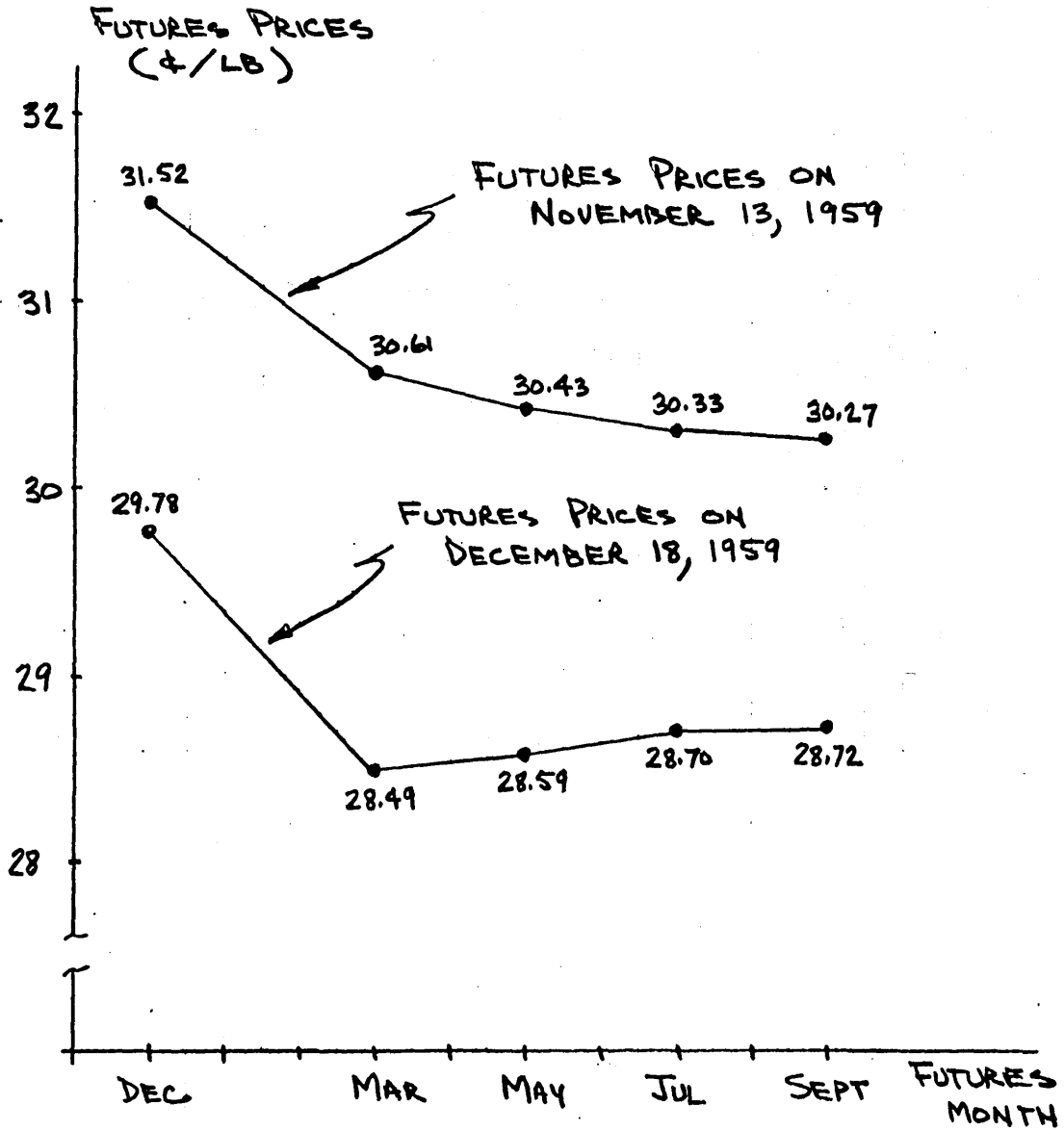
FIGURE 3-7   COCOA FUTURES PRICES,
NOVEMBER - DECEMBER, 1959

of the African main crops being harvested increased signi-
ficantly. The result was a decline in the entire futures
price structure during the interval from mid-November to
mid-December. Apparently the crops did not become fully
available to the market in time to prevent a relative
shortage during December, hence the existence of inverse
carrying charges between the December and March futures,
at both of the illustrated dates. But the increase in
crop expectations apparently was large enough to cause the
market to shift from expecting a continued relative shortage
after December to expecting something of a surplus. This
apparent shift in expectations is indicated by the shift
in the spreads between the successive futures beginning
with March, from inverse carrying charges in November to
positive carrying charges in December.

Now if Working's conclusion, which is a simple ex-
tension of the supply of storage concept, is contradicted
both by theory and by fact, where is the flaw in supply of
storage theory? The answer is that there is none. Working's
conclusion can be disputed only if the time interval between
successive price expectations is long enough to allow for
a change in the expected inventory level during that interval.
Consider equation 30 written for a general time interval
in the pattern of price expectations, starting at horizon
time, h, and having a length, dh:

$$\frac{P^{*h} + dh - P_t^{*h}}{dh} = f_{dh}^*(I_t^{*h}) \tag{32}$$

where,

P^{*h} = Expected spot price h months in the future

h = Horizon time of initial expectation

dh = Interval between expectations

I^{*h} = Inventory level expected at h

Now if we let dh approach zero, so that the inventory level can be assumed to remain constant over the very short interval, dh, we have,[1]

$$\frac{dP_t^{*h}}{dh} = f^*(I_t^{*h}) \tag{34}$$

where,

f^* = Short term supply of storage function

Then the supply of storage function linking the spot price with the price expected at some non-zero horizon time can be derived as follows. First, integrating equation 34, we have,

$$P_t^{*h} = P_t^{*0} + \int_0^h f^*(I_t^{*h}) \, dh \tag{35}$$

But since the expected spot price at a zero horizon (P_t^{*0}) is simply the spot price, we have the general supply of storage

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[1]This explains why I assumed a short horizon interval in the earlier discussion of supply of storage theory.

function for a specific horizon,[1]

$$\frac{P_t^{*h} - P_t}{h} = \frac{1}{h}\int_0^h f^*(I_t^{*h})\ dh \tag{36}$$

where,

P^{*h} = Expected spot price h months in the future

P = Spot price

I^{*h} = Expected inventory h months in the future

h = Horizon time

f^* = Short term supply of storage function

It follows from equation 19 and the above discussion that the

corresponding futures price supply of storage function can

be written,

$$\frac{P_t^{Fh} - P_t}{h} = \frac{1}{h}\int_0^h f^F(I_t^{*h})\ dh \tag{37}$$

where,

P^{Fh} = Futures price for delivery h months in the future

f^F = Short term futures supply of storage function

That is, the spread between the spot price and the expected

spot price and/or the futures price relating to some rela-

tively distant horizon time is a function of expected inventory

behavior over the horizon interval.

In certain instances, expecially in the case of an agri-

cultural commodity with a highly lumped harvest interval, the

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[1]To my knowledge this formulation is original to Samuelson
(15; pp. 217-18), though he did not put it in quite this
way.

expected future inventory pattern during a large portion

of each season can be approximately stated in terms of the

current inventory level (e.g. after the harvest the inventory

tends continuously to decline until the next harvest). That

is, one can write,

$$I_t^{*h} = g(I_t, h) \tag{38}$$

which when substituted in equation 37, yields,

$$\frac{P_t^{Fh} - P_t}{h} = \frac{1}{h} \int_0^h f^F\left[g(I_t, h)\right] dh \tag{39}$$

which is consistent with equation 18 and Working's con-

clusion if,

$$f_h^F(I_t) = \frac{1}{h} \int_0^h f^F\left[g(I_t, h)\right] dh \tag{40}$$

Most of the empirical support for Working's conclusion has

come from studies in which equation 38 has been approximately

valid, since they have involved relatively short spread

time intervals (e.g. two to three months), for commodities

with pronounced seasonal production patterns. Thus the

resulting supply of storage curves (generally using futures

prices) have been related to the short term supply of storage

function as indicated in equation 40. Even where equation 38

has not provided a very good approximation, the shape of the

short term futures supply of storage curve (see Figure 3-4)

is such that for a wide range of high inventory levels the

short term price spread is constant at carrying charges. As

long as the expected inventory pattern does not vary outside of this wide range, equation 37 can be rewritten,

$$\frac{P_t^{Fh} - P_t}{h} = \frac{1}{h} \int_0^h c \, dh \qquad (41)$$

or,

$$\frac{P_t^{Fh} - P_t}{h} = c \qquad (42)$$

where,

  c = Carrying charges

This independence of spread behavior from expected inventory behavior as long as the inventory is large accounts for the fact that the error variance around the empirical supply of storage curves reported in the literature often seems to be smallest in the flat range of the curves (i.e. where inventories are relatively large).

There remain two matters before we are finished with supply of storage theory *per se*. First, there exist good reasons for writing both the price spreads and the inventory level in equations 18 and 19 in ratio terms (I have not done so up to now in order to simplify the preceding discussion). That is, these equations should be rewritten,

$$\frac{(P_t^{*h} - P_t)/P_t}{h} = f_h^* \left(\frac{I_t}{C_t}\right) \qquad (43)$$

and

$$\frac{(P_t^{Fh} - P_t)/P_t}{h} = f_h^F \left(\frac{I_t}{C_t}\right) \qquad (44)$$

where,

  C = Recent rate of consumption

That is, the expected fraction change in price is related to the ratio of the current inventory level to the consumption rate.

In terms of the three motivations for holding inventories, the arguments for stating the price spread as a fraction of the current price are:

1) Regarding speculative holding of inventories, the required risk premium is a percent of invested capital, and in both actuals and futures the capital needed to hold a given inventory tends to vary in proportion with price.

2) With respect to hedged storage, a significant portion (but not all) of the carrying charge varies roughly in proportion with price (e.g. interest charges, insurance premiums).

3) In the case of processor coverage, the case is not clear. However, to the extent that processing margins vary in proportion with raw material costs (which would be the case if total processing profits remain relatively stable and final demand is price elastic), then the marginal convenience yield of commodity inventories, which derives from the role of

inventories in "protecting" profits, would tend to
vary with commodity prices.

The arguments for stating the inventory level as a ratio to
consumption are:

1) Inventory convenience yield to processors is
clearly determined by the length (measured in time
units) of coverage of processing needs that is
afforded by the inventory level.

2) It is necessary that as the usage rate of a
commodity grows, the capacity of the trade channels -
merchants, brokers, speculators - handling that
commodity must also grow in rough proportion. As a
result, the amount of hedging or speculative holding
of inventories which a given price spread will moti-
vate tends to vary in proportion with the usage rate.

Now if, as before, we allow the interval between expec-
tations to approach zero in equation 43, we have,

$$\frac{dP_t^{*h}/P_t^{*h}}{dh} = f^* \left(\frac{I_t^{*h}}{c_t^{*h}}\right) \tag{45}$$

or,

$$\frac{d}{dh}(\ln P_t^{*h}) = f^*(Y_t^{*h}) \tag{46}$$

where,

f^* = Short term supply of storage function

Y^{*h} = Expected inventory ratio at horizon time

Integrating 46 we have,

$$\ln P_t^{*h} = \ln P_t^{*0} + \int_0^h f^*(Y_t^{*h})\, dh \tag{47}$$

or, since P^{*0} is the spot price,

$$\ln \left(\frac{P_t^{*h}}{P_t}\right) = \int_0^h f^*(Y_t^{*h})\, dh \tag{48}$$

Operating on equation 44 in the same manner we get,

$$\ln \left(\frac{P_t^{Fh}}{P_t}\right) = \int_0^h f^F(Y_t^{*h})\, dh \tag{49}$$

Because of its greater general plausibility, I will use the ratio format embodied in equation 48 in the empirical tests discussed in the next chapter.

Finally we have the unfinished business footnoted earlier: the dispute concerning the validity of the expected price concept. Hawtrey laid out the critical view in fine detail:

"It is not merely that owing to differences in expectations of different individuals, there is no one expected price, but that there are gaps

> in the series, where no expectation exists at
> all. This is, indeed, a fatal objection to the
> introduction of any aggregates or averages of
> expectations into economic reasoning... Not only
> are there sure to be some people who have formed
> no expectations at all in regard to the economic
> quantity concerned, but those who have will have
> formed very incomplete expectations, some merely
> expecting that the quantity will exceed or fall
> short of estimates of the respective probabilities
> of a series of results. Nor will they relate to
> the same future dates."[1]

In terms of the desire to empirically test a theory

of commodity price dynamics, it seems necessary to deal with

some form of the aggregate price expectation concept.

Clearly the price expectations of market participants do

play some sort of role as a determinant of the spot price,

and equally clearly the whole array of individual price

expectations per se is neither measureable nor handleable.

Against this need for the aggregate expected price concept,

Hawtrey throws the heterogeneity of form of the individual

expectations, claiming that this provides a "fatal objec-

tion" to the use of aggregate expectations in economic

research. The verdict seems too harsh to me. In terms of

the supply of storage theory presented above, it would be

natural to consider the aggregate expected price as a

mapping of the array of individual price expectations, in

all of their various forms, into a single valued function

representative of these expectations. The proof of the

---

[1] 7; p. 203.

usefulness of this theoretical pudding ultimately must lie
in the empirical eating. If a theory embodying the aggregate
price expectation concept seems effectively to explain spot
price movements, an important argument will have been made
for the validity of employing that concept.

3.3 The Spot Price Function

The supply of storage theory outlined in the previous
section explains the behavior of intertemporal differences
in price expectations in terms of expected inventory behavior.
But as I indicated earlier, the supply of storage concept is
also useful in explaining actual spot price behavior, given
certain further assumptions.

Consider the following system of equations describing
a general commodity industry:

$$C_t = c^e - b (P_t - P^e) \tag{50}$$

$$H_t = c^e + e_t \tag{51}$$

$$I_t = I_0 + \int_0^t (H_t - C_t) \, dt \tag{52}$$

$$\frac{d P_t^{*h}}{dh} = a (I_t^{*h} - I^e) \tag{53}$$

where,

$$b > 0; \quad a > 0,$$

and,

C   =   Consumption

P   =   Spot price

H   =   Production (Harvest)

I   =   Inventory

P^{*h} =   Price expected at horizon interval, h (i.e. at time = t + h)

I^{*h} =   Inventory level expected at horizon interval, h

P^e =   Equilibrium price

c^e =   Equilibrium consumption

I^e =   Equilibrium inventory

The harvest rate is postulated as varying randomly about a
constant rate which is equal to the equilibrium consumption
rate. The equilibrium values of price and consumption are
so named because when price is at its equilibrium value,
consumption is at its equilibrium value and is equal to
production. When the expected inventory level is at its
equilibrium value in the supply of storage function

(equation 53, which is a linear version of equation 34),

the expected price remains constant.

Now we can solve the above model for the expected

future behavior of price and inventory, if we assume that

expected consumption is related to expected price by equa-

tion 50, that expected production is constant at C^e, and

that expected inventory can be derived according to

equation 52:[1]

$$C_t^{*h} = C^e - b (P_t^{*h} - P^e) \tag{54}$$

$$H_t^{*h} = C^e \tag{55}$$

$$I_t^{*h} = I_t + \int_0^h (H_t^{*h} - C_t^{*h}) \, dh \tag{56}$$

Taking the second derivative of 56 with respect to h, we have,

$$\frac{d^2}{dh^2} I_t^{*h} = \frac{d}{dh} H_t^{*h} - \frac{d}{dh} C_t^{*h} \tag{57}$$

or, using equations 53, 54, and 55,

$$\frac{d^2}{dh^2} I_t^{*h} - ab \, I_t^{*h} = - ab \, I^e \tag{58}$$

which, given the inventory at the beginning of the expec-

tation period (i.e. I_t, the current inventory), and the

restriction that both a and b must be positive, has the

---

[1] These assumptions are a direct application of Muth's
rational expectations hypothesis, in that the expected
future values of the variables in the system are inter-
related in the same manner as are the actual values. The
random element in production is not predictable, and is
assumed constant at its (zero) expected value.

stable solution,[1]

$$I_t^{*h} = I^e + (I_t - I^e) e^{-\sqrt{abh}} \qquad (59)$$

so that as the horizon becomes large, the expected in-ventory approaches the equilibrium level. Substituting 59 into 53, and integrating with respect to h, yields,[2]

$$P_t^{*h} = P_t^{*0} + \int_0^h a (I_t - I^e) e^{-\sqrt{abh}} \, dh \qquad (60)$$

or,

$$P_t^{*h} = P_t + \frac{a}{b} (I_t - I^e)(1 - e^{-\sqrt{abh}}) \qquad (61)$$

Now the expectation that the inventory will approach its equilibrium level implies that the price is expected to approach some constant level (see equation 53), and this must be the equilibrium price level since a constant

---

[1] This is only one of an infinite set of possible solutions to equation 58, given the initial inventory level and no other boundary conditions. This particular solution is based on the behavioral assumption that for very large values of t, the inventory is approximately at its equilibrium level. This is the only solution to equation 58 which does not eventually lead to an exponential explo-sion in the values of the system's variables, which explo-sion would involve the implausible combination of price and inventory values simultaneously either both above or both below their respective equilibrium levels on a con-tinuous basis.

[2] Note that equations 59 and 60 constitute a special case of equations 38 and 39.

inventory implies a consumption rate equal to the production rate.[1] Therefore, allowing the horizon time, h, to become large in equation 61, we have,

$$P^e = P_t + \sqrt{\frac{a}{b}} (I_t - I^e) \tag{62}$$

or,

$$P_t = P^e - \sqrt{\frac{a}{b}} (I_t - I^e) \tag{63}$$

Within the confines of our special case, this result is of great importance. It says that if: (a) in arriving at their expectations people assume that expected system behavior is generated by the same equation system that they feel generates actual behavior (i.e. Muth's rationale expectations hypothesis holds), and (b) people behave as if their expectations were certain to come true (i.e. their expectations constitute certainty equivalents), then the current price is a function of the current inventory level alone.

Now consider a generalized version of equations 50 through 53, such that both consumption and production are

---

[1] Samuelson (15; pp. 211-219) shows that this stability characteristic of a model having the general form of equations 53 through 56 holds as long as the demand curve has a negative slope,

$$d\, c_t / d\, P_t < 0 \qquad \text{for all } P_t$$

and the supply of storage curve has a positive slope,

$$\frac{d}{d\, I_t^{*h}} \left[\frac{d\, P_t^{*h}}{d\, h} \right] > 0 \qquad \text{for all } I_t^{*h}$$

and the behavioral assumption footnoted above is made.

functions of _lagged_ price (as is the case in cocoa), and the supply of storage curve is in its fractional form (equation 46). A general solution of the resulting equation system is no longer attainable (the differential equation corresponding to 58 becomes high order and non-linear). Nevertheless, given certain behavioral assumptions about the generation of expectations in actual commodity markets, we can rescue some of the potential generality of equation 63 for purposes of empirical testing.

First, it is common in commodity markets in general, and in the cocoa market in particular, for there to exist published forecasts of production and consumption (and therefore inventory) behavior over some finite horizon period, usually one year or less. These expectations can be substituted into equation 48 to yield a relationship between the spot price and the price expected at the end of the finite horizon interval, h_1,

$$\ln P_t = \ln P_t^{*h_1} - \int_0^{h_1} f^* (Y_t^{*h}) \, dh \tag{64}$$

where,

P = Spot price

P^{*h_1} = Spot price expected at horizon time, h_1

Y^{*h} = Inventory ratio (I^{*h}/C^{*h}) expected at horizon time, h

Now if the expected behavior of the inventory ratio over the horizon interval can be approximately stated in terms

of its beginning value (Y) and its ending value ($Y^{*h_1}_-$)

in such a way that equation 64 is integrable, then we have

the approximation,

$$\ln P_t = \ln P^{*h_1}_t - F^{*h_1}_- (Y_t, Y^{*h_1}_t) \tag{65}$$

where,

$$F^{*h_1}_- (Y_t, Y^{*h_1}_t) = \int_0^{h_1} f^*_- (Y^{*h}_t) \, dh \tag{66}$$

Second, if we can further assume that after the end

of the horizon interval, h_1, both the price and the inven-

tory ratio are expected to gradually approach their expected

equilibrium values,[1] then again using equation 48 we can

write,

$$\ln P^{*h_1}_t = \ln P^{*\infty}_t - \int_{h_1}^{\infty} f^*_- (Y^{*h}_t) \, dh \tag{67}$$

And if the expected behavior of the inventory ratio over

the period after h_1, can be approximately stated in terms

of its expected values at h_1 ($Y^{*h_1}_-$) and at infinity

($Y^{*\infty}_-$, its expected equilibrium value) in such a way that

67 is integrable, then we have,

---

[1]If the characteristic dynamic behavior of the actual commodity
system is not purely damped, this assumption may violate
Muth's rational expectations hypothesis. For example the lag
structure of the system may be such as to generate long run
fairly damped (i.e. irregular) oscillations around an equi-
librium state in response to exogenous random disturbances.
But if the system structure is complex enough to generate
oscillations, Muth's hypothesis that market expectations
are based on an awareness of that structure (at least to the
same degree that economic theorists are aware of the structure)
may be unreasonable. As long as the oscillations are fairly
damped around relatively constant equilibrium values, it may
be more reasonable to assume that market participants at any
point in time expect the system variables to approach equili-
brium in a purely damped (non-oscillatory) fashion.

$$\ln P_t^{*h1} = \ln P_t^{*\infty} - F^{*\infty}(Y_t^{*h1}, Y_t^{*\infty}) \tag{68}$$

where,

$$F^{*\infty}(Y_t^{*h1}, Y_t^{*\infty}) = \int_{h_1}^{\infty} f^*(Y_t^{*h}) \, dh \tag{69}$$

Combining 64 and 68 yields,

$$\ln P_t = \ln P_t^{*\infty} - F^{*h1}(Y_t, Y_t^{*h1}) - F^{*\infty}(Y_t^{*h1}, Y_t^{*\infty}) \tag{70}$$

Again within the limits set by the underlying assumptions, equation 70 is potentially of fundamental importance. It indicates that the spot price can be approximately stated as a function of the current inventory ratio, the market's inventory ratio forecast for some finite horizon, and the expected long run equilibrium levels of price and the inventory ratio. This theoretical concept will be tested in the next chapter.

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APPENDIX A

The FAO Cocoa Price Model

The FAO Cocoa Study Group has constructed the following

statistical model of the cocoa price mechanism (5; p. 17):

$$\ln p = 2.013397 - 0.001061\ q + 0.000742\ g - 0.008700 + e_t$$

$$\qquad\qquad (0.000162)\qquad(0.000228)\qquad(0.0001614)$$

$$R = .889 \qquad\qquad\qquad\qquad\qquad\qquad\qquad (A\text{-}1)$$

where,

p = Average monthly spot price of Accra beans
in New York, in cents/pound, deflated by
the U.S. wholesale price index.

q = Current forecast of annual world production for
the crop year beginning October 1, in thousands
of metric tons.

g = Current forecast of calendar year world grin-
dings, in thousands of metric tons.

s = Actual stocks as a percent of grindings.[1]

The FAO report gives the following explanation regar-

ding the details of the study, and the reasons for choosing

the particular model structure indicated above:

"An analysis of historical data demonstrates that
prices react inversely to estimates of crop outturn
and directly to estimates of current and future

---

[1]The report does not indicate what is meant by "actual stocks",
or which grindings are used. Presumably this variable refers
to the stocks in consuming countries at the end of the
preceding calendar year, stated as a percent of world grin-
dings during that year, since the only available series re-
lating to world cocoa stocks, published by Gill and Duffus,
takes this form.

grindings. The price effects of production and
grindings are cushioned by ideas with regard to
stocks in a manner directly related to their level.

"A simple comparison of year-to-year percentage
changes in (1) production (2) grindings, and (3)
the yearly average prices of cocoa beans in New
York or London during 18 pre-war and 10 post-war
years shows that in only 12 of these were the year-
to-year price changes in the direction to be ex-
pected from the changes in production (i.e., a
decrease in production being accompanied by an
increase in the price of beans). One of the main
reasons for this is that price develops during
the year not in relation to the final production
or grindings outturns, which are of course known
only after the end of the period, but in accordance
with expectations and forecasts during the period.
An analysis of forecasts shows that generally the
final figures differ considerably from those pre-
vailing in the market at the beginning of the year.
Moreover, the yearly price averages are not realis-
tic averages of the amounts paid for cocoa during
each year. One of the reasons is that the simple
annual figures give equal weight to months of heavy
purchasing (e.g. December-January) with months of
light purchasing (i.e. July-August).

"A more realistic way to study the effects of
changes in production, grindings and stocks on
prices is to correlate monthly or daily price
changes with changes in market ideas concerning
the development of production and grindings and
stocks. In reality there are of course many ideas
on these factors in the markets, and the ideas
change from day to day. For the purpose of his-
torical analysis it is necessary to select bench-
mark ideas, which are representative of market
opinion for certain periods of time. For this
study, the analysis is limited to forecasts and
estimates of production and grindings issued in
October, January, April and July (or the forecast
which is nearest to these months) for the years
1952-1960, which are correlated with price changes
during the month of the estimate and the succeeding
month. Thus, production and grindings forecasts
issued in January are compared with the average
monthly price of "spot" Ghana, New York, for Jan-
uary-February; the April forecasts are related to

the April-May prices. The only exception is
the July estimate, which is a combination of a
representative estimate in July for the crop just
ending and the first forecast (in August or
September) of the forthcoming crop. The rationale
for this is that at the end of the season traders
do, in point of fact, consider reports on the size
of next year's crop and on the progress of con-
sumption during the last months of the year...

"For the purpose of this study, the forecasts
issued by Gill & Duffus Ltd. of London (because
of their wide distribution and frequency of appear-
ance) and those issued by the Committee on Sta-
tistics of the Cocoa Study Group were used."

It is interesting to note that the authors of the FAO

report do <u>not</u> argue for the model structure used in equa-

tion A-1 on general theoretical grounds. Instead, the

authors seem merely to be saying that, based on their

qualitative knowledge of the cocoa market, "changes in

market ideas concerning the development of production and

grindings and stocks" should lead to certain changes in the

price of cocoa, and their goal in their statistical analysis

is to gain more knowledge about the quantitative character-

istics of these effects. They do not say why expectations

about (say) grindings should have an effect on theprice (it

is apparently considered self-evident), and it is in this

sense that they do not provide a theoretical framework for

their statistical analysis.

It is striking, on the other hand, that the model format

chosen in the FAO report comes very close to being consistent

with the theoretical discussion given in the preceding chap-

ter. To indicate this, let me start by writing the supply

of storage function in a form such that the expected frac-

tion change in price is an (increasing) linear function of

the inventory level stated as a fraction of consumption:

$$\frac{P_t^* - P_t}{P_t} = a\left[\frac{I_t}{C_t} - \left(\frac{\overline{I}}{C}\right)\right] + e_t \qquad (A-2)$$

where,

P_t^* = Expected price

P_t = Current price

I_t = Inventory

C_t = Consumption

The arguments for stating the expected price change and the

inventory level in terms of fractions have already been

made,[1] while the linear format is an approximation of

the usual supply of storage curve. The system is in

equilibrium when the inventory ratio is at its average

value, and the current price is equal to the expected price.

The expected fraction change in price as stated on the left

side of equation A-2 is the first term in the infinite

series expression for $\ln(P_t^*/P_t)$; making this substitution

and expanding I_t, we have:

---

[1]See pp. 141-143.

$$\ln\left(\frac{P_t^*}{P_t}\right) = a\left[\frac{I_{t-1} + H_t - C_t}{C_t} - \overline{\left(\frac{I}{C}\right)}\right] + e_t \qquad (A-3)$$

or,

$$\ln P_t = \left[\ln P^* + a\overline{\left(\frac{I}{C}\right)}\right] - a\left(\frac{H_t - C_t}{C_t}\right) - a\left(\frac{I_{t-1}}{C_t}\right) + e_t \qquad (A-4)$$

where,

$$H_t = \text{Production (Harvest)}$$

and where P_t^* is considered to be a constant estimate of the equilibrium price level.

But the Taylor series linear approximation of the ratio, $(H_t - C_t)/C_t$, assuming that $\overline{H} = \overline{C}$, takes the form:

$$\frac{H_t - C_t}{C_t} \approx \frac{H_t - C_t}{\overline{C}} \qquad (A-5)$$

Making this substitution, and stating the inventory ratio in percentage terms, we have:

$$\ln P_t = \left[\ln P_t^* + a\overline{\left(\frac{I}{C}\right)}\right] - \frac{a}{\overline{C}} H_t + \frac{a}{\overline{C}} C_t - \frac{a}{100}\left[\left(\frac{I_{t-1}}{C_t}\right)(100)\right] + e_t$$

$$(A-6)$$

A comparison of equations A-6 and A-1 reveals a highly similar structure. There are certain differences in the corresponding variables, but these differences are not so severe as to keep the estimated equation, A-1, from being considered as a rough approximation of the theoretical equation A-6. For example, in the theoretical equation the production and consumption variables relate to a relatively short horizon interval, while in the estimated equation they refer to twelve month intervals. In the estimated

relation, the stocks ratio divides beginning-of-year inventories by <u>last year's</u> consumption, while in the theoretical model beginning-of-period stocks are divided by <u>this period's</u> consumption. A further difference lies in the fact that the theoretical model requires certain specific relationships between the various coefficients (in particular, the coefficients of H_t and C_t should equal one another in magnitude), which relationships are not required in the estimated model.

Bearing these differences in mind, let us examine the FAO study's parameter estimates in the light of the interpretations given the corresponding parameter values in the theoretical model (equation A-6). First, comparing the coefficients of the stocks ratio, we have,

$$\frac{\hat{a}}{100} = 0.0087 \qquad\qquad (A\text{-}7)$$

or,

$$\hat{a} = 0.87 \qquad\qquad (A\text{-}8)$$

Combining this with the FAO coefficients on production (q in equation A-1) and consumption (g in equation A-1), we arrive at two different estimates of average consumption:

Production coefficient:

$$- \frac{\hat{a}}{\hat{c}} = 0.001061 \tag{A-9}$$

or,

$$\frac{\hat{}}{\hat{c}_1} = \frac{0.87}{0.001061} = 818 \tag{A-10}$$

Consumption coefficient:

$$\frac{\hat{a}}{\hat{c}_2} = .000742 \tag{A-11}$$

or,

$$\frac{\hat{}}{\hat{c}_2} = \frac{0.87}{.000742} = 1170 \tag{A-12}$$

These estimates compare with average world grindings over the 1952-60 interval of 828,000 metric tons per year. Turning to the constant term in equation A-6, we can establish the order of magnitude predicted by the theory by assuming that the (constant) expected price level is equal to the average price during the 1952-60 period, and coupling this value with the above estimate, $\hat{a}$, and the 1952-60 average value of the Gill and Duffus inventory ratio $\overline{(\frac{I}{C})}$:

$$\left[\ln P^* + a \, \overline{\left(\frac{I}{C}\right)} \right] = \left[\ln 33.1 + (0.87)(.298) \right] = 6.061 \tag{A-13}$$

which compares with the FAO constant term equaling 2.013.

We have, then, a fascinating sequence of findings: (1) the FAO equation format was chosen without a clear theoretical basis; (2) nevertheless, the chosen format is

reasonably consistent with the commodity price theory developed earlier; and (3) despite certain differences between the variables used by the FAO, and the corresponding variables ideally called for by the theory, the coefficient estimates resulting from the FAO study are of the same sign and order of magnitude predicted by the theory. These findings have strong overtones of Muth's theory of rationale expectations, and provide a certain amount of support for both the FAO results and the theoretical framework.

To pinpoint the connection with Muth's theory, let us assume that there exists a (correct) theory regarding the generation of aggregate price expectations for a given commodity, which theory consists of a single equation relating expected price to a set of independent variables in a specific manner. Then Muth would not say that all or even a large portion of the market participants regularly sit down at their desks to calculate their price expectations according to the theory (since such an assertion would be silly). Rather he would say that through some (probably largely subjective) process, the aggregate of price expectors in the market generate a price expectation close to that predicted by the theory; then by inference the theory describes the aggregative process by which the expectation is derived.

Now in this context the authors of the FAO report

can be considered as subjective expectors, not of the price

level itself, but of the general equation structure which

generates the spot price. They initially expect on what

at least appear to be largely subjective grounds,[1] that

the general equation structure represented by equation A-1

represents the price generating mechanism, and then

estimate the coefficients within this structure via least

squares. The fact that the FAO equation format is con-

sistent with the commodity price theory lends support to

Muth. The fact that the coefficients estimated by the FAO

have values reasonably close to those predicted by the

theory, despite problems regarding the variables used,

lends some support to both the FAO results and the price

theory.

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[1] Perhaps "informal" would be more descriptive than "sub-
jective". In any case, this is the point made earlier,
namely that the FAO authors don't argue for their statis-
tical analysis in terms of a theory about commodity prices.
This doesn't necessarily mean that they don't have such a
theory. It is conceivable that they assume that the theory
is so obvious and well understood that it doesn't require
discussion. But in this particular case such an assumption
seems quite unlikely, since the supply of storage theory
with which their equation format is consistent has not to
my knowledge been used explicitly to explain price be-
havior (as opposed to spread behavior) prior to this paper.

Chapter 4

The Cocoa Price Mechanism

4.0 Introduction

Our objective in this chapter is to obtain an esti-
mate of the cocoa price mechanism appropriate for use in
a model of the cocoa price-consumption subsystem, which we
in turn shall use in generating the simulations to be
discussed in Chapter 6. The first order of business,
to be covered in the next section, will be to extend the
price theory developed in Chapter 3 in such a way as to
yield a specific equation structure, the coefficients of
which are amenable to statistical estimation. In so doing,
we shall find it necessary to obtain an estimate of the
normal seasonal pattern of the current inventory ratio.
Then, before going on to obtain the initial parameter
estimates in the price equation, we shall define (in
Section 4.2) plausibility regions for each of these para-
meters based on a priori information. These will be useful
in judging the regression results.

In Section 4.3 we shall obtain ordinary least squares
estimates of the price mechanism parameters. The initial
such estimates will be generated based on the assumption
that the market's long run equilibrium price expectations
are constant. We shall then relax this assumption,

because of the considerable unexplained price variance

which it yields, and shall obtain new parameter estimates,

based on variable equilibrium price expectations stated

as a function of the long term cocoa price trend. The

new estimated equation explains 94 percent of the price

variance over the observed data period, and provides

the basis for the further investigations taken up in the

remainder of the chapter. In Section 4.4 we shall study

the degree to which the estimated parameters are stable

over the data period, by breaking the period in half,

and obtaining separate parameter estimates for the two

subperiods. Finally, in Section 4.5 we shall take into

account the serial correlation observed in the residuals

generated by the earlier results, by obtaining generalized

least squares estimates of the price equation parameters.

Appendix A presents and discusses the data used in

deriving the statistical estimates.

4.1 The Specific Equation Structure

The general equation structure to be tested here is

that of equation 70 of the last chapter, repeated here

for convenience.

$$\ln P_t = \ln P_t^{*\infty} - F^{*h_1}(Y_t, Y_t^{*h_1}) - F^{*\infty}(Y_t^{*h_1}, Y_t^{*\infty}) \qquad (1)$$

or,

$$\ln \left(\frac{P_t^{*\infty}}{P_t}\right) = F^{*h_1}(Y_t, Y_t^{*h_1}) + F^{*\infty}(Y_t^{*h_1}, Y_t^{*\infty}) \qquad (2)$$

where,

$$\ln \left(\frac{P_t^{*h_1}}{P_t}\right) = F^{*h_1}(Y_t, Y_t^{*h_1}) = \int_0^{h_1} f^*(Y_t^{*h}) \, dh \qquad (3)$$

$$\ln \left(\frac{P_t^{*\infty}}{P_t}\right) = F^{*\infty}(Y_t^{*h_1}, Y_t^{*\infty}) = \int_{h_1}^{\infty} f^*(Y_t^{*h}) \, dh \qquad (4)$$

and,

P	=	Spot price
P^{*h}	=	Expected price at horizon interval, h
Y	=	Current inventory ratio
Y^{*h}	=	Inventory ratio expected at horizon interval, h
f^*	=	Short term supply of storage function
h_1	=	A specific horizon interval

The current inventory ratio is defined as the ratio of the current world inventory to the rate of world consumption over the past 12 months. The expected inventory ratio equals the ratio of the inventory expected at the horizon time to the rate of consumption over the 12 month period prior to the horizon time. The derivations of the necessary data are given in Appendix A.

Thus, the total expected price change (defined in equation 2) from the current price to the expected equilibrium price is stated as the sum of two parts, the expected change (given by equation 3) from the present price to the price at some specific horizon time, plus the expected change (given by equation 4) from the price existing at the horizon time to the equilibrium price. To put equation 2 into a form subject to statistical estimation, something more will have to be said about: (1) the equilibrium price expectation ($P^{*\infty}$); (2) the expected price change before the horizon time (F^{*h_1} (Y_t, $Y_t^{*h_1}$)); and (3) the expected price change after the horizon time ($F^{*\infty}(Y_t^{*h_1}, Y_t^{*\infty})$).

4.1.1 Equilibrium Price Expectations -- Initially we will assume the equilibrium price expectation to be constant at the postwar average real price level (in 1957-59 dollars) of 35.2 cents per pound, basis spot Accra in New York. As is described and explained in Appendix A, the monthly spot price itself will be stated in real terms in the statistical analyses which follow. The assumption of a constant equilibrium price expectation simply implies that the market does not feel at any point that shifts in long run supply and/or demand conditions have occurred which will lead to a change in the long run average price level. It will turn out to be rewarding to relax this assumption later on in the chapter.

4.1.2 Expected Price Change before the Horizon Time

One of the keys to putting F^{*h_1}, as defined in equation 3, into a useful form lies in the choice of the horizon interval, h_1. The total expected price change was originally broken into its pre- and post-horizon parts based in part on the assumption that the market may possess fairly well defined expectations regarding the behavior of the inventory ratio before some specific horizon time. Such inventory expectations combined with the short term supply of storage curve would imply a certain expected price change over the horizon interval. The most natural horizon point for an agricultural commodity having a fairly pronounced seasonal harvest pattern, as does cocoa, is the end of the crop year. Forecasts of the annual crop can be combined with crop year consumption forecasts in estimating the year-end carryover. The pronounced seasonal pattern in the rate at which the crop reaches the market implies a pronounced seasonal pattern in the inventory ratio, so that estimates of the current inventory ratio and the year-end inventory ratio combine to yield rather well defined expectations of the behavior of the inventory ratio over the interim. Finally, it is natural for the market to attempt to estimate the inventory ratio at the end of the crop year, since if a shortage is to develop, that will likely be the time of greatest shortage.

In the cocoa market fairly regular monthly forecasts
are made indicating expected world production and (indirectly)
consumption over each crop year, beginning just before
the start of the crop year (October 1). These forecasts
can be combined with an estimate of the normal[1] world
inventory level at the beginning of the crop year to yield
a forecast of the ending inventory level; when this level
is divided by the predicted consumption rate a forecast
of the inventory ratio expected to exist at the end of the
crop year results. Data indicating the magnitude of the
current inventory ratio also exists[2], so that at any point
in time cocoa market participants have available at least
rough estimates of both the current inventory ratio and the
inventory ratio at the end of the crop year.

The question remains as to how the inventory ratio
estimates for the two ends of the horizon interval can be
used to estimate the expected price change over the interval.
The answer, as is indicated by equation 3, depends in
part on the nature of the short term supply of storage
function. The discussion in Chapter 3 suggested that at
least over most of its relevant range, the short term

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[1]The nature of this normal beginning inventory concept is
explained in Appendix A, as is the entire procedure for
calculating the expected year-end inventory ratio.

[2]See the discussion in Appendix A.

supply of storage function is likely to have a positive slope

and a negative first derivative, as is indicated in Figure 4-1,

and represented by the log function,[1]

$$\frac{d}{dh} (\ln P_t^{*h}) = f^* (Y^{*h}) = b_1 + b_2 \ln Y_t^{*h} \tag{5}$$

or in discrete form,

$$\ln \left(\frac{P_t^{*h+1}}{P_t^{*h}}\right) = b_1 + b_2 \ln Y_t^{*h} \tag{6}$$

where,

P^{*h} = Expected price at horizon interval, h

f^* = Short term supply of storage function

Y^{*h} = Inventory ratio expected at horizon interval, h

If the time unit in equation 6 is taken as one month,

then the expected price change from the present to some

horizon h_t months in the future can be written,

$$\ln \left(\frac{P_t^{*h_t}}{P_t}\right) = \sum_{h=0}^{h_t-1} (b_1 + b_2 \ln Y_t^{*h}) \tag{7}$$

since the expected price at a zero horizon is the current price.

Equation 7 can be simplified,

$$\ln \left(\frac{P_t^{*h_t}}{P_t}\right) = b_1 h_t + b_2 \sum_{h=0}^{h_t-1} \ln Y_t^{*h} \tag{8}$$

Now if the expected inventory ratio at each month over the

horizon interval can be defined in terms of the current

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[1]The log function will turn out to give quite satisfactory
results, but other functional forms might do just as well.
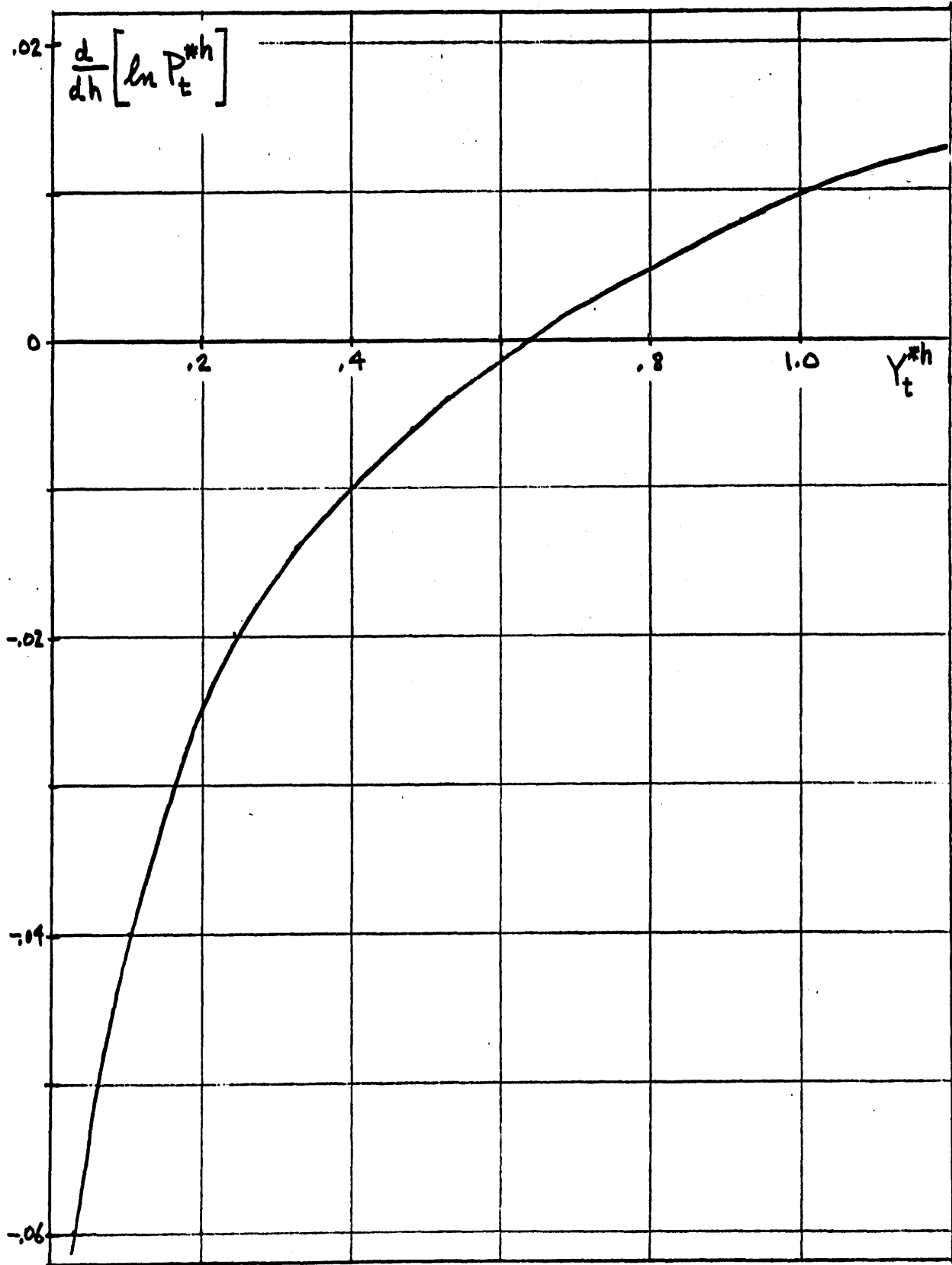
FIGURE 4-1 COCOA SHORT TERM SUPPLY OF STORAGE CURVE

inventory ratio and the ratio expected at the horizon time,

$$\ln Y^{*h} = c_h + d_h \ln Y_t + e_h \ln Y_t^{*h_t} \qquad (9)$$

then equation 8 can be rewritten,

$$\ln \left(\frac{P_t^{*h_t}}{P_t}\right) = b_1 h_t + b_2 \left[\sum_{h=0}^{h_t-1} c_h + \left(\sum_{h=0}^{h_t-1} d_h\right) \ln Y_t + \left(\sum_{h=0}^{h_t-1} e_h\right) \ln Y_t^{*h_t}\right] \qquad (10)$$

In the case at hand we have already decided that the horizon point in time is the end of the crop year, or the end of September. The "current" time for each crop year runs from September (the month in which the first crop estimates having any reliability become available) through August, after which the horizon point shifts ahead to the next September, and expectations relate to the new crop year. Thus, in terms of equation 10,

$$h_t = 12 \text{ in September,}$$

$$h_t = 11 \text{ in October,}$$

$$\vdots \qquad \vdots \qquad \vdots \qquad\qquad (11)$$

$$h_t = 1 \text{ in August.}$$

Now assume that over the years the actual behavior of the inventory ratio during each horizon interval (i.e. September-September, October-September, ..., August-September) is highly explainable in terms of the actual (i.e. not the expected) ratios at the beginning and end of each interval, using the structure of equation 9. Then Muth's rational expectations hypothesis suggests that the

equation 9 structure, incorporating the coefficients which explain the actual inventory ratio behavior in terms of the actual terminal values, would tend to be used by the market to generate the expected inventory ratio behavior during the interval in terms of the expected terminal values (where the "expected" current inventory ratio is equal to the current actual ratio).

It turns out that the seasonal pattern in the behavior of the cocoa inventory ratio is pronounced enough so that historically the pattern of the ratio during each horizon interval has in fact been highly describable by the structure of equation 9 incorporating the actual terminal ratio values. For example, taking April as the current month, and September as the horizon point, a regression of the interim behavior of the actual ratio on the terminal actual ratios (i.e. April and September) over the period in question yields the results:

$$\ln Y_{t+h} = \begin{array}{l} -0.0618 \\ (0.0526) \end{array} + \begin{array}{l} 0.8433 \\ (0.1754) \end{array} \ln Y_1^0 + \begin{array}{l} 0.0907 \\ (0.1634) \end{array} \ln Y_1^5$$

$$+ \begin{array}{l} 0.0117 \\ (0.0744) \end{array} I_2 + \begin{array}{l} 0.5480 \\ (0.1754) \end{array} \ln Y_2^0 + \begin{array}{l} 0.4286 \\ (0.1634) \end{array} \ln Y_2^5$$

$$+ \begin{array}{l} 0.0052 \\ (0.0744) \end{array} I_3 + \begin{array}{l} 0.4507 \\ (0.1754) \end{array} \ln Y_3^0 + \begin{array}{l} 0.6028 \\ (0.1634) \end{array} \ln Y_3^5$$

$$+ \begin{array}{l} 0.0483 \\ (0.0744) \end{array} I_4 + \begin{array}{l} 0.0742 \\ (0.1754) \end{array} \ln Y_4^0 + \begin{array}{l} 0.9327 \\ (0.1634) \end{array} \ln Y_4^5 + e_t$$

$$R^2 = 0.9725 \quad F(11, 32) = 103 \tag{12}$$

where,

$h = 1$ in May; $h=2$ in June; ... $h=4$ in August

$h_t = 5$

$Y_t = $ Actual inventory ratio in April

$$I_i = \begin{cases} 1 \text{ if } i=h \\ 0 \text{ if } i \neq h \end{cases}$$

$$Y_i^0 = \begin{cases} Y_t \text{ if } i=h \\ 0 \text{ if } i \neq h \end{cases}$$

$$Y_i^5 = \begin{cases} Y_{t+5} \text{ if } i=h \\ 0 \text{ if } i \neq h \end{cases}$$

The constant term and the coefficients of the indicator variables (I) are not significant at the 10 percent level, but they will be kept for the sake of convenience.[1] Obviously their exclusion would not significantly effect the remaining results. The initial (May) coefficient on the April ratio are also not significant at 10 percent. In these cases, however, the estimated coefficient values are quite plausible in that it was to be expected that during the early part of the interval the weight on the ending ratio would be small but positive, as would be the weight on the beginning ratio near the end of the interval. For this reason these coefficients will be kept as well.

The regression results given in equation 12 in effect represent the results of four separate regressions (one

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[1] The regression program used to generate these results does not have an option whereby the constant term can be suppressed.

for each of the interval months from May through August),

all run simultaneously but having no effect on one another.

Table 4-1 states these results in terms of the coefficients

of equations 9 and 10.

Table 4-1

Month	h	c_h	d_h	e_h
April	0	0.0000	1.0000	0.0000
May	1	-0.0618	0.8433	0.0907
June	2	-0.0501	0.5480	0.4286
July	3	-0.0566	0.4507	0.6028
August	4	-0.0135	0.0742	0.9327
$\sum_{h=0}^{4}$		-0.1820	2.9162	2.0548

Figure 4-2 plots the behavior of the weighting coefficients

over the horizon interval, and indicates the estimated

average behavior of the log of the inventory ratio for

the period in question, based on the given coefficients

and the average values of the April and September log

inventory ratios.

Using the results given in Table 4-1, equation 10

can be rewritten for April,

$$\ln \left(\frac{P_t^{*5}}{P_t}\right) = (b_1)(5) + b_2 (-0.182 + 2.916 \ln Y_t + 2.055 \ln Y_t^{*5})$$

where,   (13)

P = Spot price (i.e. in April)

P^{*5} = Expected price at horizon point (i.e. September)

Y = Current inventory ratio (April)

Y^{*5} = Expected inventory ratio at horizon point (September)
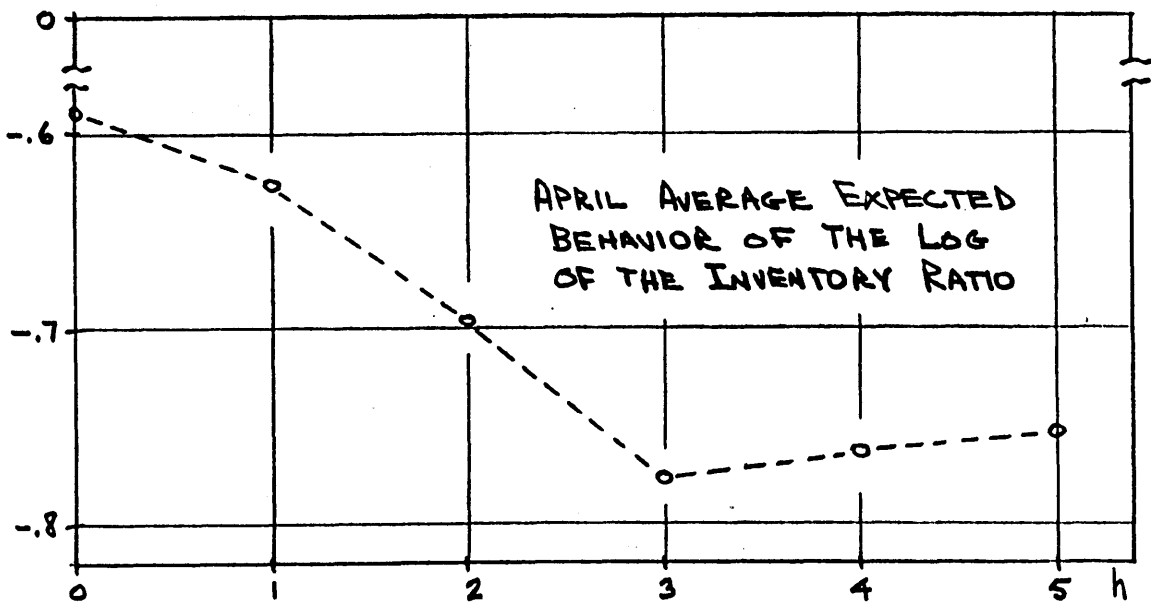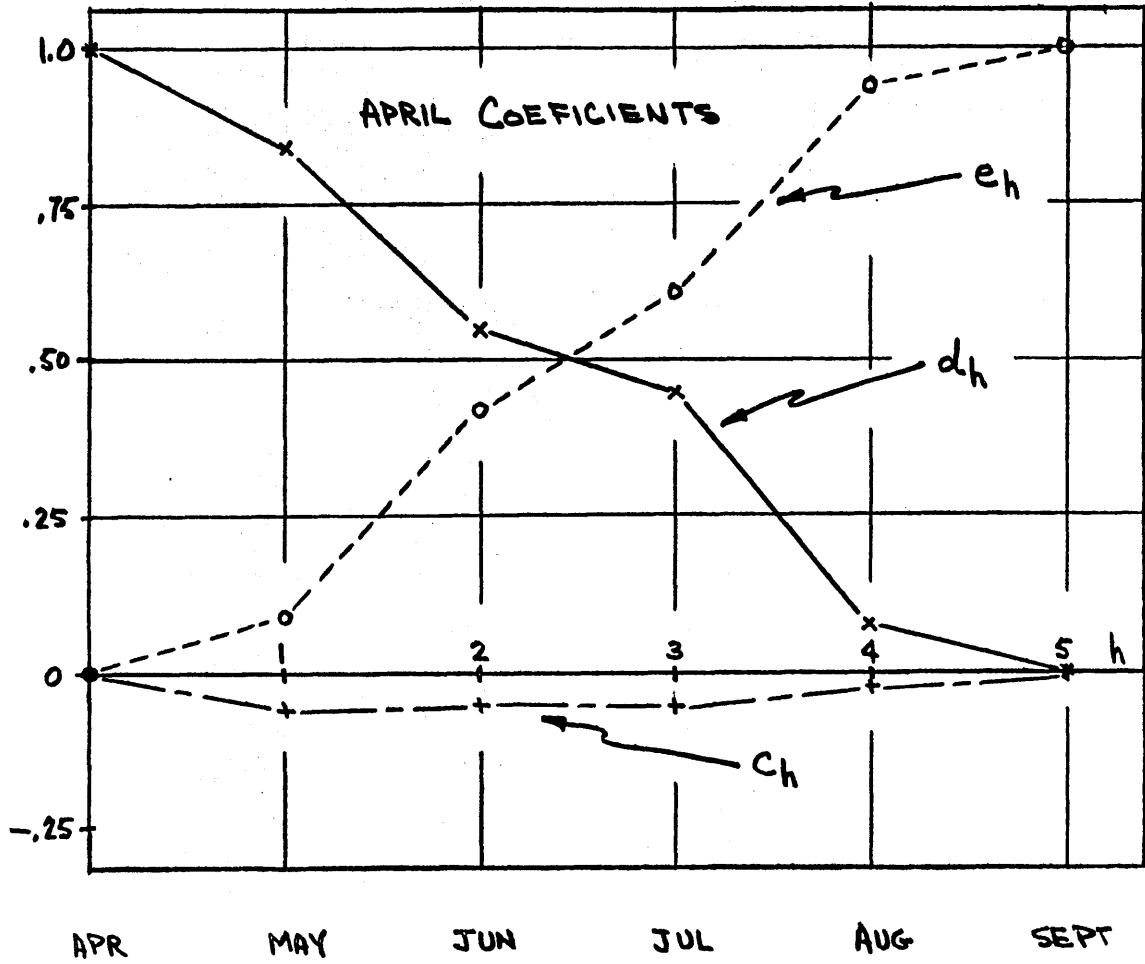
FIGURE 4-2 APRIL EXPECTATIONS FOR INVENTORY RATIO BEHAVIOR

By going through the same procedure as I have indicated for April (i.e. running a regression like equation 12, and summing coefficients as was done in Table 4-1), values for the bracketed coefficients in equation 10 can be derived for all 12 months. Table 4-2 gives these coefficients; Appendix B presents the detailed regression results.

<u>Table 4-2</u>

Month	$\displaystyle\sum_{h=0}^{h_1-1} c_h$	$\displaystyle\sum_{h=0}^{h_1-1} d_h$	$\displaystyle\sum_{h=0}^{h_1-1} e_h$
September	1.200	5.479	4.879
October	0.783	4.189	5.951
November	0.595	3.583	5.797
December	0.578	3.368	5.228
January	0.305	3.352	4.515
February	0.160	2.616	4.231
March	-0.223	3.706	2.336
April	-0.174	2.914	2.052
May	-0.038	2.194	1.910
June	-0.025	2.416	0.709
July	0.000	1.603	0.397
August	0.000	1.000	0.000

Combining the coefficients of Table 4-2 with time series for the logs of the current and expected inventory ratios, we can rewrite equation 10,

$$\ln\left(\frac{P^{*h_t}}{P_t}\right) = b_1 h_t + b_2 Z_t \tag{14}$$

where,

$$Z_t = \sum_{h=0}^{h_t-1} c_h + \left(\sum_{h=0}^{h_t-1} d_h\right) \ln Y_t + \left(\sum_{h=0}^{h_t-1} e_h\right) \ln Y_t^{*h_t}$$

$$\tag{15}$$

$$h_t = 12, 11, \ldots 1$$

That is, we have data for h_t and Z_t in equation 14, so that
we have stated the expected price change before the horizon
point as a linear combination of the coefficients (b_1 and b_2)
of the short term supply of storage function, weighted with
known data. This completes the second step toward putting
equation 2 into a form useful for statistical estimation.

4.1.3 Expected Price Change after the Horizon Time

As was mentioned and pursued above, one of the reasons for
splitting the total expected price change into its pre-
horizon and post-horizon portions was the notion that the
market may have rather specific ideas about expected
inventory behavior during the pre-horizon interval, which
ideas could be combined with the short term supply of
storage function to indicate the expected pre-horizon price
change. The other reason was that it seems plausible that
for the period after the horizon point (i.e. the end of the
crop year, after which the existing expectations regarding
inventory, production, and consumption behavior become
increasingly uncertain), market expectations would call for
the inventory ratio gradually and smoothly (apart from
seasonal fluctuations) to approach its expected long term
equilibrium value ($Y^{*\infty}$). Such an assumption can be combined
with the results of the previous section to put the expected
post-horizon price change ($F^{*\infty}(Y^{*h_1}, Y^{*\infty})$) into a form
useful for estimation.

First, from the September result of the previous section (see Table 4-2 and equation 15) we have,

$$\ln\left(\frac{P_t^{*12}}{P_t}\right) = (b_1)(12) + b_2(1.200 + 5.479 \ln Y_t + 4.879 \ln Y_t^{*12}) \tag{16}$$

where,

P^{*12} = Expected price next September

P = Current price, this September

Y = Current inventory ratio, this September

Y^{*12} = Expected inventory ratio, next September

which gives the expected price change from the current September to next September. The same relationship specifies expected September-September price changes in the future,

$$\ln\left(\frac{P_t^{*s_{n+1}}}{P_t^{*s_n}}\right) = (b_1)(12) + b_2(1.200 + 5.479 \ln Y_t^{*s_n} + 4.879 \ln Y_t^{*s_{n+1}}) \tag{17}$$

$$s_n = h_t + 12n \tag{18}$$

for $h_t = 12, 11, \ldots 2, 1.$

$n = 1, 2, \ldots$

where,

P^{*s_n} = Expected price, n Septembers after the horizon

Y^{*s_n} = Expected inventory ratio, n Septembers after the horizon

Equation 17 specifies the expected price change between any two successive Septembers in the future in terms of the expected inventory ratios for those months.

Turning to the assumption that the inventory ratio
will gradually approach its equilibrium value in the post-
horizon period, we will adopt the convenient and reasonably
flexible functional form,

$$Y_t^{*sn} = \left(\frac{Y_t^{*so}}{\overline{Y}^{*s}}\right)^{g^n} (\overline{Y}^{*s}) \tag{19}$$

or,

$$Y_t^{*sn} = (Y_t^{*so})^{g^n} (\overline{Y}^{*s})^{1-g^n} \tag{20}$$

$$0 < g < 1$$

$$n = 1, 2, \ldots$$

where,

Y^{*sn} = Expected inventory ratio, n Septembers after
the horizon

Y^{*so} = Expected inventory ratio at the horizon

$\overline{Y}^{*s}$ = Expected equilibrium September inventory
ratio

g = Parameter indicating the rapidity of Y's
approach toward equilibrium

Taking logarithms we have,

$$\ln Y_t^{*sn} = g^n \ln Y_t^{*so} + (1 - g^n) \ln \overline{Y}^{*s} \tag{21}$$

Figure 4-3 indicates the expected time patterns of $\ln Y_t^{*sn}$
for various values of g and a fixed value for $\ln Y_t^{*so}$. It
seems reasonable to assume the expected equilibrium inven-
tory ratio ($\overline{Y}^{*s}$) to be constsnt, at least over substantial
periods of time (e.g. decades). The supply of storage dis-
cussion in the last chapter, indicated that a shift in
the equilibrium value of the inventory ratio would reflect
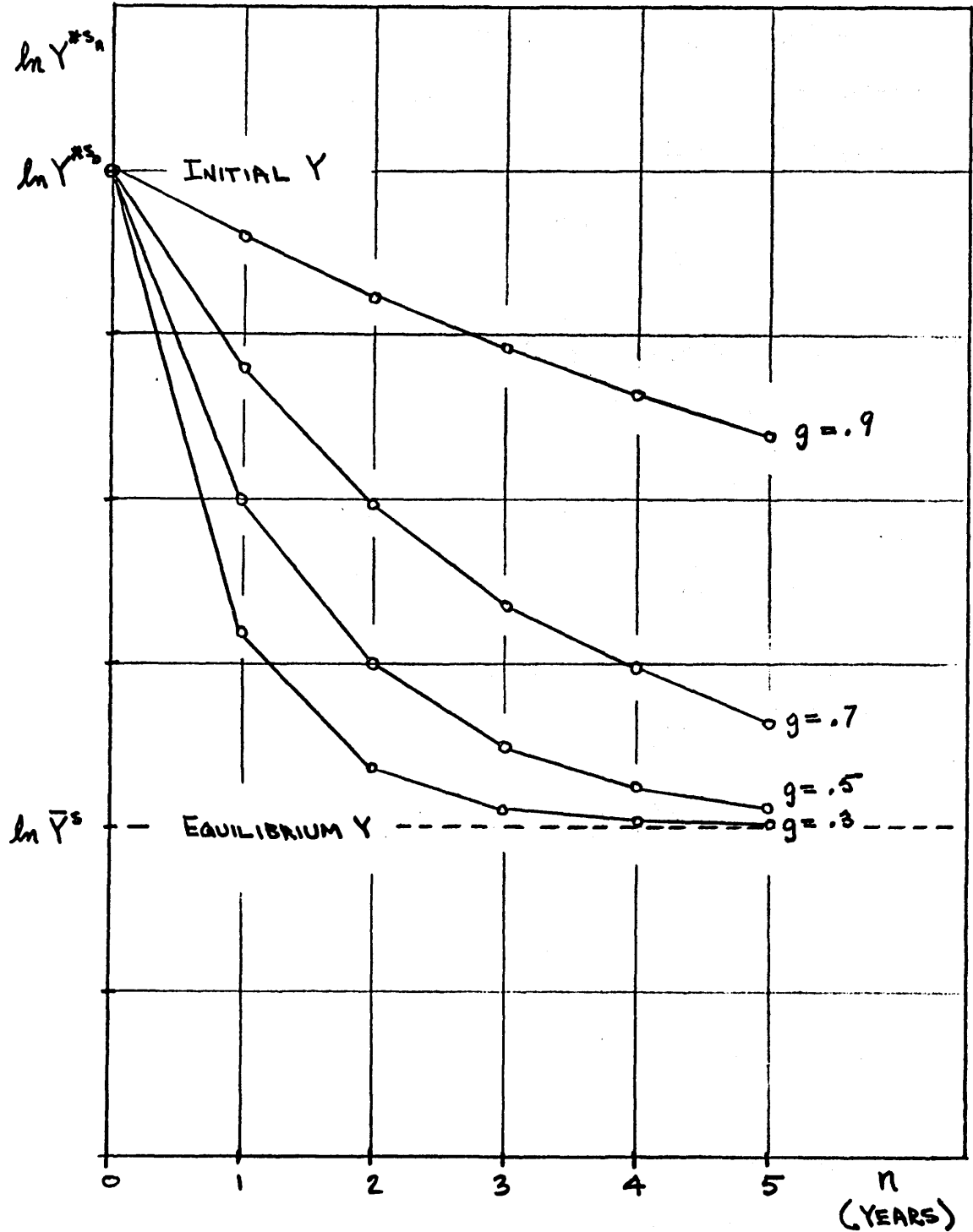
FIGURE 4-3   EFFECT OF g ON EXPECTED

INVENTORY RATIO BEHAVIOR

a corresponding shift in the supply of storage curve. Such

a shift, in turn, could only result from changes in the

institutional factors relating to the various motivations for

holding inventories, and it seems plausible that these factors

would change only very slowly over time.

Substituting equation 21 into equation 17 we have,

$$\ln \left(\frac{P_t^{*s n+1}}{P_t^{*s n}}\right) = (b_1)(12) + (b_2)(1.2)$$

$$+ (b_2)(5.479) \left[g^n \ln Y_t^{*so} + (1 - g^n) \ln \overline{Y}^{*s}\right]$$

$$+ (b_2)(4.879) \left[g^{n+1} \ln Y_t^{*so} + (1 - g^{n+1}) \ln \overline{Y}^{*s}\right] \quad (22)$$

or, rearranging terms,

$$\ln \left(\frac{P_t^{*s n+1}}{P_t^{*s n}}\right) = \left\{(b_1)(12) + b_2 \left[1.2 + (5.479 + 4.879) \ln \overline{Y}^{*s}\right]\right\}$$

$$+ b_2 g^n \left[(5.479 + 4.879 g)(\ln Y_t^{*so} - \ln \overline{Y}^{*s})\right] \quad (23)$$

But the expression in braces must equal zero, since if the

system is in equilibrium, such that $\ln Y_t^{*so} = \ln \overline{Y}^{*s}$

(i.e. the second term equals zero), then the price is not

expected to change (i.e. $\ln (P_t^{*s n+1}/P_t^{*s n}) = 0$). Thus we have,

$$\ln \left(\frac{P_t^{*s n+1}}{P_t^{*s n}}\right) = b_2 g^n (5.479 + 4.879 g)(\ln Y_t^{*so} - \ln \overline{Y}^{*s}) \quad (24)$$

The expected price change from the horizon point to a point

n_1 years beyond the horizon is given by,

$$\ln \left(\frac{P^{*s_{n_1}}}{P^{*s_0}}\right) = \sum_{n=0}^{n_1-1} \ln \left(\frac{P_t^{*s_{n+1}}}{P_t^{*s_n}}\right) \tag{25}$$

or, substituting 24 into 25,

$$\ln \left(\frac{P_t^{*s_{n_1}}}{P_t^{*s_0}}\right) = b_2 (5.479 + 4.879\ g)(\ln Y_t^{*s_0} - \ln \overline{Y}^{*s}) \sum_{n=0}^{n_1-1} g^n \tag{26}$$

so that letting n_1 become indefinitely large, we have (remembering that $s_0 = h_t$, the interval to the end of the crop year),

$$\ln \left(\frac{P_t^{*}}{P_t^{*h_t}}\right) = b_2 \left(\frac{5.479 + 4.879g}{1-g}\right)(\ln Y_t^{*h_t} - \ln \overline{Y}^{*s}) \tag{27}$$

This completes the third and final step toward putting equation 2 into a form useful for purposes of estimation.

4.1.4 The Complete Specified Structure -- Substituting the results of equations 14 and 27 into equation 2, and recalling the assumption of a constant equilibrium price expectation, we have the final specified equation structure to be used for estimation,

$$\ln \left(\frac{\overline{P}}{P_t}\right) = a + b_1 h_t + b_2 Z_t + b_3 \ln Y^{*h_t} + e_t \tag{28}$$

where,

$$a = -b_3 \ln \overline{Y}^{*s} \tag{29}$$

$$b_3 = b_2 \left(\frac{5.479 + 4.879\ g}{1-g}\right) \tag{30}$$

and where,

$\bar{P}$ = Post war average real spot price of Accra cocoa in New York

P = Monthly average real spot price of Accra cocoa in New York

h = Horizon interval

Z = Variable defined in equation 15

Y^{*h} = Expected inventory ratio at horizon time

$\bar{Y}^{*s}$ = Expected September equilibrium inventory ratio

g = Parameter indicating the rapidity of Y's approach toward equilibrium

e = Error term

4.2 A Priori Parameter Plausibility Notions

Before going on to estimate the coefficients of equation 28, it is appropriate that we say what we can about the values which we would consider plausible[1] for the four basic parameters: b_1 and b_2, the short term supply of storage parameters; g, the time constant for the system's expected approach toward equilibrium after the horizon point; and

---

[1]While this discussion on parameter plausibility regions precedes the estimation sections of this chapter, I (unfortunately) did not write this section before obtaining the estimates described in the sections which follow. While I have tried to keep the estimation of the plausibility regions on as objective a basis as possible, I have no doubt that my knowledge of the statistical results must have had at least some influence on my thought process. This takes away some, but certainly not all, of the usefulness of the estimated plausible ranges.

$\overline{Y}^{*s}$, the expected September equilibrium value of the inventory ratio.[1] Table 4-3 at the end of this section summarizes the plausibility regions discussed in the paragraphs which follow.

4.2.1 Plausible Values for b_1 and b_2 -- Rewriting

equation 6 for the zero horizon case, we have,

$$\ln \left(\frac{P_t^{*1}}{P_t}\right) = b_1 + b_2 \ln Y_t \tag{31}$$

where,

P^{*1} = Price expected in one month

P = Current price

Y = Current inventory ratio.

Thus, b_1 is roughly equal to the expected fraction price change over the next month when the current inventory ratio equals 1.0 (since $\ln 1 = 0$),

$$\ln \left(\frac{P_t^{*1}}{P_t}\right)\Bigg|_{Y_t = 1} \approx \left.\frac{P_t^{*1} - P_t}{P_t}\right|_{Y_{t=1}} \approx b_1 \tag{32}$$

And since the average monthly percentage price rate of change over the data interval was approximately zero, b_2 is approximately related to b_1,

---

[1] As indicated by equations 29 and 30, the set of coefficients in the estimated equation structure (equation 28) form a direct transformation of the basic system parameters, b_1, b_2, g, and Y^{*s}. Therefore the ensuing discussions regarding plausible value ranges for the basic parameters indirectly specify plausible ranges for the regression coefficients as well.

$$0 \approx b_1 + b_2 \overline{\ln Y_t} \tag{33}$$

or,

$$b_1/b_2 \approx - \overline{\ln Y_t} \tag{34}$$

The average value of the inventory ratio for the data interval was 0.53. A plausible range of estimates of the equilibrium average inventory ratio thus might run roughly from 0.40 to 0.65 (my own subjectively determined limits), or in terms of logs, -0.92 to -0.43. Thus the rough estimates of plausible upper and lower limits for the b_1/b_2 ratio are,

Upper limit:

$$b_1/b_2 = 0.92$$

Lower limit:

$$b_1/b_2 = 0.43$$

An inventory ratio equal to 1.0 compares with the average inventory ratio for the data interval of 0.53, and as such represents a situation of some surplus. It was suggested in the supply of storage discussion in Chapter 3 that under conditions of surplus, the expected price rate of change will exceed carrying charges by some amount indicative of the returns expected by the storers of the excess inventory. Thus we have,

$$b_1 = s + r f \tag{35}$$

where,

s = Monthly storage cost fraction
r = Expected monthly rate of return beyond interest cost
f = Average equity fraction of inventory

Normal monthly storage costs for cocoa (including interest) are approximately equal to one percent of the cocoa price for storage in a registered terminal warehouse, and perhaps as low as 0.6 percent for some of the larger cocoa storers using their own facilities.[1] The average speculative cocoa storer probably has an equity interest in his inventory of somewhere between 20 and 80 percent. One would expect him to demand a fairly substantial before tax return on this equity interest, probably somewhere between 10 and 50 percent per annum, or roughly one and four percent per month, beyond the interest rate which he pays for debt capital. These figures combine to give rough upper and lower limit estimates for b_1:

Upper limit:

$$b_1 = .01 + (0.04)(0.80) = .042$$

Lower limit:

$$b_1 = .006 + (0.01)(0.20) = .008$$

4.2.2 Plausible Values for g -- It is difficult to reduce the plausible value range for g, the time constant for the system's expected post-horizon approach toward

---

[1] These approximate storage costs were gained from discussions with members of the cocoa trade.

equilibrium, from its already prescribed range between zero and one. It does strike me, however, that g values much below 0.5 or much above 0.8 would indicate decay rates somewhat faster or slower, respectively, than I would feel to be plausible (see Figure 4-3).

4.2.3 Plausible Values for $\overline{Y}^{*s}$ -- The average value for the current inventory ratio in September over the data interval was 0.448. The average expected September inventory ratio was 0.493. These figures roughly identify the center of the plausible region of values for the expected September equilibrium inventory ratio, $\overline{Y}^{*s}$. Estimates much above 0.60 or much below 0.35 would seem questionable to me.

Table 4-3: Approximate Parameter Plausibility Limits

Parameter	Lower Limit	Upper Limit
b_1	.008	.042
b_1/b_2	0.43	0.92
g	0.50	0.80
$\overline{Y}^{*s}$	0.35	0.60

4.3 Ordinary Least Squares Estimates

The results of estimating equation 28 using ordinary least squares are as follows,

$$\ln \left(\frac{\bar{P}}{P_t}\right) = \underset{(.052)}{.761} + \underset{(.0072)}{.0160} \; h_t + \underset{(.0112)}{.0368} \; Z_t + \underset{(.067)}{.866} \ln Y^{*h}{}_t + e_t \tag{36}$$

$$R^2 = .843 \qquad F(3, 128) = 229 \qquad d = 0.194$$

where d is the Durbin-Watson statistic, a parameter indicative of the degree of serial correlation in the residuals.[1] The estimated system parameters[2] are:

$$b_1 = .0160 \qquad\qquad b_1/b_2 = .44$$

$$g = .64 \qquad\qquad \bar{Y}^{*}s = .46$$

---

[1] For a detailed discussion of the Durbin-Watson statistic see Durbin and Watson (2); Johnston (4; p. 192) also includes a short treatment of the subject. Theil and Nagar (5) develop a one-sided significance test for d, indicating that for 100 or more observations, the null hypothesis of independence in the true errors should be rejected if d falls below,

$$\text{One Percent Level:} \quad Q_1 = 2 \left(\frac{T-1}{T-n} - \frac{2.32635}{T+2}\right)$$

$$\text{Five Percent Level:} \quad Q_5 = 2 \left(\frac{T-1}{T-n} - \frac{1.64485}{T+2}\right)$$

where,

T = Number of observations
n = Number of explanatory variables

and where the variance of the first differences in the dependent variable is small relative to the variance of the dependent variable itself. This latter condition is met by the data with which we are dealing.

[2] b_1 is given directly by the regression, and the calculation of b_1/b_2 is straightforward. g is calculated via equation 30, using the regression estimates for b_3 and b_2. $\bar{Y}^{*}s$ is calculated via equation 29, using the regression estimates for a and b_3.

All of the parameters fall within the plausibility ranges

set forth in Table 4-3, although both b_1 and b_1/b_2 are

near the lower limits of their respective ranges. The F

ratio is significant at the one percent level, as are all

of the parameters except b_1, which is significant at five

percent.[1] Figure 4-4a shows the estimated price behavior[2]

based on equation 36, along with the behavior of the actual

price, the current inventory ratio, and the expected inven-

tory ratio.

The most disturbing aspects of these results are

the values of R^2 and d, the Durbin-Watson statistic. The

Durbin-Watson statistic of 0.194, corresponding to a serial

correlation coefficient of 0.910, indicates a high degree of

serial correlation in the residuals. This, coupled with the

fact that equation 36 only explains about 84 percent of the

price (more accurately, log price) variation, suggests either

---

[1] The discussion in Appendix A indicates that certain of the
data has been constructed by filling in missing data points
via interpolation. This process reduces the effective degrees
of freedom for statistical analysis, since the separate "tests"
which the 132 months in the data interval provide for the
structure of equation 36 become somewhat less independent of
one another. I will not attempt to correct the significance
tests for this reduction in degrees of freedom, but merely
suggest that it be kept in mind in reviewing the regression
results.

[2] The estimated price is calculated from equation 36 in the
following manner,

$$P_t = (\bar{P}) \left(\frac{P_t}{\bar{P}}\right) = (\bar{P}) \, EXP \left[- \ln \left(\frac{\bar{P}}{P_t}\right)\right]$$

where $\bar{P}$ = 35.2 cents/lb., the average real post war price
of spot Accra in New York.
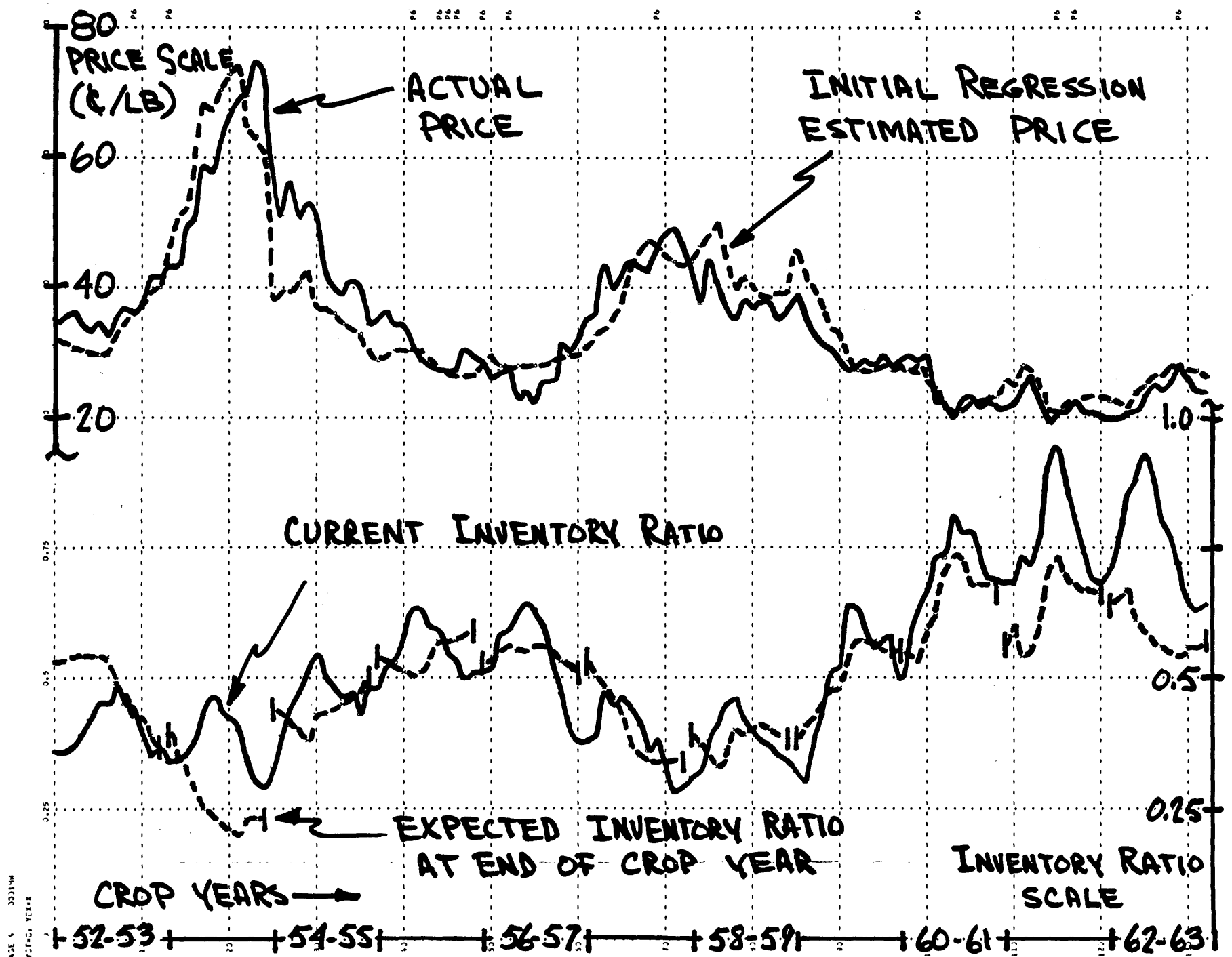
FIGURE 4-4 a-- ACTUAL PRICE VS. INITIAL ESTIMATE, AND CURRENT AND EXPECTED INVENTORY RATIOS
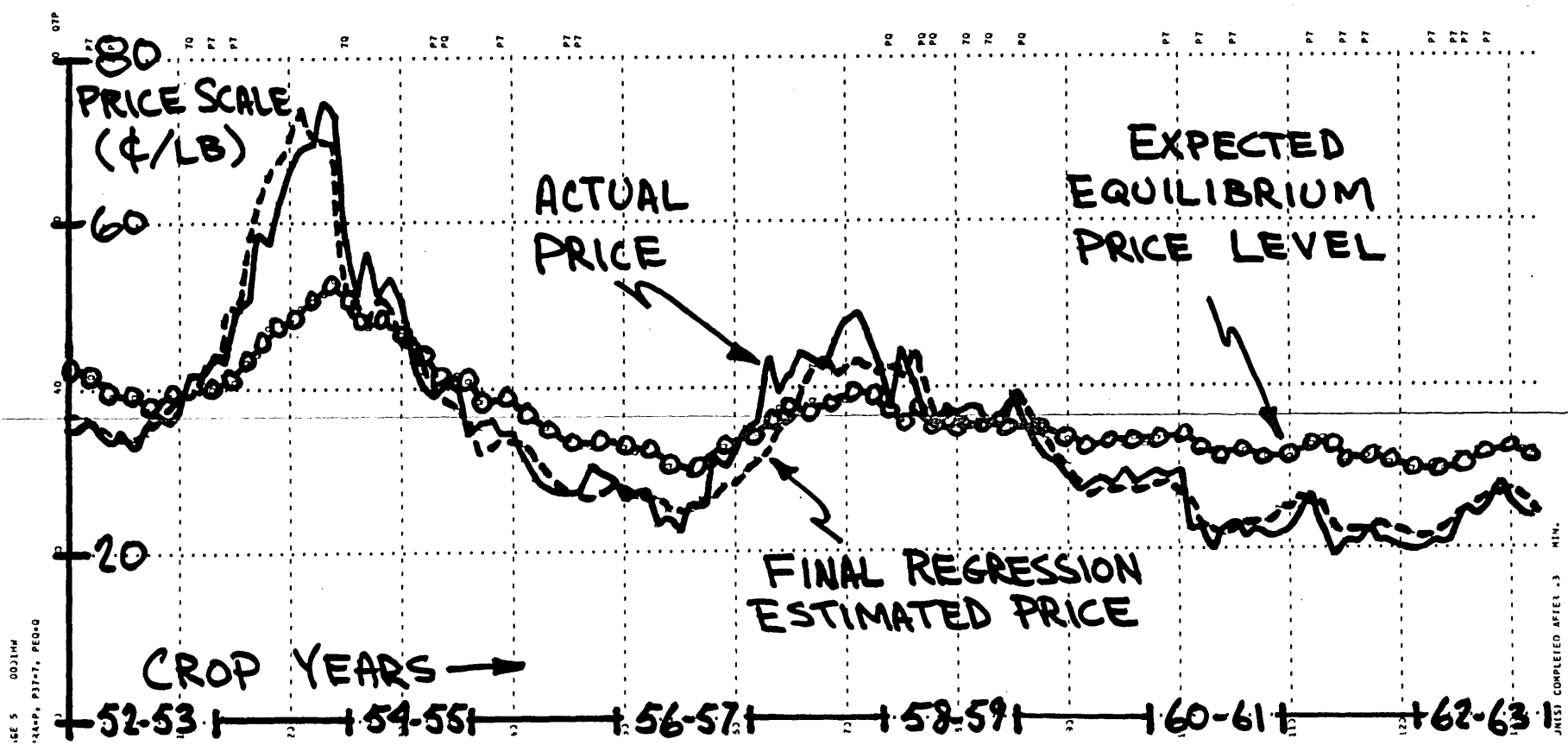
FIGURE 4-4 b-- FINAL REGRESSION RESULTS

that one or more variables other than those included in the regression exert a significant influence on the current price level, or that equation 37 has been misspecified. The magnitude and dynamic characteristics of the un-explained price variation are evident in Figure 4-4 a.

If one or more variables of importance have been left out of equation 36, among the most likely candidates are those variables which might be expected to exert an influence on the expected equilibrium price level, $P^{*\infty}$. In equation 36, $P^{*\infty}$ was assumed to be constant at the average postwar price level. On the other hand, it would seem more plausible that the long run expected price level would vary with events in the cocoa market. If we define the equilibrium cocoa price level as that (real) price at which the long run growth rate of production will equal the long run growth rate of consumption, there is no reason to expect that this level doesn't change over time. Structural shifts in demand and/or supply would cause a change in the equilibrium price level, and while such shifts are generally likely to be gradual, they are to be expected, and at times they may in fact be fairly rapid (e.g. the effects of swollen shoot on the supply of cocoa in the late forties and early fifties).

Either one of (or some combination of) two broad approaches toward describing the market's determination of

its equilibrium price expectations would seem plausible:

(1) the equilibrium price expectation is equal to some

smoothed version of the actual price, indicating that the

market bases its expectations of future prices primarily

on the level of past prices; or (2) the long run expected

price is relatively high if the long run price trend has

been up, and is relatively low if the long trend has

been down, indicating that the market tends to extrapolate

past price movements in forming its expectations.

The role of the equilibrium price in determining the

current price within the specified structure of equation

28 will be made clearer if we multiply that equation

through by -1, and bring the expected equilibrium price

over to the right side,

$$\ln P_t = -a - b_1 h_t - b_2 Z_t - b_3 \ln Y^{*h}t + \ln P_t^{*\infty} - e_t \tag{37}$$

where we can write,

$$P_t^{*\infty} = M_t \bar{P} \tag{38}$$

where,

$P^{*\infty}$ = Expected equilibrium price
$\bar{P}$ = Average postwar price
M = A variable price expectation multiplier

such that,

$$\ln P_t^{*\infty} = \ln M_t + \ln \bar{P} \tag{39}$$

or reverting to the format of equation 28,

$$\ln \left(\frac{\bar{P}}{P_t}\right) = a + b_1 h_t + b_2 Z_t + b_3 \ln Y^{*h}t - \ln M_t + e_t \tag{40}$$

In equation 36, M was assumed constant and equal to 1.0.

In the first of the alternatives suggested above,
M would be a function of some smoothed (distributed lagged)
version of past price levels. I have made various attempts
at identifying such a functional relation using ordinary
least squares regression, without obtaining any meaningful
results. In one set of estimates I tried specifying,

$$M = \frac{\text{smoothed } P_t}{\bar{P}} \tag{41}$$

or,

$$P^{*\infty} = \text{smoothed } P_t \tag{42}$$

where I specified various smoothing functions and replaced
$\bar{P}$ with smoothed P in equation 28.[1] The results without
exception were reductions in R^2 from the results of
equation 36, and implausible values for some of the basic
parameters in the price equation. I also tried using
regression to specify the lag distribution, and while R^2
was increased, the lag coefficients were implausible
(fluctuating between positive and negative values), and
certain of the estimates of the original coefficients
again became implausible. These results strike me as
surprising, as I would have expected equilibrium price
expectations to be at least weakly related to some smoothed

---

[1]In particular I tried both first and second order smoothing
functions, with average lag times of both 36 months and
60 months (i.e. four combinations in all).

version of the actual price. That may yet be the case,

but I have found no evidence of it in my studies.

The second alternative suggested above for formu-

lating equilibrium price expectations proves to be far

more fruitful. For the purposes of estimation I define

the price expectation multiplier as an exponential

function[1] of the past cocoa price trend. The estimated

price trend, in turn, is a weighted average of the

fraction price rate of change for past months, with the

weighting function estimated via regression.

$$M_t = EXP \left(b_4 \sum_{i=1}^{n} a_i \frac{\Delta P_{t-i}}{P_{t-i}} \right) \tag{43}$$

where,

$$\sum_{i=1}^{n} a_i = 1.0 \tag{44}$$

and where,

M = Price expectation multiplier

b_4 = Sensitivity parameter

a = Weighting coefficient in distributed lag
function

ΔP = Monthly change in real spot price

P = Monthly average real spot price

---

[1] I use an exponential function both for the sake of conveni-
ence and because it seems reasonable (as will be indicated
more clearly later). The convenience of the exponential
function arises from the fact that the natural logarithm
of an exponential is equal to the exponent (see equation 39).

where the distributed lag coefficients are to be speci-
fied via regression. Equation 44 simply serves to define
the various a_i as weighting coefficients in a pure avera-
ging process, wherein the summed weights equal unity.[1]
Figure 4-5 indicates the multiplier curve shape for vari-
ous values of the sensitivity parameter, b_4.

Using the equation 40 format the regression results
are,

$$\ln \left(\frac{\bar{P}}{P_t}\right) = \begin{array}{c} .440 \\ (.052) \end{array} + \begin{array}{c} .0175 \\ (.0053) \end{array} h_t + \begin{array}{c} .0289 \\ (.0082) \end{array} Z_t + \begin{array}{c} .455 \\ (.066) \end{array} \ln Y^{*ht}$$

$$- 29.0 \sum_{i=0}^{19} a_i \left(\frac{\Delta P}{P}\right)_i + e_t \tag{45}$$

$$R^2 = .948 \qquad F(23, 108) = 86$$

In order to allow the distributed lag function to cover a
significant time range, while still keeping the number of
independent variables in equation 45 within the limits
set by the available computer program and by the existing
degrees of freedom, each of the lagged price change
variables in equation 45 was actually the average fraction
price rate of change over a four month interval. Thus in

---

[1] It should be noted that in averaging the real fraction price
rate of change, we are in effect assuming that at any point
in time the general commodity price level is expected
to remain constant at its current value (or better, that
there are no well defined aggregate expectations for either
a general inflation or a general deflation in commodity prices).
This assumption is probably not too far wrong for the period
in question during which the general commodity price level
was relatively stable.
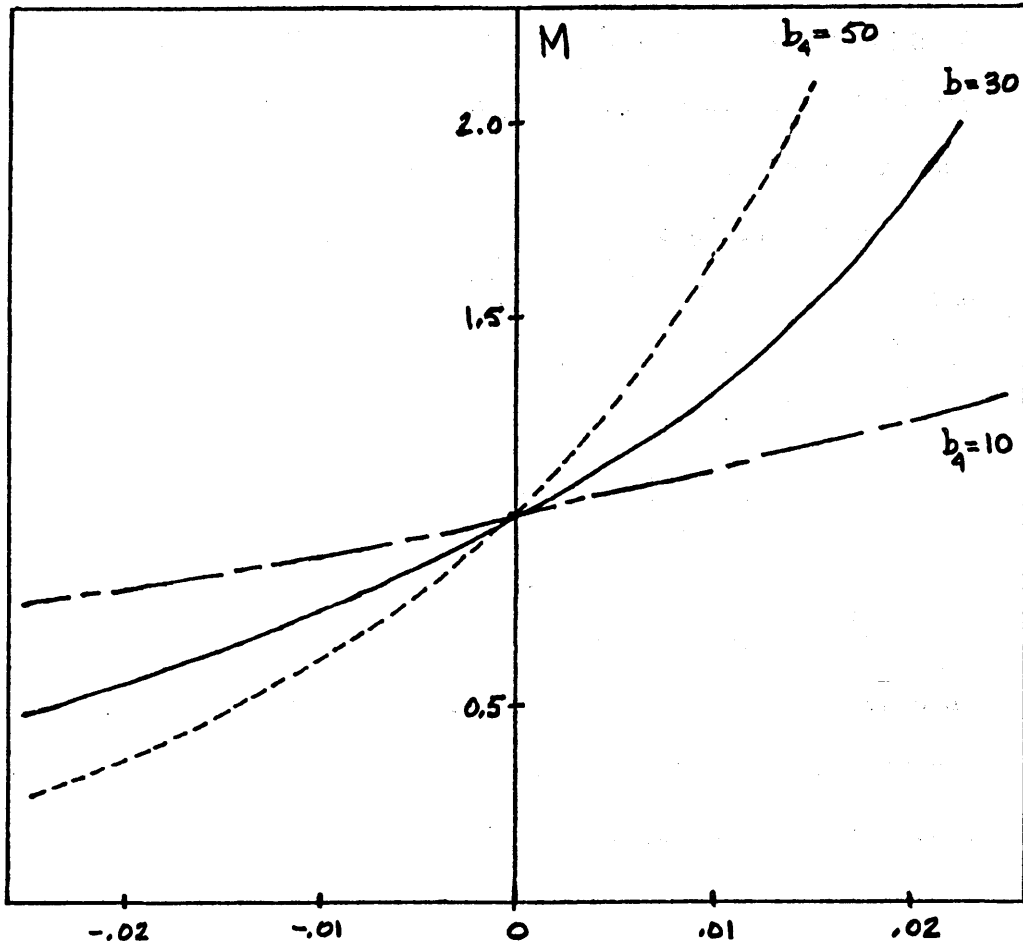
FIGURE 4-5   PRICE TREND MULTIPLIER

CURVE SHAPES

equation 45,

$$\left(\frac{\Delta P}{P}\right)_i = \frac{1}{4} \sum_{k=4i+1}^{4i+4} \frac{P_{t-k} - P_{t-k-1}}{P_{t-k-1}} \tag{46}$$

so that the total distributed lag in equation 45 covers a period of 80 months (20 four month averages). The regression did not yield the estimate, $b_4 = 29.0$, directly, but rather yielded the coefficient products, $- b_4 a_i$, indicated in Table 4-4. Separate estimates of b_4 and the a_i are yielded by the $- b_4 a_i$ products coupled with the identity expressed in equation 44, as is also indicated in Table 4-4.

The improvement in R^2 from equation 36 to equation 45 is marked. The new F ratio, and all of the coefficients except $b_4 a_0$, $b_4 a_1$, and $b_4 a_2$ are significant at the one percent level. The basic system parameter values are,

$$b_1 = .0175 \qquad\qquad b_1/b_2 = .61$$

$$g = .49 \qquad\qquad \overline{Y}^{*}s = .38$$

Based on Table 4-3, g is just implausibly low, and $\overline{Y}^{*}s$ is on the lower end of the plausibility region.

Figure 4-6 plots the distributed lag coefficients, a_i, given in Table 4-4 versus the lag times covered by each coefficient. While I suspected that equilibrium price expectations might be influenced by some lagged version of the price rate of change, the relative smoothness of the estimated lag shape is surprising, given the number of degrees

Table 4-4:   Regression and Smoothed Parameter Estimates

i	$-b_4 a_i$	$s_{b_4 a_i}$	a_i	a_i^*
0	- 1.67	.336	.056	.056
1	- 1.97	.324	.068	.067
2	- 2.08	.303	.072	.071
3	- 2.21	.294	.076	.072
4	- 2.27	.298	.078	.073
5	- 1.68	.305	.058	.072
6	- 1.88	.286	.065	.072
7	- 2.20	.285	.076	.070
8	- 2.03	.260	.070	.068
9	- 1.52	.239	.052	.065
10	- 1.97	.230	.068	.062
11	- 1.81	.244	.062	.057
12	- 1.54	.234	.053	.051
13	- 1.20	.224	.041	.043
14	- 0.86	.226	.030	.035
15	- 0.91	.233	.031	.026
16	- 0.56	.208	.019	.018
17	- 0.32	.175	.011	.012
18	- 0.23	.177	.008	.008
19	- 0.11	.190	.004	.004
Total	-29.04		1.000	1.000
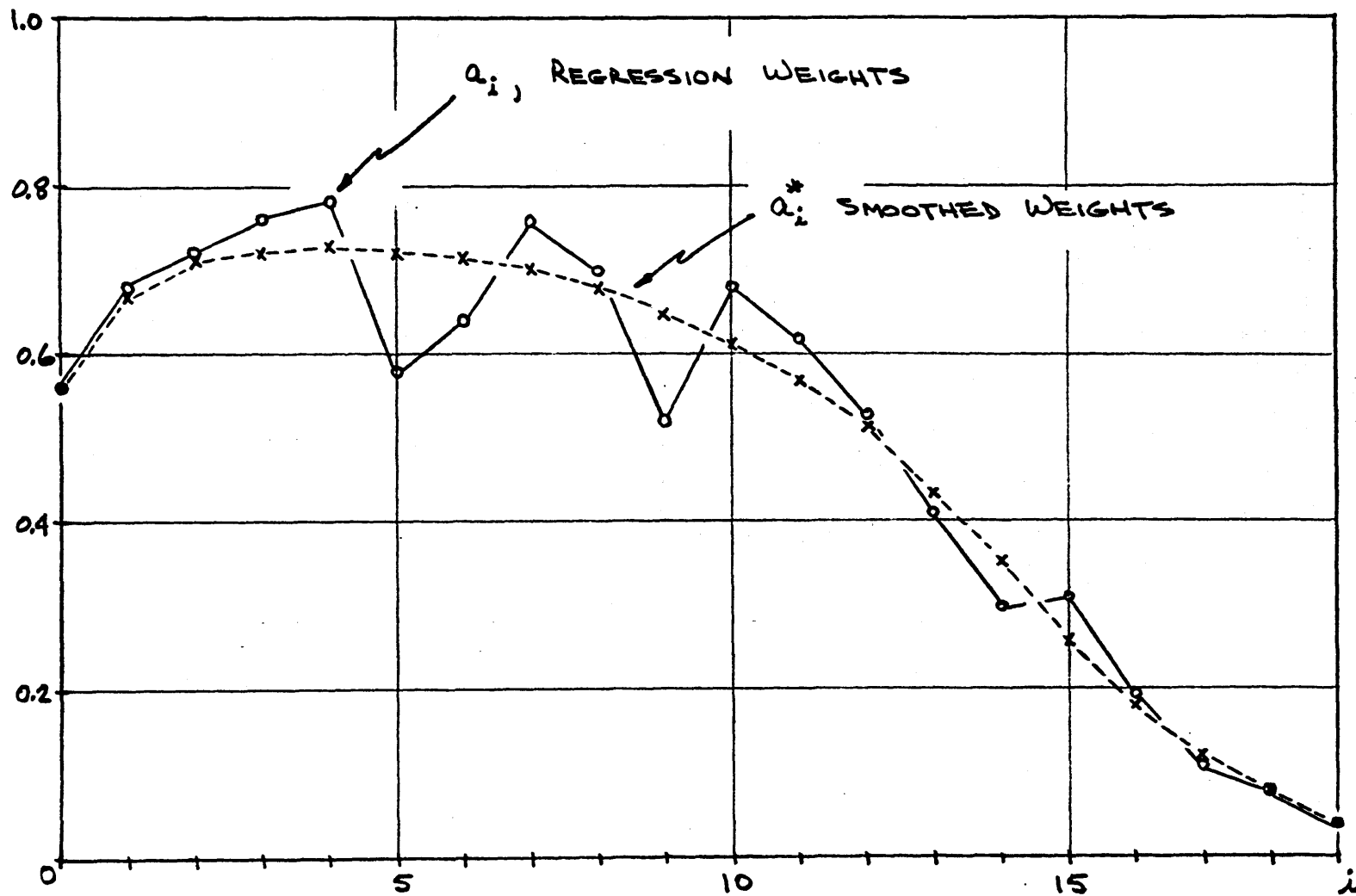
FIGURE 4-6 REGRESSION AND SMOOTHED WEIGHTING FUNCTIONS ON PRICE TREND

of freedom used up in its estimation. The natural

tendency for the lag coefficients to approach zero for

large lag values explains why the last three coefficients

in Table 4-4 are not statistically significant, even

though their values are plausible.

I cannot see a plausible explanation for such short

term fluctuations which do show up in the regression esti-

mated lag shape in Figure 4-6. Therefore I have visually

drawn a smooth curve through the estimated points, yielding

the a_i^* given in Table 4-4 (actually I summed my initial

visual coefficient estimates, and then adjusted these

initial estimates such that the sum of the a_i^* equals 1.0).

A new regression, using this specified lag structure, yields,

$$\ln \left(\frac{\bar{P}}{P_t}\right) = \underset{(.038)}{.469} + \underset{(.0044)}{.0132}\, h_t + \underset{(.0069)}{.0248}\, z_t + \underset{(.048)}{.481} \ln Y^{*h}t$$

$$- \underset{(2.0)}{28.8} \sum a_i^* \left(\overline{\frac{\Delta P}{P}}\right)_i + e_t \tag{47}$$

$$R^2 = .942 \qquad F\,(4,\,127) = 513 \qquad d = 1.05$$

The R^2 using the smooth lag structure remains high,

and the F ratio and all of the coefficients are significant

at the one percent level (though as the data becomes increas-

ingly "mauled", in the words of Professor Kuh, the meaning-

fulness of these hypothesis tests becomes increasingly

questionable). The estimates of the original system para-

meters are,

$$b_1 = .0132 \qquad\qquad b_1/b_2 = .53$$

$$g = .57 \qquad\qquad \overline{Y}^{*}s = .38$$

all of which are within the plausibility ranges set forth

in Table 4-3.

In judging the plausibility of the estimate, $b_4 = 28.8$

(Figure 4-5 shows the curve shape of the price expecta-

tion multiplier for $b_4 = 30$), it is useful to consider the

range of variation during the data interval which this

estimate implies for the long run expected equilibrium price

level. Inspection of the data yields the high and low

values of the lagged fraction price rate of change,

$$\underline{\text{High:}} \quad \sum_{i=0}^{19} a_i^{*} \left(\overline{\frac{\Delta P}{P}}\right)_i = 0.0154 \text{ in August, } 1954$$

$$\underline{\text{Low:}} \quad \sum_{i=0}^{19} a_i^{*} \left(\overline{\frac{\Delta P}{P}}\right)_i = -0.0068 \text{ in April, } 1956$$
$$\text{and December, } 1962$$

indicating a high smoothed percentage price rate of change

of over one percent per month, and a low of not quite minus

one percent per month. These values, substituted into

equation 43 yield,

$$\underline{\text{High:}} \quad M_t = \text{EXP} (28.8) (.0154) = 1.56$$

$$\underline{\text{Low:}} \quad M_t = \text{EXP} (28.8) (-.196) = 0.82$$

such that further substitution into equation 38 yields,

$$\underline{\text{High:}} \quad P_t^{*} = (1.56) (35.2) = 54.8 \text{ cents/lb.}$$

$$\underline{\text{Low:}} \quad P_t^{*} = (0.82) (35.2) = 28.8 \text{ cents/lb.}$$

The high equilibrium price expectation of 54.8 cents/lb.

in August, 1954, compares with the peak monthly average

real price level of Accra beans of 74.1 cents/lb. during

the previous month.[1] The low equilibrium expectations of

28.8 cents/lb. in April, 1956, and December, 1962, compare

with market lows of 22.7 cents in March, 1956, and 19.8

cents in September, 1962. When viewed in the context of

the cocoa market's bullish fever in 1954, and the market's

bearish despondency in 1956 and during most of the 1960's,

these estimated high and low values of equilibrium price

expectations seem fairly reasonable.

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[1]One measure of the validity of the estimated peak equilibrium
expectation of 54.8 cents per pound is the futures pattern
which existed at the time of the peak. During the week
ending August 13, 1954, the then traded futures reached
the contract highs indicated below. When these highs are
stated in real terms, and the then existing forward Accra
premiums over the futures are added, the real Accra equi-
valent of (say) the March futures peak was about 64 cents
per pound, or some nine cents over the estimated peak
equilibrium expectation.

Futures Month	Contract Highs	Real Equivalents	Forward Accra Premiums	Real Forward Accra Equivalents
September	64.55	69.5	---	---
December	59.90	64.3	4.7	69.0
March	55.90	60.0	4.0	64.0
May	55.00	59.2	---	---

The one disturbing aspect of the results given by equation 47 is the Durbin-Watson statistic of 1.05, corresponding to a serial correlation coefficient of 0.48, and indicating the continued (though diminished) existence of significant serial correlation in the residuals. Thus it is still likely either that the structure of equation 47 is misspecified, or that some variable influencing the current price level has been omitted. In either case it is unlikely that the error is very important, since the structure of equation 47 does explain over 94 percent of the variance of the price logarithm, and it is to be expected that some of the variance is unexplainable by available data. In any case, I have made no attempts further to explain price behavior by adding to or modifying the structure of equation 47. On the other hand the existence of serial correlation in the residuals indicates that the parameter estimates in equation 47 are somewhat inefficient. Section 4.5 deals with this problem.

4.4 Stability of the Estimated Structure

It is of interest to investigate the degree to which the parameter estimates and the goodness of fit given by the structure specified in equation 47 vary over sub-intervals of the total data interval under study. The use of a single equation structure to explain behavior over the entire data interval implies the assumption that the actual structure of

the cocoa price mechanism did not change over that interval. If this assumption is valid, it seems reasonable to further assume that the parameter estimates and the goodness of fit yielded by the specified structure should not vary significantly either between reasonably long sub-intervals of the total data interval, or between any of these sub-intervals and the total interval.

To test the stability of the relationship indicated by equation 47 I have divided the data interval into two halves of 66 months each, the first running from September, 1952, through February, 1958, the second from March, 1958, through August, 1963. The regression results are,

First Period:

$$\ln \left(\frac{\bar{P}}{P_t}\right) = \begin{array}{c} .435 \\ (.057) \end{array} + \begin{array}{c} .0061 \\ (.0088) \end{array} h_t + \begin{array}{c} .0157 \\ (.0129) \end{array} Z_t + \begin{array}{c} .457 \\ (.069) \end{array} \ln Y^{*h}t$$

$$- \begin{array}{c} 27.1 \\ (2.6) \end{array} \sum a_i^* \left(\frac{\Delta \bar{P}}{P}\right)_i + e_t \qquad (48)$$

$$R^2 = .929 \qquad\qquad F(4, 61) = 200$$

Second Period:

$$\ln \left(\frac{\bar{P}}{P_t}\right) = \begin{array}{c} .571 \\ (.066) \end{array} + \begin{array}{c} .0066 \\ (.0048) \end{array} h_t + \begin{array}{c} .0053 \\ (.0085) \end{array} Z_t + \begin{array}{c} .663 \\ (.082) \end{array} \ln Y^{*h}t$$

$$- \begin{array}{c} 31.0 \end{array} \sum a_i^* \left(\frac{\Delta \bar{P}}{P}\right)_i + e_t \qquad (49)$$

$$R^2 = .946 \qquad\qquad F(4, 61) = 269$$

In terms of goodness of fit, the evidence is that the relationship is somewhat unstable. The standard test[1] for the

---

[1] See Chow (1) for the derivation of this test; Johnston (4; pp. 136-8) includes a summary of Chow's article.

stability of a set of k regression coefficients estimated
for two consecutive data intervals of m and n periods,
respectively, as well as for the total interval of m + n
periods, uses the F ratio,

$$F = \frac{\left(\sum_{t=1}^{m+n} e_{Tt}^2 - \sum_{t=1}^{m} e_{1t}^2 - \sum_{t=m+1}^{m+n} e_{2t}^2\right) \Big/ k}{\left(\sum_{t=1}^{m} e_{1t}^2 + \sum_{t=m+1}^{m+n} e_{2t}^2\right) \Big/ (m + n - 2k)} \qquad (50)$$

where,

F = F ratio with $(k, m + n - 2k)$ degrees of freedom

k = Number of regression coefficients

m = Number of periods in first data interval

n = Number of periods in second data interval

e_T = Residuals from regression for total data interval

e_1 = Residuals from regression for first data interval

e_2 = Residuals from regression for second data interval.

Clearly the following relations will hold,

$$\sum_{t=1}^{m} e_{1t}^2 \leq \sum_{t=1}^{m} e_{Tt}^2 \qquad (51)$$

and,

$$\sum_{t=m+1}^{m+n} e_{2t}^2 \leq \sum_{t=m+1}^{m+n} e_{Tt}^2 \qquad (52)$$

or,

$$\left(\sum_{t=1}^{m+n} e_{Tt}^2 - \sum_{t=1}^{m} e_{1t}^2 - \sum_{t=m+1}^{m+n} e_{2t}^2\right) \geq 0 \qquad (53)$$

since the sub-interval regressions need meet fewer constraints

(degrees of freedom) than does the regression for the total

interval. If the relation (set of coefficients) being tested

is quite stable, there will be little change in the coeffi-

cients between the three regressions, and the expression

in equation 53 will be close to zero, thus yielding a low

F ratio. If the relation is not stable, the coefficients

will likely vary, and the specified structure will likely

fit each of the separate sub-intervals much better than it

fits the total interval (because of inconsistencies in the

requirements of the two sub-intervals). Under these circum-

stances the expression in equation 53, and therefore the

F ratio, will tend to be quite large.

Substituting the error sums of squares from equations

47, 48, and 49 into equation 50 yields,

$$F = \frac{(.788 - .413 - .253) / 4}{(.413 + .253) / (66 - 66 - 8)} = 5.69$$

which is significant (i.e. indicates instability) at the five

percent level. The sensitivity of this test to changes in

the error sums of squares is indicated by the comparisons,

First Period:

$$R_t^2 = .913 \qquad R_1^2 = .929$$

Second Period:

$$R_t^2 = .928 \qquad R_2^2 = .946$$

where the R_t^2 are the coefficients of determination generated

by the total interval relation during each of the two sub-

intervals. The sub-interval regressions explain 18 and 22 percent, respectively, of the variance left unexplained by the total interval regression in each of the sub-intervals. Put another way, the sub-interval estimates add 1.8 and 1.9 percent, respectively, to the variance levels explained by the total interval regression. While these shifts in the goodness of fit of the relations do not seem major, they are large enough to be statistically significant against the above F test.

If the statistical test run on the entire set of coefficients indicates instability, observation of the behavior of the individual coefficients points even more strongly in the same direction. Table 4-5 lists the various coefficients generated by the three regressions. As is indicated in the table, the sub-interval estimates of the short term supply of storage coefficients (b_1 and b_2) leave something to be desired in terms of both statistical significance and plausibility. In addition, the post-horizon time constant (g) is implausibly large for the second half of the interval. Moreover, the values of b_1, b_2, and g vary quite widely over the three regressions.

These results regarding the values of individual parameters are neither as indicative of instability nor as damaging to the foregoing theoretical discussion as they may at first appear to be. This is made clear by inspection

Table 4-5:   Subinterval and Total Interval Parameter Estimates

Parameter	Plausibility Range		Total Interval Estimate	First Half Estimate	Second Half Estimate
a			.469 (.038)	.435 (.057)	.571 (.066)
b_1	High:	.042	.0132 (.0044)	.0061*+ (.0088)	.0066+ (.0048)
	Low:	.008			
b_2			.0248 (.0069)	.0157+ (.0128)	.0053+ (.0085)
b_3			.481 (.048)	.457 (.069)	.663 (.082)
b_4			28.8 (2.0)	27.1 (2.6)	31.0 (6.3)
b_1/b_2	High:	.92	.53	.39	1.24*
	Low:	.43			
g	High:	.80	.57	.69	.92*
	Low:	.50			
$\bar{Y}^{*}s$	High:	.60	.38	.39	.42
	Low:	.35			

*   indicates implausible value

+   indicates insignificant value at five percent

of the correlation coefficient matrix for the independent

variables over the two sub-intervals as well as the total

interval, given in Table 4-6. The most striking increases

in intercorrelation relative to the total interval occur

during the second half, in the form of increases in ρ_{23},

ρ_{24}, and ρ_{34}. During the first half, ρ_{12} and ρ_{13}

also increased noticeably. These increased correlation

coefficients are symptomatic of increased problems of

multicolinearity, which also show up in the form of larger

standard errors for the corresponding regression coeffi-

cients (see Table 4-5).

The evidence of Tables 4-5 and 4-6 suggests that the

pattern of intercorrelation between the independent variables

varies significantly between the two sub-intervals, pre-

senting problems of multicolinearity in the estimation

primarily of b_1 during the first half, and b_2, b_3, and b_4

during the second half. The joining of the two sub-intervals

Table 4-6: Correlation Coefficients, Independent Variables

Key for each cell:	(ρ_{ij}, total interval);		(ρ_{ij}, first half);	(ρ_{ij}, second half)
Variable	1) h	2) z	3) $\ln Y^{*}s$	4) $\sum_i a_i^{*}(\frac{\Delta \bar{P}}{\bar{P}})_i$
1) h	1.0	-.76,-.84,-.69	.04, .17, -.05	.06, .03, 0
2) z	---	1.0	.49, .27, .65	-.48,-.35,-.60
3) $\ln Y^{*}s$	---	---	1.0	-.77,-.73,-.90
4) $\sum_i a_i^{*}(\frac{\Delta \bar{P}}{\bar{P}})_i$	---	---	---	1.0

into one total interval has the effect of reducing these

problems of multicolinearity, thereby giving more reliable

(efficient) coefficient estimates (witness the statistical

significance and plausibility of all of the total interval

estimates).

4.5   Generalized Least Squares Estimate

The existence of serial correlation in the true error

component of a variable reduces the efficiency of the ordinary

least squares parameter estimates in the equation structure

assumed to be generating that variable.[1] Not only is efficien-

cy lost, but ordinary least squares no longer is the "best"

estimation procedure, in the sense of giving the most effi-

cient estimates of the system parameters. The most efficient

estimates are instead given by the generalized least squares

estimation procedure. Since the Durbin-Watson statistic for

equation 47 confirms the existence of serial correlation

in the regression residuals, and thus suggests the existence

of autocorrelation in the true errors, it is appropriate

that we obtain the generalized least squares parameter esti-

mates.

A fairly simple procedure is available for obtaining

approximate generalized least squares estimates if it seems

---

[1]For a discussion of this point, and all that follows re-
garding autocorrelated errors, see Johnston (4; pp. 177-99,
particularly pp. 185-7).

reasonable to make the assumption regarding the true error,

$$e_t = \rho\, e_{t-1} + u_t \tag{54}$$

where,

e = True error term in regression structure
ρ = Serial correlation coefficient of true error
u = Normal, independent, homoscedastic random disturbance term

If this assumption is made, an estimate[1] of ρ is provided by the serial correlation coefficient of the regression residuals, which in the case of equation 47 is equal to 0.48. The (approximate) generalized least squares parameter estimates are then obtained by transforming all of the variables used in the original regression as follows,

$$V_t^T = V_t - \rho\, V_{t-1} \tag{55}$$

where,

V^T = Transformed variable
V = Original variable

and then obtaining ordinary least squares estimates of the parameters in the original equation structure, using the transformed variables. The residuals from this regression are estimates of the u's in equation 54, and therefore should not show significant autocorrelation if the assumption under-lying equation 54 is correct. This reduction in serial correlation in the error term explains the increased effi-ciency of the generalized least squares estimates.

---

[1] Because of the inclusion of lagged price first differences on the right hand side of equation 47, this estimate of is likely to be somewhat downward biased.

The generalized least squares results for the structure of equation 47 are,

$$\ln \left(\frac{\bar{P}}{P_t}\right)^T = \begin{array}{c} .265 \\ (.025) \end{array} + \begin{array}{c} .0092 \\ (.0050) \end{array} h_t^T + \begin{array}{c} .0209 \\ (.0079) \end{array} z_t^T + \begin{array}{c} .524 \\ (.061) \end{array} \ln Y_t^{*h_t^T}$$

$$- \begin{array}{c} 25.7 \\ (3.0) \end{array} \sum a_i^* \left(\frac{\Delta \bar{P}}{P}\right)^T + u_t \qquad (56)$$

$$R^2 = .85 \qquad F_{(4, 126)} = 183 \qquad d = 2.19$$

where the superscript, T, indicates that the variable has been transformed according to equation 55, with $\rho = .48$. The constant term in equation 56 (a^T) is related to the constant term (a) in the earlier equations,

$$a^T = (1 - \rho)(a) \qquad (57)$$

or in this case,

$$a = \frac{a^T}{1 - \rho} = \frac{.265}{.52} = .508$$

The Theil-Nagar test mentioned in an earlier footnote indicates that with $d = 2.21$, the null hypothesis of no positive serial correlation in the true error should be accepted.[1] To this extent the assumption underlying equation 54 is supported.

Thus the coefficient estimates in equation 56 can be assumed to be relatively efficient. These coefficients, all of which are significant at one percent except b_1, which is

---

[1] In fact, the generated Durbin-Watson statistic indicates the existence of a mild degree of negative serial correlation.

significant at ten percent, yield the basic parameter estimates,

$$b_1 = .0092 \qquad b_1/b_2 = .44$$

$$g = .66 \qquad \overline{Y}^{*s} = .38$$

All of these estimates fall within their respective plausi-

bility regions, though b_1, b_1/b_2 and $\overline{Y}^{*s}$ are close to their

lower limits.

Ever since allowance was made for variable equili-

brium price expectations (equation 45), the estimates of

$\overline{Y}^{*s}$, the expected equilibrium September inventory ratio,

have consistently fallen near the lower end of the specified

plausibility range (i.e. the estimates have consistently

fallen below the average September value of the inventory

ratio of 0.45). This may reflect the critical dependence

of the calculated estimate of $\overline{Y}^{*s}$ on the assumed "normal"

value of equilibrium price expectations, as can be shown

by repeating the first part of equation 40 (we are only

interested in the constant term),

$$\ln\left(\frac{P}{P_t}\right) = a + \ldots \tag{58}$$

or, using equation 29,

$$\ln\left(\frac{P}{P_t}\right) = -b_3 \ln \overline{Y}^{*s} + \ldots \tag{59}$$

Say that the normal equilibrium price expectation is not $\overline{P}$

(the postwar average real price level), but rather is equal

to some other price level, $\overline{\overline{P}}$. Then $\overline{Y}^{*s}$ can only be accur-

ately estimated from the regression constant term if the

dependent variable takes the form,

$$\ln\left(\frac{\bar{P}}{P_t}\right) = -b_3 \ln \bar{Y}^{*s} + \ldots \tag{60}$$

But we know that,

$$\ln\left(\frac{\bar{P}}{P_t}\right) = \ln\left(\frac{\bar{\bar{P}}}{P_t}\right) - \ln\left(\frac{\bar{\bar{P}}}{\bar{P}}\right) \tag{61}$$

so that equation 60 becomes,

$$\ln\left(\frac{\bar{P}}{P_t}\right) = \ln\left(\frac{\bar{\bar{P}}}{\bar{P}}\right) - b_3 \ln \bar{Y}^{*s} + \ldots \tag{62}$$

That is, $\bar{Y}^{*s}$ is related to the constant terms in all of the earlier regressions,

$$a = \ln\left(\frac{\bar{\bar{P}}}{\bar{P}}\right) - b_3 \ln \bar{Y}^{*s} \tag{63}$$

or,

$$\bar{Y}^{*s} = EXP\left[\frac{\ln(\bar{P}/\bar{\bar{P}}) - a}{b_3}\right] \tag{64}$$

In the earlier regressions, which yielded the relatively low estimates of $\bar{Y}^{*s}$, $\bar{P}$ was set equal to 35.2 cents/lb. If, for example, the true normal equilibrium price expectation were $\bar{\bar{P}}$ = 32.5 cents/lb., then the $\bar{Y}^{*s}$ estimate yielded by the results of equations 56 and 57 would be,

$$\bar{Y}^{*s} = EXP\left[\frac{\ln(35.2/32.5) - .508}{.524}\right] = .44$$

which is roughly equal to the average September inventory ratio over the data interval. From this calculation it seems that the estimated normal equilibrium price expectation of 35.2 cents/lb. may be a bit high, but the basic conclusion to be

drawn is that estimates of the normal equilibrium price and inventory ratio expectations are not identifiable from the regression results alone.

4.6 Conclusions

Figure 4-4b shows the behavior over the data interval of the estimated price and the estimated equilibrium price expectation based on equations 56 and 57, along with the behavior of the actual price and the current and expected inventory ratios. Figure 4-1, referred to earlier in this chapter, shows the short term supply of storage curve,

$$\frac{P_t^{*1} - P_t}{P_t} = .0092 + .0209 \ln Y_t \qquad (65)$$

implied by the generalized least squares estimates of b_1 and b_2. The general shape and location of this curve is consistent with the existing literature on the supply of storage concept.

One of the more interesting implications of the foregoing results is the implied behavior of long run price expectations. The observation is often made in commodity trading circles that the bullish enthusiasm in a market is always highest near a major price peak, and that general bearishness tends to reach its high level near a major price trough. As is indicated in Figure 4-4b, the above mechanism, whereby long run price expectations (probably as good an

indicator as any of the general "tone" of a market) are a direct function of the lagged price rate of change, generates behavior consistent with this observation.

A second potentially interesting implication of the above results will be left as a subject for further study. The second and third terms of equation 56, with the transformed variables replaced by the original variables, define the expected price change from the present to the end of the crop year (see equation 14),

$$\ln \left(\frac{P^{*h_t}}{P_t}\right) = .0092 \; h_t + .0209 \; Z_t \tag{66}$$

These estimates of the expected spot price change can be compared with the existing data on futures spreads, thereby providing the basis for the further investigation of certain of the supply of storage relations mentioned in Chapter 3. Such a study would not have to be limited to dealing with spot-September spreads. The short term supply of storage curve, the existing data for the current and expected inventory ratios, and the expected seasonal patterns in the inventory ratio (given in Appendix B), call all be combined to give the implied expected average prices for each month between the current month and September (the horizon month).

In general, the statistical results obtained above (i.e. equations 56 and 57) give significant support to the price theory developed in the last chapter and the early part

of this chapter -- far more support, in fact, than could
legitimately have been hoped for given the rather long
and involved set of assumptions which had to be made in
order to carry out the statistical tests. The goodness
of fit seems quite good -- over 94 percent of the variance
in the monthly average cocoa price has been explained --
and all of the parameter estimates are plausible. In
any event, the above results provide a satisfactory enough
explanation of cocoa price behavior to be acceptable for
use in the study of the intermediate term cocoa market
dynamics to be taken up in Chapter 6.

List of References

1) Chow, Gregory C., "Tests of Equality between Sets of Coefficients in Two Linear Regressions", Econometrica, Vol. 28 (July, 1960), pp. 591-605.

2) Durbin, J., and Watson, G.S., "Testing for Serial Correlation in Least Squares Regression", Parts I and II, Biometrika, Vol. 37 (1950), pp. 409-28; and Vol. 38 (1951), pp. 159-78.

3) Fisher, Franklin M., A Priori Information and Time Series Analysis: Essays in Economic Theory and Measurement, Amsterdam, 1962.

4) Johnston, J., Econometric Methods, McGraw Hill, New York, 1963.

5) Theil, H., and Nagar, A.L., "Testing the Independence of Regression Disturbances", American Statistical Association Journal, Vol. 56 (December, 1961), pp. 793-806.

Appendix A

The Data for Chapter 4

1.0 Cocoa Prices

The cocoa price series used in the above statistical
analyses is the monthly average spot price of Accra beans
in New York (sources: D-2 and D-4), deflated by the Bureau
of Labor Statistics index of wholesale commodity prices
(1957-59 = 100; source: D-1). While there are many vari-
eties of cocoa beans in use, the price of Accra beans is
commonly used to represent the aggregate price structure of
the cocoa market. This reflects the fact that (1) Ghana
accounts for roughly one third of world production; and
(2) the prices of the various cocoa varieties tend in the
main to move together. The cocoa price series has been
deflated because of the role which long term equilibrium
price expectations play in the theoretical model. Pre-
sumably the long term equilibrium price of cocoa tends to
vary at least roughly with the general level of commodity
prices (hence the use of the BLS commodity index) because
of substitution effects on both the supply and demand ends
of the system. By using the deflated cocoa price series in
the regressions, shifts of this sort in equilibrium price
expectations are eliminated (i.e. the equilibrium price ex-
pectation at any point in time is stated in terms of 1957-59
prices).

2.0 The Current Inventory Ratio

The current inventory ratio used in the chapter is

defined:

$$Y_t = \frac{I_t}{\sum\limits_{i=t-11}^{t} c_i} \qquad\qquad (A\text{-}1)$$

where,

    Y = Current inventory ratio
    I = Current end-of-month world inventory
    c = Monthly world grind

That is, the current inventory is related to world consump-

tion over the past 12 months.[1] Since there exist no published

monthly series on world inventories or world consumption, I

have constructed series from such data as does exist. The

inventory level is defined as the level of beans sold by the

producing nations but not yet consumed (ground), and as such

can be derived from the initial inventory level coupled

with monthly series for the world grinding rate and total

producer sales.

---

[1] I am using consumption and grinding interchangeably here
because such data as exists relating to consumption comes
in the form of grinding statistics. The grinding rate will
of course not provide an accurate measure of consumption in
those instances where the resulting products (i.e. liquor,
or powder and butter) are simply held in inventory rather
than consumed (as might be done in tropical countries to
facilitate storage). For the period under study there is
no evidence of any significant fluctuations in inventories of
cocoa products, so that the grinding-consumption distinction
is not important here. This may not continue to be the case
in the future, however, with the producing nations expanding
their grinding capacities and negotiating agreements which
may involve the withholding of beans (or more likely, products)
from the market.

2.1 Monthly World Grind -- The shortest time interval

used in published estimates of world grind is one year. On

the other hand, quarterly grind figures for the major con-

suming nations are available for most of the period under

study. If the world grinding rate can be assumed to follow

the same pattern within each year as does the aggregate

grind of the leading consuming nations, then an estimate

of the quarterly world grind can be derived. Table A-1

gives the quarterly grind rates of the eight leading con-

suming nations along with the estimated quarterly world grind

rate. The world grind rate for the fourth quarter of 1952

(for which there are no national grind estimates) has been

estimated by setting it equal to 0.269 times the 1952 world

grind, where 0.269 is the average fourth quarter fraction of

annual grind for the aggregated major consumers over the

1953-1963 period.

We next need to further break down the quarterly

world grind figures into monthly estimates. To cope with

this problem I have devised a method for breaking the quar-

terly grindings figures down into estimates of monthly

grindings. Table A-2 and Figure A-1 provide an example

of the method, using the estimated quarterly world grind as

the raw data. The method is based on the assumption that

monthly grindings can be described as being the sum of a

systematic component and a random component,

Table A-1: National Grinds and Estimated World Grind*

Year	Quarter	US	UK	Holnd	France	Japan	Italy	Grmny	Spain	World
1953	1	66.5	30.9	16.6	11.9	-	-	-	-	215
	2	54.5	31.9	18.2	11.6	-	-	-	-	199
	3	54.9	25.7	15.0	10.0	-	-	-	-	180
	4	58.9	31.1	15.6	13.8	-	-	-	-	204
1954	1	56.4	31.7	17.0	12.4	1.3	-	-	-	211
	2	51.7	29.3	12.5	13.6	.9	-	-	-	192
	3	45.1	25.6	10.1	10.9	.6	-	-	-	164
	4	40.5	28.2	10.6	12.1	.8	-	-	-	164
1955	1	45.8	29.3	15.1	10.2	.7	4.3	-	-	185
	2	42.6	26.5	13.2	10.4	.6	4.5	-	-	172
	3	47.5	20.6	12.8	9.5	.5	4.1	-	-	167
	4	52.0	24.3	15.3	12.7	1.0	5.8	-	-	195
1956	1	56.1	23.5	15.2	11.9	1.0	5.3	19.8	4.2	199
	2	54.0	23.2	15.9	12.2	.8	5.7	17.7	6.1	197
	3	50.4	20.3	15.5	10.5	.7	5.0	21.8	4.8	187
	4	62.7	25.7	18.6	15.8	1.7	6.3	29.1	4.6	239
1957	1	59.9	29.4	19.5	17.1	1.5	8.5	25.1	5.8	237
	2	57.1	26.3	19.3	13.9	1.5	6.5	19.0	5.8	212
	3	51.6	23.9	18.4	13.1	1.5	5.7	24.7	4.6	204
	4	62.9	29.1	19.9	17.8	1.6	7.1	35.5	5.4	255
1958	1	55.9	25.6	19.0	16.1	1.2	7.4	28.2	5.1	238
	2	48.4	25.8	16.5	14.5	1.3	4.8	19.9	6.3	207
	3	47.8	20.6	14.3	10.0	1.4	4.3	20.9	3.1	184
	4	54.2	22.5	14.5	13.2	2.0	5.1	23.0	6.0	211
1959	1	54.1	20.2	19.2	13.6	1.8	7.3	22.4	7.4	232
	2	49.3	20.9	18.7	12.5	1.5	7.4	18.8	4.9	213
	3	44.5	14.0	16.6	9.7	1.5	4.1	20.3	2.5	180
	4	53.9	17.9	19.5	13.2	2.3	7.3	29.6	4.9	236
1960	1	56.7	19.1	20.8	12.8	2.3	6.5	26.8	4.9	233
	2	49.6	19.2	20.1	13.3	1.7	7.2	20.9	4.6	213
	3	48.4	15.5	19.1	10.3	2.0	6.2	26.5	4.5	206
	4	60.7	20.2	23.4	15.2	3.1	7.7	32.9	6.7	264
1961	1	59.8	20.1	25.2	15.5	3.1	9.6	29.5	6.6	259
	2	56.7	20.3	24.2	14.7	2.9	9.2	24.3	5.2	241
	3	57.1	16.5	21.0	12.3	3.1	8.6	28.0	4.4	231
	4	67.7	23.3	25.8	17.1	4.9	8.0	34.1	6.0	286
1962	1	63.5	25.4	26.1	15.9	4.5	9.6	30.8	5.9	276
	2	60.8	24.2	24.5	16.8	4.4	7.7	27.2	5.9	261
	3	58.6	19.8	23.2	13.5	5.0	8.5	32.3	5.1	252
	4	67.9	24.5	27.0	17.8	6.8	10.4	36.5	6.3	299
1963	1	69.4	25.6	27.7	17.4	6.2	10.4	32.0	8.2	303
	2	61.6	25.4	25.1	16.7	5.4	10.3	28.8	7.7	279
	3	60.5	19.6	23.7	13.4	6.1	8.0	31.3	5.7	260
	4	69.0	22.7	26.7	17.2	7.0	8.1	35.1	6.3	296

* National Grinds from Gill and Duffus monthly reports.

Table A-2

Example of Procedure for Constructing Monthly World Grind

1956:		1	2	3	4
Quarterly grind, Q_i		199.1	196.8	187.3	238.8
1) m^*_{ij} = initial estimate of grind in j^{th} month of ith quarter	$m^*_{i1} = 1/9\ Q_{i-1} + 2/9\ Q_i$	66.0	65.9	63.5	73.9
	$m^*_{i2} = 1/3\ Q_i$	66.4	65.6	62.4	79.6
	$m^*_{i3} = 2/9\ Q_i + 1/9\ Q_{i+1}$	66.1	64.6	68.1	79.4
2) Used to adjust the m^*_{ij}'s to get the m_{ij}'s	$Q^*_i = \sum_{j=1}^{3} m^*_{ij}$	198.4	196.0	194.0	233.0
	$M = Q_i/Q^*_i$	1.004	1.004	0.964	1.025
3) m_{ij} = final estimate of grind in j^{th} month of ith quarter	$m_{i1} = M\ m^*_{i1}$	66.2	66.1	61.3	75.8
	$m_{i2} = M\ m^*_{i2}$	66.6	65.9	60.3	81.6
	$m_{i3} = M\ m^*_{i3}$	66.3	64.8	65.7	81.4
4) Check: Q_i should equal Q_i	$Q_i = \sum_{j=1}^{3} m_{ij}$	199.1	196.8	187.3	238.8

GRIND
THOUSANDS OF TONS PER MONTH

MONTHLY
GRIND
ESTIMATES

QUARTERLY AVERAGE GRIND

1956
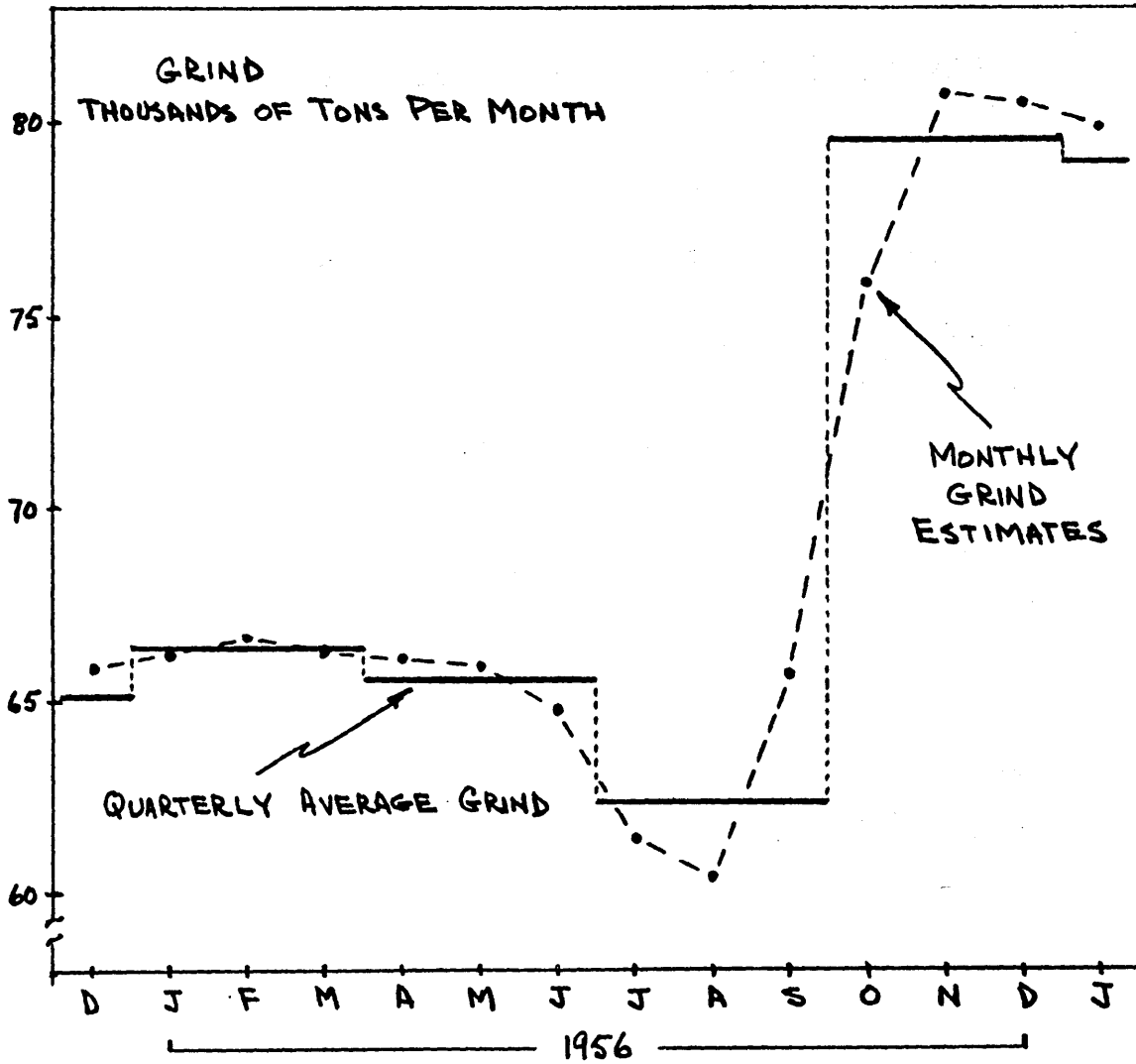
FIGURE A-1 EXAMPLE OF PROCEDURE FOR
CONSTRUCTING MONTHLY WORLD GRIND ESTIMATES

$$c_t = c_t^s + e_t \qquad\qquad (A\text{-}2)$$

where,

c = Monthly world grind
c^s = Systematic component of c
e = Random component of c

As will be discussed in detail in Chapter 5, the systematic

component is at least approximately equal to the sum of a

time trend (due to population growth, etc.) and a constant

times a distributed lagged version of the monthly average

price of cocoa. Both of these terms are highly serially

correlated, and it is this serial correlation which forms

the basis of the procedure described below for calculating

the monthly grind.

The specific steps taken in the estimation method are

the following (the numbered steps correspond to sections

in Table A-2):

1) A set of initial estimates of monthly grind

is derived.

a) The initial estimate of the grind during

the <u>middle</u> month of any quarter is equal

to the average monthly grind during that

quarter.[1]

---

[1] In this step and in the remaining steps the varying number
of days per month is ignored. In effect, the monthly grind
estimates are adjusted for the length of each month.

b) The initial estimate of the grind during the *first* month of any quarter is assumed to lie on a straight line between the middle month grind in that quarter and in the preceding quarter (i.e. linear interpolation).

c) Similarly, the initial estimate of the grind during the *last* month of any quarter is assumed to lie on a straight line between the middle month grind in that quarter and in the succeeding quarter.

2) A quarterly multiplier needed to adjust the initial monthly estimates to obtain final estimates is derived.

a) The three initial monthly grind estimates for each quarter are summed.

b) The multiplier is equal to the actual quarterly grind divided by the summed initial monthly estimates for that quarter.

3) The final monthly grind estimates are equal to the product of the corresponding initial monthly grind estimates and the multiplier for that quarter.

4) As a check, the three final monthly estimates for each quarter are summed, and the sum is compared with the actual quarterly grind; the two should be equal.

Table A-3 gives the estimated monthly world grind for the entire period under study.[1]

2.2 Monthly Producer Sales -- As is the case with consumption, there exists no published series on the total cocoa sales of producing nations. On the other hand, Gill and Duffus does publish their estimate of the monthly cumulative sales for each crop year of Brazil, the former British West African nations (Ghana, Nigeria, and Sierra Leone), and the former French West African nations (Ivory Coast, Cameroun, Togo, Gabon, and the French Congo). Together these countries produce roughly three-quarters of the world's cocoa. If the cumulative world sales rate for each crop year can be assumed to follow the same pattern as the aggregated cumulative sales of the major producers, an estimate of monthly world sales can be derived.

Table A-4 gives the cumulative sales of the major producers for each crop year, the estimated world cumulative sales, and the estimated world monthly sales rate. Note that the sales for each crop year begin before the start of the official crop year (October 1), reflecting forward sales made by the producing countries before the harvest period.

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[1]A more refined procedure for estimating monthly grind from the quarterly data would make use of the Chapter 5 regression results describing the determination of the quarterly (and indirectly, monthly) world grinding rate. I have not employed that approach here due to time considerations.

Table A-3: Monthly World Grind

	52-3	53-4	54-5	55-6	56-7	57-8	58-9	59-60	60-1	61-2	62-3
Sep	-	61	54	58	66	71	62	63	73	80	87
Oct	62	66	54	63	76	82	68	74	84	91	96
Nov	64	69	54	66	82	87	71	81	91	98	101
Dec	67	69	56	66	81	86	73	81	90	97	102
Jan	71	70	61	66	80	82	76	79	87	93	102
Feb	73	71	63	67	80	80	79	78	87	92	102
Mar	71	69	62	66	77	76	77	76	85	91	99
Apr	68	66	59	66	73	72	74	73	82	88	96
May	66	64	57	66	70	69	71	70	80	87	93
Jun	64	61	57	65	69	66	68	70	79	86	91
Jul	61	57	55	61	67	62	60	67	76	83	87
Aug	59	54	55	60	66	60	57	67	75	82	84

Table A-4A: Cumulative Sales, Major Countries, By Crop Years

	52-3	53-4	54-5	55-6	56-7	57-8	58-9	59-60	60-1	61-2	62-3
Aug	24	42	15	20	20	16	18	19	15	36	35
Sep	58	71	67	51	59	40	60	48	43	96	131
Oct	110	126	138	118	128	89	118	95	160	167	262
Nov	171	188	202	183	233	206	208	165	285	288	406
Dec	234	260	255	266	309	259	275	266	387	364	514
Jan	307	343	321	344	403	325	358	383	508	483	634
Feb	366	418	382	399	482	371	429	448	579	668	691
Mar	437	457	406	435	540	405	462	586	710	771	703
Apr	474	496	437	485	578	426	503	631	757	789	753
May	525	536	464	517	599	486	548	660	828	811	786
Jun	551	546	509	558	603	498	590	695	878	827	794
Jul	568	559	534	590	614	515	622	752	890	848	846
Aug	586	580	580	628	629	547	638	771	919	866	874
Sep	586	593	597	642	661	559	647	781	923	878	889
Oct	586	593	599	642	688	559	648	781	923	878	889
Nov	586	593	599	642	688	559	683	781	923	878	889
Dec	586	593	599	642	688	559	683	781	923	878	889

Table A-4B: Cumulative Sales, World, By Crop Years

	52-3	53-4	54-5	55-6	56-7	57-8	58-9	59-60	60-1	61-2	62-3
Aug	32	55	20	26	26	22	24	25	19	46	45
Sep	78	93	89	67	77	55	80	64	55	123	170
Oct	148	164	184	154	166	122	156	127	203	214	340
Nov	230	245	269	239	302	283	276	220	362	369	526
Dec	314	339	340	348	401	355	364	354	491	466	666
Jan	412	448	428	450	523	446	474	510	644	618	822
Feb	492	546	509	522	626	509	568	597	735	855	895
Mar	587	596	541	569	701	556	612	780	901	987	911
Apr	637	647	582	635	750	585	666	840	960	1010	976
May	705	700	618	676	777	667	726	879	1050	1038	1019
Jun	740	713	678	730	783	683	782	925	1114	1059	1029
Jul	763	730	711	772	797	707	824	1001	1129	1086	1096
Aug	787	757	773	822	816	751	845	1027	1166	1109	1133
Sep	787	774	795	840	858	767	857	1040	1171	1124	1152
Oct	787	774	798	840	893	767	859	1040	1171	1124	1152
Nov	787	774	798	840	893	767	905	1040	1171	1124	1152
Dec	787	774	798	840	893	767	905	1040	1171	1124	1152

Table A-4C: Monthly World Sales

	52-3	53-4	54-5	55-6	56-7	57-8	58-9	59-60	60-1	61-2	62-3
Sep	46	38	86	63	69	74	72	51	49	82	140
Oct	70	72	95	90	90	102	77	64	148	91	170
Nov	82	81	85	85	136	161	119	140	159	155	187
Dec	85	94	71	109	99	73	89	134	129	97	140
Jan	98	108	88	102	122	91	110	156	154	152	156
Feb	79	98	81	72	103	63	94	87	90	237	74
Mar	95	51	32	47	75	47	44	184	166	132	16
Apr	50	51	41	65	49	29	54	60	60	23	65
May	68	52	36	42	27	82	60	39	90	28	43
Jun	35	13	60	54	5	16	56	47	63	20	10
Jul	23	17	33	42	14	23	42	76	15	27	67
Aug	79	47	87	76	41	68	47	44	83	68	103

2.3 Current Inventory -- Once the initial (September, 1952) end-of-month inventory level is determined, the remainder of the inventory series can be generated by the equation,

$$I_t = I_{t-1} + .99 \; s_t - c_t \tag{A-3}$$

where,

I_t = Current end-of-month inventory

s_t = Monthly world sales

c_t = Monthly world consumption

The sales rate is adjusted for the normal one percent weight loss between the time of sale and the time of consumption.

While there exists no published monthly series for total world inventories, Gill and Duffus (D-2) does publish a series of estimated year-end cocoa stocks in consuming countries. The estimate for December 31, 1952, of 192,000 tons can be used as a base from which to estimate the level of sold but not yet consumed stocks on September 31, 1952. If we assume an average delay of roughly two months between early season sales and the resulting imports into consuming countries, then total imports into consuming countries during the fourth quarter of 1952 would equal total sales during August-October, 1952, or 147,000 tons after adjustment for weight loss. The fourth quarter world grind has already been estimated at 193,000 tons. This yields an estimate of total stocks in consuming countries on September 31

of 238,000 tons (192 + 193 - 147 = 238). In addition,

the inventory level would include the July sales (still in

transit), which generally equal roughly three percent of the

old crop, or in this case 19,000 tons. Thus the initial in-

ventory level is estimated at 257,000 tons (238 + 19 = 257).

3.0 The Expected Inventory Ratio

The expected inventory ratio for a given month refers

to the inventory level expected to exist at the end of the

next September, devided by expected world consumption during

the preceding 12 month period (i.e. October through September).

$$Y_t^* = \frac{I_t^*}{C_t^*} \tag{A-4}$$

where,

Y^* = Expected inventory ratio

I^* = Expected inventory next September

C^* = Expected consumption, current crop year

Again there exist no published monthly series for either the

expected inventory level or the expected consumption rate

over the October-September interval, and I have therefore

had to construct such series. The expected inventory level

next September is simply equal to the estimated normal in-

ventory last September (discussed in detail below) plus ex-

pected producer sales minus expected world grindings over

the October-September interval.

3.1 <u>Expected World Grind</u> -- While no forecasts of world grindings for the October-September interval are regularly issued, Gill and Duffus does issue forecasts of the total calendar year world grind in their monthly reports (D-2). Table A-5 gives the Gill and Duffus calendar year grind forecasts for the months in which they were made, plus my estimates of what the Gill and Duffus forecasts would have been for those months in which no forecasts were made. The "new" forecasting year begins in the September prior to the calendar year being forecast (i.e. the initial forecast of world consumption during calendar 1956 listed in the table was made in September, 1955), and ends the following August. The "old" forecasting year begins in the September of the calendar year being forecast, and runs through the following August. The final row in Table A-5 gives the Gill and Duffus grind estimate on the second August after the end of the calendar year in question (to be used in Chapter 5).

The footnotes to the table indicate which forecasts were either made <u>per se</u> or verbally indicated in the Gill and Duffus reports. All of the other forecasts fall into one of three categories <u>vis a vis</u> the existing Gill and Duffus forecasts, and have been estimated according to the following rules:

Rule 1: The first Gill and Duffus forecast comes in the old year. (This happened in 1952, 1954, and 1955.) Then all forecasts in the <u>old year</u> prior to the first actual forecast are estimated as being equal to that first forecast. This rule is based on the observation that the existing old year forecasts

Table A-5: World Grind Forecasts

	1952	1953	1954	1955	1956	1957	1958	1959	1960	1961	1962	1963
						New Year						
Sep		675B	734B	730B	742+	800B	775B	800+	902B	965B	1107B	1171B
Oct		675B	739B	730B	748	800+	775B	805	892B	962B	1110B	1167B
Nov		675B	741B	730B	754	796	776B	811	889B	976B	1092B	1161B
Dec		675B	751B	730B	760	793*	776B	816	886B	979B	1090*	1164B
Jan		675B	762B	730B	766	820.	776B	822	881B	991B	1090*	1171*
Feb		675+	762B	705B	771+	847*	789B	827*	892B	983B	1085*	1156*
Mar		692	762B	706B	768	858*	793B	834*	896*	987*	1094*	1153*
Apr		706	763B	706B	766*	861.	796B	832.	897*	989*	1103*	1167*
May		720	765B	706B	771*	864	796B	830*	897*	1008*	1098*	1167*
Jun		735	767B	706B	773-	868	796*	839.	897*	1008*	1100*	1168*
Jul		749	767B	706B	775*	871*	798*	848	897*	1008*	1102*	1168*
Aug		764	767B	707B	773-	874*	800*	857*	877*	1014*	1098*	1162*
						Old Year						
Sep	675A	778*	767A	707A	771*	874	815*	847	887*	1022*	1100*	
Oct	675A	783*	767A	707A	766*	874	824.	837*	884*	1025*	1096*	
Nov	675A	785*	767A	707A	769.	875	833	834.	898*	1007*	1090*	
Dec	675A	795*	767*	707	772*	875	842*	831*	901*	1005*	1093*	
Jan	675A	806*	767*	707*	786.	875*	832.	826*	913*	1001*	1100*	
Feb	675*	806*	742*	701*	800*	888*	821*	837*	905*	997*	1092*	
Mar	692*	805*	743*	703-	796*	892.	821*	841*	909*	995*	1093*	
Apr	690*	805.	743-	704*	799-	895*	823-	848*	910*	1004*	1092*	
May	690*	804*	743*	704*	801	895.	824*	848*	914*	1005*	1093*	
Jun	683*	804*	743-	704.	804	895*	824.	848*	914*	1009*	1094*	
Jul	684*	803*	743*	704*	806*	895.	823	848*	913*	1006*	1096*	
Aug	684*	803*	744.	704.	809*	895*	823*	848*	914*	1006*	1094*	
Aug3	706*	803*	727*	717*	804*	900*	841*	858*	915*	1028*		

Blank	Interpolated	A Calculated According to Rule 1
*	Actual Gill and Duffus Forecast	B Calculated According to Rule 2
+	Interpreted from Gill and Duffus Statement	

tend to be fairly stable.

Rule 2: The first Gill and Duffus forecast comes sometime
after September of the new year (e.g. the first
actual forecast of 1962 consumption was made in
December, 1961, at 1,090,000 tons). The dif-
ference between this forecast and the simul-
taneous forecast of old year consumption is
obtained (e.g. in December, 1961, consumption
for 1961 was forecast at 1,005,000 tons; 1962
consumption was forecast to be 1,090 - 1,005 = 85
thousand tons greater than 1961 consumption).
All new year forecasts prior to the first actual
forecast are estimated by adding this difference
to the existing simultaneous old year forecast
(e.g. the October, 1961 actual forecast of 1961
consumption equals 1,025,000 tons; therefore
the October, 1961, estimated forecast of 1962
consumption equals 1,025 + 85 = 1,110 thousand
tons). The rationale behind this rule is that
early season forecasts of calendar year grind
tend to be derived by first estimating the change
relative to the previous year's grind (reflec-
ting population growth, changes in price, etc.),
and then adding this difference to the current
estimate of last year's grind. The rule simply
obtains the first available forecast change in
consumption, and assumes that the change fore-
casts for earlier months were all equal to this
first available value.

Rule 3: There is no Gill and Duffus forecast for a given
month, but there are forecasts in both earlier
and later months. In these cases the estimated
forecasts are linear interpolations between the
existing actual forecasts, based on the obser-
vation that the forecasts tend to change rela-
tively smoothly.

Given the series of new and old calendar year grind
forecasts, I have constructed a series of crop year grind
forecasts (i.e. covering the October-September interval,
as called for in equation A-4) as follows:

$$c_t^* = (f_4^0)(c_t^{*0}) + (f_{1-3,t}^{*n})(c_t^{*n}) \qquad (A-5)$$

$$f_{1-3,t}^{*n} = (w_t)(f_{1-3}^n) + (1 - w_t)(\overline{f}_{1-3}) \qquad (A-6)$$

where,

c^* = Expected consumption, current crop year

c^{*0} = Current estimate of old calendar year consumption.

c^{*n} = Current estimate of new calendar year consumption.

f_4^0 = Actual fraction of old calendar year world grind ground in fourth quarter.

f_{1-3}^{*n} = Expected fraction of new calendar year world grind ground in first three quarters.

f_{1-3}^n = Actual fraction of new calendar year world grind ground in first three quarters.

$\overline{f}_{1-3}$ = Average fraction of calendar year world grind ground in first three quarters

w = Weighting function described in Figure A-2.

That is, the current crop year grind forecast is equal to the estimated fourth quarter grind in the old calendar year (the first term in equation A-5), plus the estimated grind over the first three quarters of the new calendar year (the second term in equation A-5).

The old year fourth quarter grind estimate is derived by multiplying the current old year grind forecast by the actual fraction of old year consumption ground in the fourth quarter. This approach is based on the assumption that the estimated old year fourth quarter grind fraction (for which there is no data) is fairly close to the actual fraction.

The expected grind over the first three quarters of
the new year is equal to the product of the expected three-
quarters fraction and the grind forecast for the entire
year. The expected fraction early in the crop year is
assumed to equal the average fraction. Then as more data
regarding prices and the grind itself becomes available,
the expected fraction is assumed to approach the actual
fraction in a manner determined by the weighting function
used in equation A-6 and shown in Figure A-2. The timing
of the shift in the weighting function is based on the notion
that there exists roughly a five to nine month average delay
in the effect of price changes on consumption, so that by
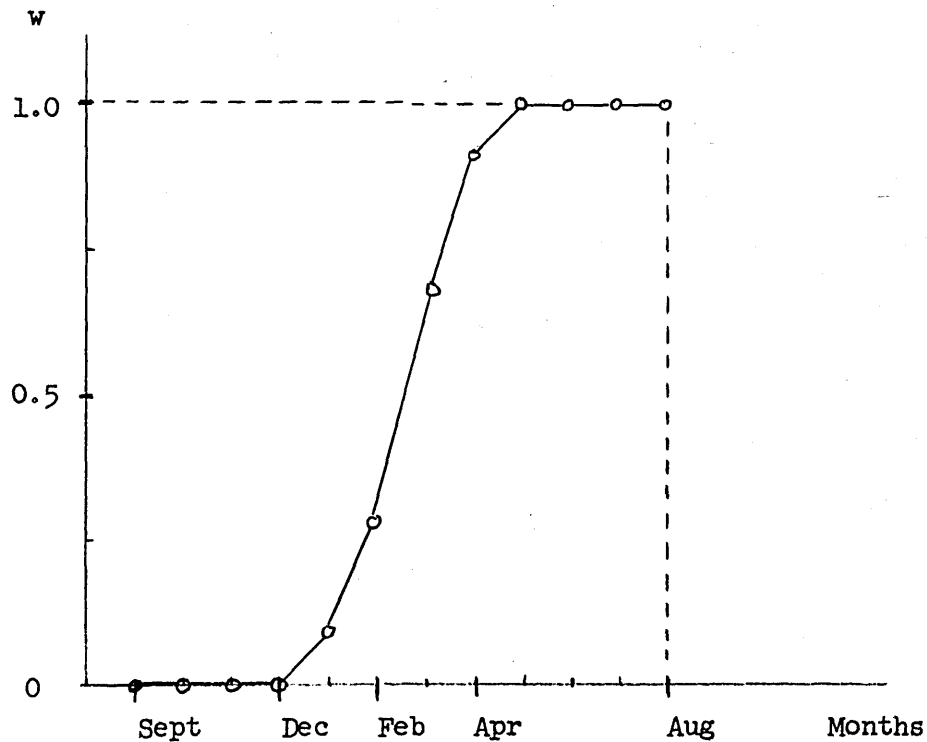
Figure A-2: Weighting Function

May most of the price pattern which will determine calendar year consumption is known, and the estimated grinding pattern over the calendar year therefore should be reasonably accurate.

3.2 Expected Producer Sales -- As is evident from Table A-4, each summer generally sees forward sales of the new crop, so that on the average 9.3 percent of the new crop has already been sold by the official crop year starting date, October 1. Thus the estimated sales level during the current crop year should at least approximately equal 90.7 percent of the current expected crop, plus 9.3 percent of the next year's expected crop. On the other hand, cocoa market participants seem to find it difficult enough to generate reliable estimates of the current crop, without worrying about the size of future crops. If pressed, it is likely that the trade would, on the average, estimate next year's crop as being equal to this year's crop. If this assumption is even approximately correct, then expected sales over the crop year are closely approximated by the current forecast size of the current crop (i.e. 90.7% + 9.3% = 100%).

Gill and Duffus issues forecasts of current crop year production in their monthly reports. Table A-6 lists forecasts of the old and new crops for the period under study. The footnotes identify those forecasts which were

Table A-6: World Crop Forecasts

	51-2	52-3	53-4	54-5	55-6	56-7	57-8	58-9	59-60	60-1	61-2	62-3
New Year												
Sep		785*	782A	779A	790+	835+	857A	830A	898B	990B	1061A	1212A
Oct		788.	756*	769	788	835+	840	822	900*	993B	1101A	1209A
Nov		791*	748*	759	786	844	822	814	906.	996*	1011A	1230*
Dec		791*	730*	749*	784	853*	804	807*	912*	1057*	1025*	1158*
Jan	734*	791*	714*	736*	782*	885.	786*	835.	941*	1109*	1079*	1154*
Feb	-	795*	719*	733*	786*	916*	756*	862*	958*	1166*	1175*	1104*
Mar		794*	721*	737*	798.	929*	753.	862*	1002*	1194*	1209*	1105*
Apr		789*	721	743	810*	925.	750*	868.	1024*	1192*	1172*	1104*
May		784*	720*	750*	813*	920	753	875*	1022*	1171*	1156*	1103*
Jun		786*	740*	756.	820.	915	755*	873.	1025*	1167*	1150*	1119*
Jul		779*	742*	763*	828*	911*	755	871	1012*	1169*	1151*	1126*
Aug		779*	742.	782.	832.	905*	754*	870*	995*	1157*	1138*	1128*
Old Year												
Sep	634	782*	743*	800*	835*	900	756*	872	1002*	1146*	1129*	
Oct	633	784*	743*	805.	835*	895	758.	874*	1005.	1152*	1126*	
Nov	632	783*	742*	810	837.	890	760	881.	1008	1162*	1126*	
Dec	631	782*	752*	815	839*	885	761*	889*	1011*	1158*	1110*	
Jan	630*	782*	752*	819*	839.	879*	760.	889*	1012*	1150*	1110*	
Feb	630*	782*	757*	812*	839*	884*	759*	894*	1017*	1154*	1111*	
Mar	630*	782*	757*	802.	840*	884.	759*	903*	1034*	1153*	1113*	
Apr	630*	782.	757*	792*	840.	885*	759.	903*	1033*	1149*	1122*	
May	630*	782*	757*	794*	840	885.	759*	903*	1033*	1149*	1124*	
Jun	630*	777*	757.	795.	839	885*	759.	903*	1033*	1149*	1122*	
Jul	630*	777*	757*	796*	839*	885.	759	903*	1033*	1149*	1122*	
Aug	630*	777.	757.	796.	839*	885*	759*	903*	1033*	1149*	1124*	

Blank   Interpolated
*   Actual Gill and Duffus Forecast
\+   Interpreted From Gill and Duffus Verbal Statement

A   Calculated According to Rule 1
B   Calculated According to Rule 2

made directly or indirectly by Gill and Duffus. The re-
maining forecasts were generated according to one of the
following rules, pertaining to various specific situations:

Rule 1: A Gill and Duffus forecast of the Ghana main crop
exists, though a world crop forecast has not yet
been made. In such cases I have applied the Gill
and Duffus forecast percentage change in Ghana's
crop to the remaining (unforecast) African crops,
based on the general observation that the African
crops tend to move together. All other crops
are assumed to remain constant, except those for
which Gill and Duffus has also issued an indi-
vidual forecast (typically the Brazilian main
crop). The composite of the Gill and Duffus fore-
casts and derived forecasts of the individual
crops forms the total estimated new crop forecast.

Rule 2: The first Gill and Duffus world new crop produc-
tion forecast has yet to be made, and no indivi-
dual nation forecasts exist. (This happened
only in September, 1959, and September and Octo-
ber of 1960.) For these months the same approach
as was applied in Rule 2 for estimating grind
forecasts has been used, based on the same rationale.

Rule 3: There is no Gill and Duffus forecast for a given
month, but there are forecasts in both earlier
and later months. As in the case of consumption,
these forecast estimates are linear interpolations
between the existing forecasts.

3.3 Expected Inventory -- The expected inventory level
at the end of the crop year is given by the equation,

$$I_t^* = I_t^{nb} + .99 \, S_t^* - C_t^* .\tag{A-7}$$

where,

I^* = Expected inventory, end of current crop year
I^{nb} = Estimated normal inventory, beginning of
current crop year
S^* = Expected producer sales, current crop year
C^* = Expected consumption, current crop year

The derivations of expected sales (adjusted in equation A-7

for one percent weight loss) and expected consumption have just been described. The estimated normal beginning inventory is given by the equations,

$$I_t^{nb} = I_{t-12}^{nb} + .99 \; S_t^{no} - C_t^o \qquad \text{(A-8)}$$

$$S_t^{no} = 0.907 \; O_t^o + 0.093 \; O_t^n \qquad \text{(A-9)}$$

where,

I^{nb} = Estimated normal inventory, beginning of current crop year

I_{t-12}^{nb} = Estimated normal inventory, beginning of old crop year

S^{no} = Estimated normal sales, old crop year

C^o = Actual consumption, old crop year

O^o = Actual world production, old crop year

O^n = Actual world production, new crop year

That is, the normal beginning inventory this year is equal to the normal beginning inventory last year, plus the sales which would normally have been made in the interim (the 0.907 and 0.093 represent the fact that on the average 9.3 percent of each crop is sold during the preceding crop year), minus actual consumption during the interim.

It is necessary to define and employ a "normal" beginning inventory concept as is done above if the expected inventory at the end of the current crop year is to be insulated from unusual sales patterns during the old crop year. For example, an alternative to the above procedure would be to use the actual beginning inventory in equation A-7 on the assumption that the market can make a reasonably close estimate of that inventory level. But in that case

the expected inventory at the end of the crop year following

a cocoa withholding movement (as occurred in 1957) would

have a serious downward bias in that the beginning inventory

would be abnormally low (since a large portion of the

previous crop would still have been held by producers at

the beginning of the crop year).

The use of actual consumption and production data in

deriving the normal beginning inventory level represents

an approximation, based on the assumption that the market's

estimates of consumption during the old crop year and of old

crop production (new crop production enters into the deriva-

tion in only a minor way) are reasonably accurate. Once

the initial normal inventory level (i.e. the normal inven-

tory in September, 1952) is determined, all later values can

be generated by entering the relevant actual crop and con-

sumption data into equations A-8 and A-9. Since there is no

evidence of an abnormal sales pattern having existed in

1952, the initial normal inventory level has been assumed to

be equal to the estimated actual inventory level in September,

1952, of 257,000 tons.

4.0 Some Comments Regarding the Nature of the Data

Perhaps the most controversial aspect of this chapter

is the degree to which and manner in which the data used has

been constructed. While the data construction procedures are

all based on what to me seem to be reasonable assumptions, it
is certainly possible that some of these assumptions are
wrong, in which case the constructed data in question would
not be representative of the true values of the relevant
variables. Under such circumstances regression analysis
cannot provide a very powerful test leading to the rejection
or modification of the theory underlying a particular equa-
tion specification. A poor fit, or implausible coefficients
may reflect unrepresentative data rather than an invalid the-
ory. On the other hand, it is unlikely that unrepresentative
data would by chance yield an acceptable fit and plausible co-
efficients in a regression testing a particular theory. That
is, a regression using constructed data and resulting in a
high F ratio and plausible and significant coefficients (as
is the case in this chapter) does lend confirmation to
the theory being tested.

The fundamental question is whether the construction
of data along the general lines described in earlier sec-
tions of this appendix represents a valid and worthwhile
step in the general statistical theory-testing process. Put
another way, if the most natural theory evolved to answer
a particular question involves variables for which there
exists no (or incomplete) data, then in statistically tes-
ting that theory is it preferable to bend the theory to
match the available data, or is it better to supplement the

data to meet the requirements of the theory? Of course
this is not a black and white issue. The answer in any
specific case depends in large measure on one's confidence
in his own ability to judge the validity of the particular
data construction procedure being employed, which in turn
depends on the degree of his own knowledge of the actual
system being studied.

However it does strike me that much of the existing
econometric literature, especially in the area of commodity
price studies, tends to lean too far in the direction of
tailoring the theory to meet the available data, even to the
point where the theoretical rationale for the specified
equation structure in a regression is often left unclear
(e.g. the FAO cocoa study discussed in Chapter 3). In
some sense it appears less arbitrary to use existing data
to test a generally plausible model which has not been
developed in detail, than to use plausible but partially
constructed data to test a model resulting from a detailed
theoretical discussion. The result is that annual data
may be used where quarterly or monthly data are called for,
and variables suggested by theoretical considerations may
be left out of empirical studies altogether.

This argument for the use of constructed data where
it is called for by theoretical considerations is comple-
mentary to Fisher's "maxim of selective estimation",

"In any given problem, we must use all of the a
priori information at our command to select from
the experiments performed for us by Nature those
which can reasonably be considered controlled."
(emphasis Fisher's)[1]

The difference is one of emphasis. Where Fisher argues

for intelligently weeding out the data to increase the

reliability of estimation, the above paragraphs argue

for intelligently filling in data gaps for the same pur-

pose. In both cases the action taken (weeding out;

filling in) is based on the rational use of a priori

information. In both cases, Fisher's etiquette is

appropriate,

"However those (selection) decisions are made,
the conscious, rational arguments used in making
them must be reported fully and openly so that
other men with other prejudices may evaluate them
also ... anyone can fool himself, but he will
find it somewhat harder to fool his colleagues also."
(emphasis Fisher's)[2]

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[1] 3; p. 6.

[2] 3; p. 15.

List of Data Sources

D-1) <u>Business Statistics</u>, (bi-annual), U.S. Department
of Commerce, Washington

D-2) <u>Cocoa Market Reports</u>, (monthly), Gill and Duffus
Ltd., London

D-3) <u>Cocoa Statistics</u>, (quarterly), FAO, Rome

D-4) <u>Cocoa Statistics</u>, (annual), Gill and Duffus Ltd.,
London

Appendix B

Regression Results for Seasonal Inventory Behavior

Table B-1 gives the regression results for all 12 months corresponding to equation 12 and Table 4-1 in the main body of the chapter. The c_h columns give the constant term for $h = 1$, and the constant term plus the indicator coefficient for $h > 1$.

The d_h and e_h standard errors are only stated once in each column, since they are the same for all horizon times. For the c_h column the first standard error is for the intercept, the second is for all of the indicator coefficients.

The same pattern of loss of statistical significance near the two ends of the intervals as was observed in section 4.1.2 persists. Some of the low valued d_h's (i.e. for large h) also are negative, and thus are implausible (in that they imply that the larger the current inventory ratio is, the smaller will be the expected inventory ratio near the end of the horizon interval). Nevertheless, the undesireable coefficients are small enough to have essentially no effect on subsequent results, and have therefore been kept for the sake of convenience (i.e. to avoid running further regressions).

Table B-1

h	September c_h	d_h	e_h	October c_h	d_h	e_h	November c_h	d_h	e_h
0	0	1.0	0	0	1.0	0	0	1.0	0
1	.069 (.073)	.971 (.122)	.056 (.107)	.055 (.073)	.901 (.117)	.035 (.115)	.029 (.071)	.804 (.127)	.144 (.117)
2	.118 (.104)	.874	.087	.074 (.103)	.730	.168	.092 (.100)	.619	.279
3	.126	.713	.207	.126	.559	.301	.137	.542	.369
4	.171	.562	.320	.171	.509	.373	.167	.271	.649
5	.219	.535	.375	.181	.244	.658	.133	.201	.734
6	.229	.332	.608	.146	.192	.734	.056	.201	.688
7	.189	.279	.682	.066	.182	.695	.014	.045	.874
8	.104	.254	.653	.012	.028	.885	-.017	-.046	1.026
9	.028	.069	.859	-.030	-.080	1.052	-.014	-.054	1.034
10	-.025 (.090)	-.054 (.080)	1.032 (.076)	-.024	-.075	1.050	---	---	---
11	-.025 (.090)	-.054 (.080)	1.032 (.076)	---	---	---	---	---	---
$\sum_{h=0}^{h_t-1}$	1.200	5.479	4.879	0.783	4.189	5.951	0.595	3.583	5.797

Table B-1 (cont.)

h	December c_h	December d_h	December e_h	January c_h	January d_h	January e_h	February c_h	February d_h	February e_h
0	0	1.0	0	0	1.0	0	0	1.0	0
1	.071 (.071)	.790 (.159)	.155 (.137)	.056 (.070)	.847 (.200)	.143 (.163)	.092 (.071)	.610 (.215)	.383 (.179)
2	.115 (.101)	.670	.275	.127 (.100)	.498	.484	.074 (.101)	.541	.471
3	.157	.344	.595	.103	.443	.561	.002	.428	.509
4	.128	.282	.676	.026	.390	.552	-.002	.152	.793
5	.049	.263	.643	.006	.146	.803	-.012	.017	.981
6	.013	.075	.853	-.011	.058	.954	.000	-.131	1.094
7	-.013	-.016	1.006	-.007	-.030	1.018	---	---	---
8	-.010	-.040	1.025	---	---	---	---	---	---
$\sum_{h=0}^{h_t-1}$	0.0578	3.368	5.228	0.305	3.352	4.515	0.160	2.616	4.231

Table B-1 (cont.)

h	March c_h	d_h	e_h	April c_h	d_h	e_h	May c_h	d_h	e_h
0	0	1.0	0	0	1.0	0	0	1.0	0
1	-.015 (.050)	.943 (.161)	.084 (.145)	-.062 (.052)	.843 (.175)	.091 (.163)	-.009 (.054)	.634 (.214)	.382 (.118)
2	-.079 (.071)	.839	.126	-.050 (.074)	.548	.429	-.021 (.077)	.467	.609
3	-.057	.510	.480	-.057	.451	.603	-.008	.093	.919
4	-.057	.379	.679	-.014	.074	.933	---	---	---
5	.010	.035	.967	---	---	---	---	---	---
$\sum_{h=0}^{h_t-1}$	-0.223	3.706	2.336	-0.174	2.914	2.052	-0.038	2.194	1.910

h	June c_h	d_h	e_h	July c_h	d_h	e_h	August c_h	d_h	e_h
0	0	1.0	0	0	1.0	0	0	1.0	0
1	-.016 (.046)	.933 (.243)	.150 (.227)	.000 (.040)	.603 (.190)	.397 (.195)	---	---	---
2	-.009 (.065)	.483	.559	---	---	---	---	---	---
$\sum_{h=0}^{h_t-1}$	-0.025	2.416	0.709	0.000	1.603	0.397	0	1.0	0

Chapter 5

World Cocoa Consumption and Consumption Expectations

5.0 Introduction

In order to complete the model of the price-consump-

tion subsystem, we need to add to the price formulation

derived in the last chapter estimates of the structural

relations which generate monthly world cocoa consumption,

and monthly forecasts of consumption. Section 5.1 deals

with consumption, and Section 5.2 covers consumption expec-

tations; Appendix A discusses the data introduced in the

chapter.

5.1 World Cocoa Consumption

We are interested here in estimating an equation for

monthly world cocoa consumption, suitable for use in simu-

lating the dynamic behavior generated by the price-consump-

tion subsystem. In doing so, we shall have to deal with

two problems:

> 1) Aggregation problem -- World cocoa consumption is the
> summation of the cocoa consumption rates of all of the
> countries in the world. These national consumption
> rates in turn are functions of, among other variables,
> the respective national populations and incomes.
> Some method will have to be devised for statistically
> estimating the relationship between world consump-
> tion and such national population and income data as
> are available and relevant.
>
> 2) Data interval problem -- World cocoa consumption
> data are only available on an annual basis. For the

years since 1953 (later in some cases) the consump-
tion data for the major consuming nations are available
on a quarterly basis. Monthly consumption data is
not generally available for these nations, much less
for the world. Some method will have to be devised for
estimating the price, income, and population effects
on monthly consumption, given these data limitations.

5.1.1 <u>Indirect Estimation Approach</u> -- Tackling the

aggregation problem first, we can write the identity,

$$C_t = c_t^M / F_t \tag{1}$$

based on the definition,

$$F_t = c_t^M / C_t \tag{2}$$

where,

C = World cocoa consumption

c^M = Aggregate cocoa consumption, major consuming nations

F = Major nations' share of world consumption

The eight leading consuming nations for which quarterly

grind data is available are, in order of their 1963 grinds:

the United States, the German Federal Republic, the Nether-

lands, the United Kingdom, France, Italy, Japan, and Spain.

Their share of world consumption, approximately 65 percent

in 1963, might be hypothesized to be roughly constant,

or a trend-like function of time. We could then get at an

estimated relationship for world consumption by estimating

the equation for the eight nation aggregate grind. We can

write the further identity,

$$c_t^M = (Q_t^M)(N_t^M) \tag{3}$$

where,

c^M = Aggregate cocoa consumption, major consuming nations

Q^M = Aggregate per capita cocoa consumption, major consuming nations

N^M = Aggregate population, major consuming nations,

leaving us with the equation to be estimated,

$$Q_t^M = f\left(P_t^L \mid Y_t^M, S_t^L, t\right) \tag{4}$$

where,

P^L = Lagged cocoa prices

Y^M = Aggregate per capita income, major consuming nations

S^L = Lagged sugar prices

t = Time

The partition in equation 4 separates the endogenous (cocoa price) variables from the exogenous variables. The rationale for including lagged cocoa prices and per capita income as explanatory variables is straightforward. Sugar prices are included because sugar is at the same time the most important complement and the most important substitute for cocoa. The question as to whether these two roles largely cancel out one another will be answered in terms of the statistical results. Finally, time is included as an independent variable in equation 4 in order to represent trends in tastes. Equations 1 through 4 represent an indirect approach toward estimating the world cocoa consumption

function in that they first generate the major nations' per capita consumption rate, and then combine this rate with the major nations' aggregate population and an estimate of their share of world consumption in order to generate an estimate of world consumption.

Now there remains the data interval problem. We have monthly data for cocoa and sugar prices, but we only have quarterly data for aggregate per capita cocoa consumption and income. Yet we want to estimate the distributed lag shape(s) in the cocoa and sugar price effects on _monthly_ consumption. This turns out not to present such a difficult problem. Trade lore, as supported by Figure 2-2, has it that world consumption is a function of a distributed lagged version of the cocoa price, with an average lag time of about seven months. There are two reasons for the existence of such a lag. First, chocolate manufacturers tend to base their current finished chocolate prices on the cost of the cocoa beans which they have recently processed (i.e. they tend to use a FIFO costing procedure). Since the manufacturers generally carry cocoa bean coverage ranging from three to nine months, their current costs reflect prices lagged from three to nine months. Second, once chocolate prices change, there is a further lag in the adjustment in chocolate consumption. Ignoring sugar prices for the moment, equation 4 can be written for a _monthly_ time interval, using a logarithmic

format,[1]

$$\ln q_t^M = k + d_1 \sum_{i=1}^{n} g_i P_{t-i} + d_2 y_t^M + d_3 t \tag{5}$$

where,

$$\sum_{i=1}^{n} g_i = 1 \tag{6}$$

and where,

q^M = Aggregate monthly per capita cocoa consumption

y^M = Aggregate monthly per capita real income

P = Monthly average real cocoa price

t = Time, in months

Then, making use of linear approximations,[2] it can be shown

that the equation for _quarterly_ consumption takes the form,

---

[1]The use of current per capita income in this specification represents a first approximation of the income effect on consumption. It is likely that some lagged version of income, or perhaps a variable embodying the "permanent income" concept, would be more appropriate. .

[2]See Appendix B for a discussion of the relationship between equations 5 and 7.

$$\ln Q_T^M = a + b_1 \sum_{i=1}^{n+2} c_i \, P_{3T+1-i} + b_2 \, Y_T^M + b_3 \, T \qquad (7)$$

where,

$$a \quad = \quad k + \ln 3 \qquad\qquad (8a)$$

$$c_1 \quad = \quad g_1/3$$

$$c_2 \quad = \quad (g_1 + g_2)/3$$

$$\vdots$$

$$c_i \quad = \quad (g_{i-2} + g_{i-1} + g_i)/3 \qquad\qquad (8b)$$

$$\vdots$$

$$c_{n+1} \quad = \quad (g_{n-1} + g_n)/3$$

$$c_{n+2} \quad = \quad g_n/3$$

$$b_1 \quad = \quad d_1 \qquad\qquad (8c)$$

$$b_2 \quad = \quad d_2 \qquad\qquad (8d)$$

$$b_3 \quad = \quad 3 \, d_3 \qquad\qquad (8e)$$

and where,

Q^M = Aggregate quarterly per capita cocoa consumption

Y^M = Aggregate quarterly per capita real income

P = Monthly average real cocoa price

T = Time, in quarters

If we can estimate the lag coefficients (i.e. the c's) in equation 7, then we can use equation set 8 to derive the lag coefficients (the g's) in the monthly consumption function, equation 5. Figure 5-1 indicates two different lag structures for the monthly relation, along with the corresponding

FIGURE 5-1 PLAUSIBLE PRICE LAG DISTRIBUTION SHAPES

lag structures for the quarterly equation,[1] which would be
plausible on an a priori basis. It is evident that if we
wish to use regression to estimate the lag structure in the
quarterly equation, we will have to include seven or more
lagged cocoa prices as independent variables, along with the
income and time variables. Moreover it is reasonable to
assume that any effect which sugar prices have on cocoa
consumption involves a lag similar in length and shape to the
cocoa price lag, so that the measuring of sugar price effects
entails the inclusion of an additional set of seven or more
lagged sugar prices. At this point we begin to run short
of degrees of freedom, since we have available only 32
observations on aggregate quarterly per capita cocoa con-
sumption.[2]

One alternative open to us is to specify one or more
lag shapes (e.g. the lag distributions shown in Figure 5-1),
and then to run a series of regressions using the specified
lag shapes with various average lag times (obtained by
shifting the lag distributions along the lag time axis) to
determine which shape and which average lag time explains the
largest amount of the variance in cocoa consumption. Such a

---

[1] The lag distributions for quarterly consumption are derived
from the monthly distributions by summing the lagged price
effects on the three separate monthly consumptions in each
quarter, and adjusting the new lag coefficients so that their
sum equals one. The quarterly distribution lag times refer
to the lag between the price and the middle month of each quarter.

[2] The national quarterly grind figures were given in Table A-1
in Appendix A of Chapter 4. The German and Spanish grind fi-
gures are only available starting with the first quarter of 1956.

procedure will limit even more than usual the usefulness

of conventional hypothesis testing procedures.

5.1.2 Initial Statistical Results -- Running various

regressions using the general format of equation 7 yields

several interesting and useful results:

(a) Cocoa Price Lag Distribution -- Table 5-1

indicates the coefficients of determination (R^2) yielded

by a series of regressions using the specific equation 7

format incorporating both of the lag distributions given

in Figure 5-1 (i.e. the quarterly formats), with each dis-

tribution tested for several average lag times.[1] The

evidence is not dramatic, but a mild preference is indicated

for the wide distribution with an average lag time of seven

months.[2] This specified lag structure includes past prices

with lags ranging from four months to 10 months (see Figure

5-1). The variance left unexplained by pre-specifying the

lag weights can be determined by rerunning the regression

including these lagged prices as separate variables, and

allowing the regression to specify the lag weights (we are

not including sugar prices yet, so that we have a sufficient

number of degrees of freedom for this). The resulting R^2

---

[1]See Appendix C for the detailed regression results.

[2]It should be emphasized that this represents a fairly crude
attempt to identify the specific lag shape and the average
lag time. It could well be that the actual lag differs in
shape, and may even have a variable lag time.

Table 5-1:   Coefficients of Determination

Average lag (months)	5	6	7	8	9
Narrow distribution	.8900	.8972	.8973	.8914	.8756
Wide distribution	.8900	.9006	.9011	.8929	.8781

Table 5-2:   Lag Coefficients

Lag Time (months)	4	5	6	7	8	9	10
Pre-specified coefficient	.042	.117	.217	.250	.217	.117	.042
Regression estimated coefficient	-.524	.945	.368	-.336	.215	.318	.014

Table 5-3:   Serial Correlation Coefficients among Lagged Prices

Order of Coefficient, i	1	2	3	4	5	6
Coefficient	.96	.90	.88	.83	.77	.73

equals .9270, versus .9011 using the pre-specified lag

shape. Table 5-2 compares the regression estimated lag

weights with the pre-specified weights. The implausible

variations in the regression estimates (which include some

negative weights) reflect the high degree of colinearity

among the lagged prices, indicated in Table 5-3.

(b) Sugar Price Coefficient -- Determining the

effect of sugar prices on the aggregate major nations'

cocoa consumption presents a basic data problem in that

sugar is subject to several different control programs

in the eight countries in question. The result is that

while there exists a world market for sugar, much of the

sugar which complements or competes with cocoa beans in the

major cocoa consuming nations is not priced in that market.

The gathering of separate monthly sugar price series for

each of the eight countries represents a task difficult

enough to be avoided unless the need for such series is

clearly indicated. Such a clear indication does not exist

on a priori qualitative grounds, since the trade and/or the

literature do not seem to be clear on whether sugar's more

important role vis-a-vis cocoa is that of a substitute or

that of a complement.

Two sugar price series which are relatively easily

obtained (and which are given in Appendix A for the 1952-63

data interval) are the monthly average series for spot raw

sugar in the United States and in the world market (i.e.

the market for world sugars conducted by the New York

Coffee and Sugar Exchange). When these series are deflated

via the BLS Wholesale Commodity Price Index, lagged using

the wide distribution, and included as extra explanatory

terms in equation 7 either together or individually, their

regression coefficients are in all cases statistically

insignificant at the 25 percent level.[1] The inclusion of

both of the sugar terms together lifts the regression R^2

from .9011 to .9056, hardly an important improvement.[2]

(c) Time and Income Coefficients -- Not only do sugar

prices not seem to have an important effect on aggregate

per capita consumption in the major consuming nations, but

within the framework of equation 7, the same holds true

for both aggregate per capita real income and time. Whether

these variables are included separately or individually,

their regression coefficients are statistically insignificant

at well above the 25 percent level.[3] The regression results,

---

[1]See Appendix C.

[2]It should be stressed here that the raw sugar price series
used in the regressions are at best loosely representative
of the refined sugar price series for the various nations
included in the aggregate.

[3]As is indicated in Appendix A, the aggregate per capita
income variable used in the regressions is actually the
aggregate of the eight countries' national consumption
expenditures (in the national income sense) converted to
dollars using IMF exchange rate data, deflated using the BLS

when both income and time are included as explanatory

variables along with lagged price (wide lag distribution,

seven month average lag), are,

$$\ln Q_T^M = -1.038 - .109\ I_2 - .183\ I_3 + .007\ I_4$$
$$\qquad (.340)\quad (.023)\qquad (.023)\qquad (.025)$$

$$-.0113 \sum c_i\ P_{3T+1-i} + 1.036\ Y_T^M - .00144\ T + e_T \qquad (9)$$
$$(.0015) \qquad\qquad\qquad (1.731)\qquad (.00400)$$

where,

Q^M = Aggregate quarterly per capita cocoa consumption (tons/thousand)

Y^M = Aggregate quarterly per capita national consumption expenditures ($ thousand/person)

P = Monthly average real spot price of Accra in New York

T = Time in quarters (1956 first quarter = 13)

I_i = Quarterly indicators (I_i = 1 in i th quarter)

The low statistical significance of time and income when

both are included can in part be attributed to problems of

colinearity, as the time-income correlation coefficient is 0.968.

But this does not erase the fact that the time and income

coefficients remain insignificant at the 25 percent level

3,cont. Wholesale Commodity Price Index, and divided by the aggregated populations. Quarterly national consumption expenditure data is more readily available than is quarterly national income data. If anything, the use of consumption expenditure data should increase the magnitude of the coefficient on the income variable in equation 7, since consumption expenditures tend to be somewhat income inelastic.

even when they are included individually in the regression.[1]

The income regression coefficient in equation 9 indicates
an average income elasticity for per capita bean consumption
of .254,[2] which is in line with estimates made by the FAO
Cocoa Study Group.[3] The time coefficient indicates a
negative trend in the influence of tastes and other time
related factors, perhaps reflecting a gradual increase in
the use of cocoa butter substitutes during the period in
question.

(d) Price Coefficient -- At the average postwar real
price of 35.2 cents per pound, the price coefficient in
equation 9 indicates a price elasticity for aggregate per
capita consumption of -0.407,[4] which again is consistent

---

[1] See Appendix C.

[2] Given the format,
$$\ln Q = a + b\ Y$$
the elasticity of Q with respect to Y is given by,
$$E = \frac{dQ}{dY} \cdot \frac{Y}{Q} = b\ Y$$
The average value for Y in equation 9 for the 1956-63 in-
terval is 0.245, giving the average elasticity estimate,
$$\bar{E}_Y = (1.036)\ (.245) = .254$$

[3] See Reference 1, p. 39. Examples of the income elastici-
ties estimated by the FAO are:

EEC	0.3	U.S.	0.1
Mediterranean Countries	0.5	Canada	0.1
U.K.	0.0	Japan	0.7

[4] Referring to the earlier footnote on the elasticity cal-
culation,
$$\bar{E}_P = (-.0113)\ (35.2) = -0.407$$

with earlier FAO findings.[1]

    5.1.3 Direct Estimation Approach -- These statistical results suggest the possibility of a more direct approach toward obtaining an estimate of the world cocoa consumption function useful for studying the dynamic characteristics of the price-consumption subsystem.

    Our primary interest in this section is to accurately describe the (endogenous) cocoa price effect on consumption, since this is the part of the consumption equation which plays a role in determining the subsystem's dynamic characteristics. In addition, we would like to have estimates of the ways in which various factors other than cocoa prices (e.g. populations, incomes, sugar prices) influence cocoa consumption in order to have available reasonable representations of the exogenous consumption influences on the price-consumption subsystem. The above statistical results relating to per capita cocoa consumption in the major consuming nations indicate that: (a) sugar prices do not seem to play an important role in determining consumption; (b) the influence of aggregate per capita income is also

[1]See Reference 2, p. 12. The FAO estimates of the cocoa bean price elasticities of demand in various countries are:

U.S.	- .35	U.K.	- .27
Belgium	- .26	Austria	- .35
France	- .35	Denmark	- .49
Netherlands	- .41	Germany	- .49
		Sweden	- .35

not clearly important, and in any case, aggregate income
(or more accurately, aggregate per capita national consump-
tion expenditures) over the 1956-63 period can be approxi-
mately represented by an exponential time trend.

These conclusions, coupled with the fact that the
eight nations' aggregate population is itself approximately
an exponential time trend, point toward the representation
of all of the exogenous influences (i.e. all but the cocoa
price influence) on aggregate cocoa consumption as a single
trend-like function of time, at least for the 1956-63
interval. And if such a representation is valid for the
major consuming nations, there is no reason to believe that
it would not be valid for the world as a whole, thereby
allowing us to skirt the aggregation problem. There are
two further reasons why representing the exogenous factors
via a time trend represents an attractive prospect. First,
what we are after here is an estimate of the world cocoa
consumption function useful in simulating the cocoa price-
consumption dynamics. The generation of such simulations
will be simplified if the exogenous consumption influences
can be represented by a single time related variable. Second,
as is brought out and emphasized in Appendix A, the available
data on the exogenous influences on aggregate consumption
leave a good deal to be desired.

Thus the direct estimation of quarterly world consumption

as a function of lagged cocoa prices (keeping the wide

distribution) and of time suggests itself. The specific

format to be estimated is adapted from equation 7,

$$\ln C_T = a + b_1 P_T^L + b_2 T \tag{10}$$

where,

C = Quarterly world consumption (thousands of tons/quarter)

P^L = Monthly average real spot Accra in New York, lagged via the quarterly form of the wide distribution (see Figure 5-1)

T = Time in quarters (1953 first quarter = 1)

We can establish rough plausibility notions for b_1

and b_2 as follows. Using the earlier footnotes regarding

the computation of price elasticity at the average postwar

real price level of 35.2 cents per pound, we have,

$$E_p = 35.2 \, b_1$$

where,

E_p = Price elasticity of cocoa consumption

Then the FAO range of elasticity estimates (footnoted

earlier) gives an estimated plausibility region for b_1,

High $b_1 = \dfrac{.50}{35.2} = .0142$

Low $b_1 = \dfrac{.25}{35.2} = .0071$ \tag{12}

Regarding b_2, which is the exogenous quarterly consumption growth

rate, we know that the major nations' aggregate population

grew at a rate of 1.19 percent per annum, or 0.30 percent

per quarter, over the 1956-63 period (see Appendix A).

In addition we also know that the aggregate per capita income of these nations over the same period grew at a rate of about 0.90 percent per quarter (see Appendix A), which, given an income elasticity of about .20 based on the FAO estimates, gives a consumption growth rate due to income growth of 0.18 percent per quarter. The combined population and income growth rates yield the estimate of b_2,

$$b_2 = .0030 + .0018 = .0048 \tag{13}$$

Against this we must keep in mind the apparent downward trend in the desire for cocoa in the major consuming nations, and the known upward trend in cocoa demand in the developing countries and especially in the U.S.S.R. We might thus define the plausibility region for b_2 as ranging from about .0020 to about .0070.

5.1.4 Regression Results Using the Direct Approach --

The results from regressing equation 10, using data for the 1953-63 interval,[1] are, (14)

$$\ln C_T = 5.587 - .109\ I_2 - .186\ I_3 - .019\ I_4 - .00720\ P_T^L + .00617\ T + e_T$$
$$(0.045)\ (.021)\quad (.021)\quad (.021)\quad (.00084)\quad (.00077)$$
$$R^2 = .93 \quad F(5,38) = 97 \quad d = 1.58$$

where,

I_i = Quarterly indicator variables ($I_i = 1$ in the i th quarter)

[1] Table A-1 in Appendix A of Chapter 4 gives the quarterly world consumption data.

The F ratio and all of the coefficients except that of I_4

are significant at the one percent level. The low coef-

ficient on I_4 simply indicates that in the normal seasonal

pattern, fourth quarter consumption is almost equal to

first quarter consumption.

The price and time coefficients in equation 14 are

near the lower and upper ends of their plausibility regions,

respectively.[1] This may be symptomatic of problems of

colinearity, since the price-time correlation coefficient

for the 1953-63 data interval equals - 0.65. On the other

hand, the parameter plausibility regions are based largely

on information regarding the major cocoa consuming nations.

It may be that in the rest of the world the price elasticity

of consumption has been lower and the growth in demand has

been higher than has been the case in the major nations.

In fact there is considerable statistical evidence that

this is the case -- enough evidence to justify accepting

the above coefficients. For example, with the dramatic

1953-54 price increase world cocoa consumption fell 8.5

percent (from 1953 to 1954) while consumption in the U.S.S.R.

and Eastern Europe rose 3.3 percent.[2] The corresponding

figures for the 1957-58 bull market are - 7.7 percent for

the world, and + 12.0 percent for Russia and Eastern Europe.

[1]The estimated price elasticity is (-.0072) (35.2) = -.252;
the estimated annual exogenous growth rate in demand is
(4) (.0062) (100) = 2.48 percent per annum.

[2]Reference 3.

Over the total 1953-63 interval, while world consumption was only increasing 43 percent, consumption in the U.S.S.R. and Eastern Europe rose 287 percent. This general pattern was repeated in other areas outside of the major cocoa consuming nations.[1]

Equation 14 gives the estimated structure generating quarterly consumption. The relationships linking equations 5,7, and 8 indicate the further steps needed to derive the monthly cocoa consumption function,

$$\ln c_t = k_i - .00720 \ P_t^L + .00206 \ t + e_t \qquad (15)$$

$$P_t^L = \sum_i g_i \ P_{t-i} \qquad (16)$$

where,

c   =   Monthly world cocoa consumption (thousands of tons/month)

P   =   Monthly average real spot Accra in New York

P^L =   P, lagged via the monthly form of the wide distribution

t   =   Time, in months (February, 1953 = 1)

---

[1] It should be noted here that because of the apparent differences in the price elasticity and growth rate of world consumption and of aggregate major nations' consumption, the method used to construct quarterly world consumption data (see section 1.0 of Appendix A of Chapter 4) involves some distortion. The assumption made was that the quarterly world consumption pattern within each year in the data interval was the same as the quarterly consumption pattern of the aggregated major nations. Since world consumption has grown faster than has the major nations' consumption, this procedure results in an over-statement of world consumption in the first and second quarters of each year, and an understatement of world consumption in the third and fourth quarters. Also, the quarter-to-quarter consumption changes within each year (but not the year-to-year changes) reflect the price elasticity of the aggregated major nations, not of the world.

and where the g_i are the lag coefficients of the wide

distribution monthly format given in Figure 5-1, and the k_i

are monthly seasonal constants given in column 2 of Table 5-4.

These monthly constants have been derived from the quarterly

constants given in equation 14 by first computing the average

monthly constant for each quarter (see equation 8a), and

then estimating the monthly seasonal variation via the

procedure described in Section 2.1 of Appendix A of Chapter 4.

The Durbin-Watson statistic for equation 14 indicates

that the independence hypothesis can be rejected at the one

percent level.[1] Figure 5-2a shows the actual and estimated

quarterly consumption rates, where the estimated rate is

converted from the log estimates given by equation 14. It

can be seen that for roughly the first and last three

years the estimated consumption rate is somewhat low,

while for the middle five years it tends to be high. This

pattern accounts for such serial correlation in the resi-

duals as is indicated by the d statistic.

Actually, there is no strong reason for believing that

the time trend in the exogenous influences on consumption

must follow a purely linear (i.e. linear in logs) exponential

growth pattern. In fact, the pattern of the error term in

Figure 5-2a points toward a slightly non-linear exponential

---

[1] The one percent significance point for 44 observations and
six coefficients is given in Reference 4, and equals 1.58.

Table 5-4

Monthly Seasonal Consumption Constants[1]

(1)	(2)	(3)
Month	Linear Exponential Growth Format	t^2 Exponential Growth Format
January	4.496	4.531
February	4.502	4.537
March	4.466	4.501
April	4.412	4.448
May	4.376	4.412
June	4.350	4.386
July	4.301	4.337
August	4.275	4.311
September	4.331	4.367
October	4.430	4.467
November	4.486	4.522
December	4.492	4.528

---

[1]The seasonally adjusted monthly consumption series shown in Figure 2-2 was generated by dividing the monthly consumption series derived in Appendix A of Chapter 4 by the seasonal coefficients,

$$a_i = (e^{k_i}) / (\sum_{i=1}^{12} e^{k_i})$$

where the k_i are those given in column 2.

Figure 5-2a — Estimated Consumption / Actual Consumption

Figure 5-2b — Estimated Consumption / Actual Consumption
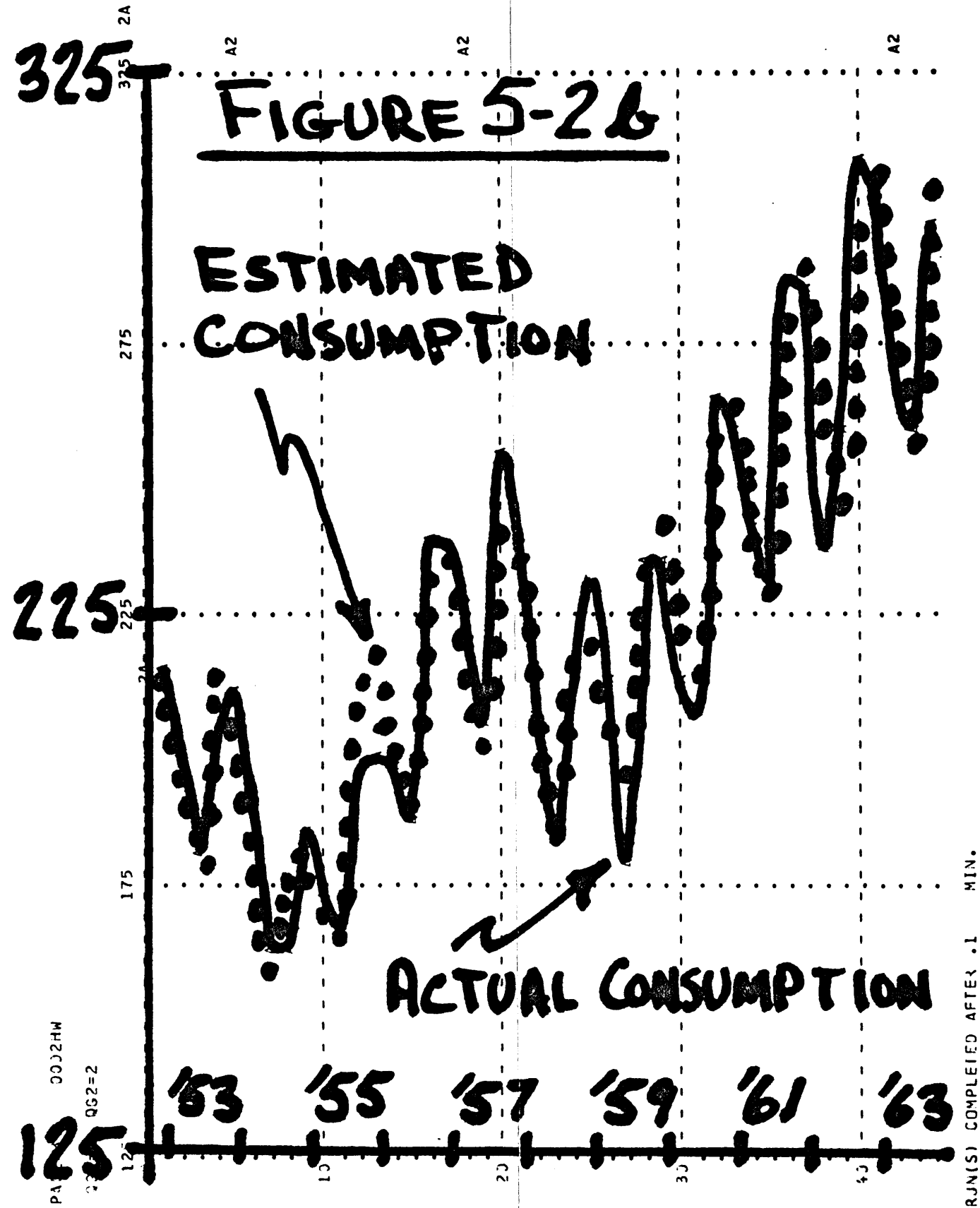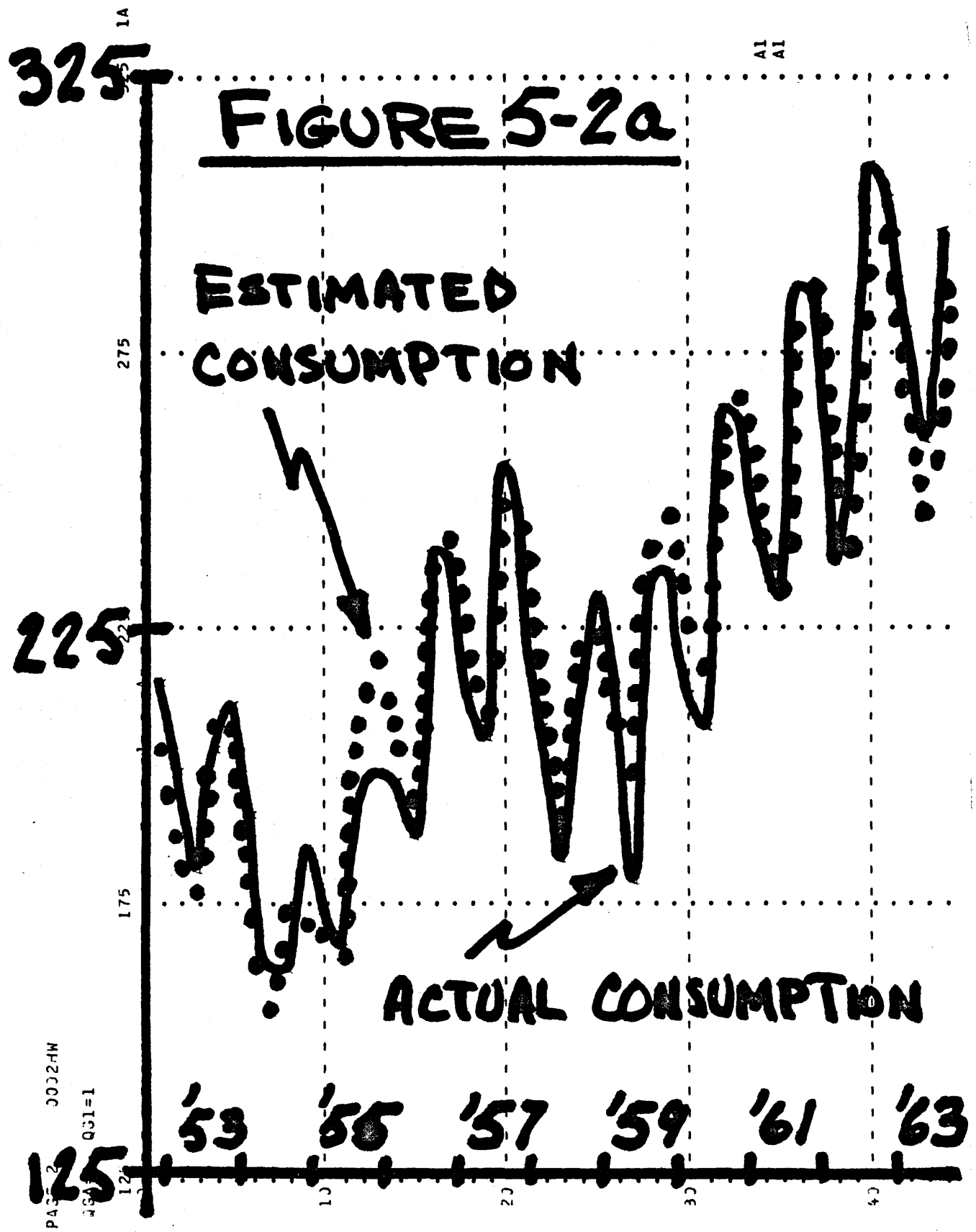
growth form having a higher degree of curvature than that of

linear exponential growth. We can estimate such a form by

adding a T^2 term to the independent variables used in equa-

tion 14. The new regression results are,

$$\ln C_T = 5.587 - .108\ I_2 - .185\ I_3 - .018\ I_4 - .00667\ P_T^L$$
$$(0.039)\quad (.018)\qquad (.018)\qquad (.018)\qquad (.00072)$$

$$- .00155\ T + .000178\ T^2 + e_T \qquad\qquad (17)$$
$$(.00201)\qquad (.000044)$$

$$R^2 = .95 \qquad\qquad F\ (6,37) = 116 \qquad d = 2.16$$

The inclusion of the T^2 term: (a) has little effect on

the estimated seasonality pattern or on the price coefficient;

(b) causes the linear time coefficient to become statistically

insignificant; (c) increases the R^2 slightly from .93 to

.95; and (d) moves the Durbin-Watson statistic into the

region where the hypothesis of no significant serial cor-

relation in the disturbances cannot be rejected. Figure 5-2b

shows the new quarterly consumption estimates along with the

actual data. A further indication of the degree to which

equation 17 explains actual world consumption over the 1953-63

period is given by Table 5-5, which compares the annual

world consumption estimates generated by equation 17 with the

corresponding actual series (which is the base data series

used in generating the quarterly world consumption series, as

described in Section 2.1 of Appendix A of Chapter 4).

Table 5-5: Actual vs. Estimated Annual World Consumption

Year	C	$\hat{C}$	Percent Error	Year	C	$\hat{C}$	Percent Error
1953	798	804	+ 0.8	1959	861	851	- 1.2
1954	731	728	- 0.4	1960	916	931	+ 1.6
1955	719	714	- 0.7	1961	1017	1011	- 0.6
1956	821	834	+ 1.6	1962	1088	1087	- 0.1
1957	908	886	- 2.4	1963	1138	1143	+ 0.4
1958	840	843	+ 0.4				

The monthly version of equation 17 is given by,

$$\ln C_t = k_i - .00667 \, P_t^L - .00052 \, t + .000020 \, t^2 + e_t \quad (18)$$

where the k_i are given in column 3 of Table 5-4.

It seems clear from the above results that the non-linear growth format provides a somewhat better portrayal of the actual trend in the exogenous influences on cocoa demand over the 1953-63 interval than does the linear exponential growth format. It does so primarily because it more accurately represents the 1953-1954 consumption bulge associated with decontrol in the U.K., as well as the accelerating growth in cocoa demand in the iron curtain countries and in the less developed countries in general. On the other hand, the continuously increasing rate of exponential growth in demand generated by the non-linear format would imply a somewhat questionable assumption in a study of cocoa market dynamics covering several decades. We will have occasion to make use of both growth representations (i.e. both equation 15 and equation 18) in the dynamic simulations to be run in the next chapter.

5.2 Consumption Expectations

In discussing consumption forecasts, it is common for members of the cocoa trade to refer to the implied percentage or fraction change in consumption as a basis on which to judge the plausibility of the forecasts. That is,

expected consumption in the new calendar year is forecast

as being some fraction above or below the current estimate

of old calendar year consumption.[1]

$$C_t^{*n} = (1 + G_t^{*n}) \; C_t^{*o} \qquad\qquad (19)$$

where,

C^{*n} = Estimated world consumption, new calendar year

C^{*o} = Estimated world consumption, old calendar year

G^{*n} = Estimated fraction growth in new consumption

Similarly, the old year consumption estimate is based on

estimated consumption in the preceding year (which we shall

call the old, old calendar year).

$$C_t^{*o} = (1 + G_t^{*o}) \; C_t^{*oo} \qquad\qquad (20)$$

where,

C^{*o} = Estimated world consumption, old calendar year

C^{*oo} = Estimated world consumption, old, old calendar year

G^{*o} = Estimated fraction growth in old consumption

Our objective in this section is to estimate the way in

which cocoa market participants arrive at their fraction change

forecasts for new and old year consumption. Using equations 19

---

[1]As discussed in the last chapter, the designation of "new"
and "old" for purposes of defining expectations shifts just
before the beginning of each crop year. From September through
December, the new calendar year is the coming year, and the
old calendar year is the current year. From January through
August, the new calendar year is the current year, and the
old calendar year is the previous year.

and 20, estimates of these mechanisms can then be combined with estimates of old, old year consumption (which estimates will generally be close to actual old, old year consumption) to arrive at the corresponding forecasts of consumption itself.

5.2.1 Model for Fraction Change Estimates -- In the absence of observed structural changes in demand (e.g. the development of an effective cocoa substitute, or governmental control or decontrol of consumption in an important consuming area), three main variables are used by the cocoa trade in deriving their fraction change estimates, G^{*n} and G^{*o}: (a) the estimated long term consumption trend; (b) recent price levels compared to prices existing a year earlier; and (c) the annual fraction change exhibited in recent grindings. The weight placed on these three variables (or estimates thereof) in arriving at the consumption forecast for a given calendar year is likely to shift as more and more information pertaining to that year becomes available. Using Muth's rational expectations hypothesis, we would expect the cocoa trade to form their initial consumption forecasts for a given year (before any relevant actual grind data is available) as if they believed consumption to be generated, at least approximately, by the structure described in (say) equation 15. That is, they would expect new year consumption to be some constant growth fraction greater than old year consumption, plus or minus an adjustment fraction reflecting cocoa price changes.

Using the wide price lag distribution shown in
Figure 5-1 and employed in equation 15, the total period of
prices affecting new calendar year consumption runs from
April of the old calendar year through July of the new calen-
dar year, or a total of 16 months (all of which do not
receive equal weight in the annual lag distribution). In
September, when the first new year forecast is made, only
five of these 16 monthly average prices are available.
It therefore seems reasonable to expect a relatively heavy
weight to be placed on the estimated long term trend in
arriving at the early new year consumption forecasts, with
a correspondingly light weight placed on the available
relevant price change data. That is, in equation form,

$$G_t^{*n} = d_{1,i}\ \overline{G}^* + (1-d_{1,i})\ (\overline{G}^*+E^*\ P_t^A) \tag{21}$$

or,

$$G_t^{*n} = \overline{G}^* + (1-d_{1,i})\ E^*\ P_t^A \tag{22}$$

where,

G^{*n} = Estimated fraction growth in new consumption

$\overline{G}^*$ = Estimated long run fraction growth trend

d_1 = A weighting function

E^* = Estimated price elasticity of consumption

P^A = Relevant fraction change in price

and where d_1 probably starts out close to 1.0 in September,
and then gradually declines as more price information
becomes available.

The relevant fraction change in price is the fraction

difference between the average price relevant to new year

consumption and the average price for the corresponding old

year period. In turn, the average price relevant to new

year consumption is the average real price level over the

period running from last April (the first month relevant

to new year consumption) to the most recent month for

which the average price is known. In equation form,

$$P_t^A = \frac{\sum_{i=April(1)}^{t-1} P_i - \sum_{i=April(2)}^{t-13} P_i}{\sum_{i=April(2)}^{t-13} P_i} \tag{23}$$

where,

April(1) = Preceding April

April(2) = Two April's ago

With the passing of each month, an additional month is

added to the averaging process in equation 23 until July

(the last month relevant to the new calendar year) is

included, after which P^A remains constant.

As the new calendar year is entered there gradually

becomes available data relating to the actual new year

consumption rate being forecast. Beginning roughly in

May of the new year, when the first quarter grind statis-

tics for the major consuming nations are known, the market

begins to modify its fraction consumption change forecast given by equation 22 by averaging this forecast with the available data for the actual new year fraction consumption change to date. The new equation takes the form,

$$G_t^{*n,o} = d_{2,i} \left[\overline{G}^* + (1-d_{1,i}) \, E^* \, P_t^A \right] + (1-d_{2,i}) \, c_t^A \qquad (24)$$

or,

$$G_t^{*n,o} = a_i + b_i \, P_t^A + (1-d_{2,i}) \, c_t^A \qquad (25)$$

where,

$$a_i = d_{2,i} \, \overline{G}^* \qquad (26a)$$

$$b_i = d_{2,i} \, (1-d_{1,i}) \, E^* \qquad (26b)$$

and where,

$G^{*n,o}$ = Estimated fraction growth in new and old consumption

$\overline{G}^*$ = Estimated long run fraction growth trend

d_2 = A weighting function

E^* = Estimated price elasticity of consumption

P^A = Relevant fraction change in price

c^A = Relevant fraction change in actual consumption

and where d_2 equals 1.0 through March of the new calendar year, and then gradually declines as more actual grind information becomes available. In September, the calendar year in question shifts from being the new year to being the old year.

The relevant fraction change in consumption is the fraction difference between the average actual consumption rate relevant to the year being forecast, and the average

consumption rate for the corresponding period one year

earlier. When actual consumption is first taken into account

in May of the new year being forecast, the consumption

averaging period is defined as covering the last two months

of the old year, and the first four months of the new

year. Then, in June and July, the most recent month is

added to the averaging period, and the oldest month is

dropped, so that in July the averaging period covers the

first six months of the new year. With the passing of each

month from August through the following January (by which

time it is the old year fraction change which is being

forecast), the most recent month is added to the averaging

period, so that in January the average covers the entire

calendar year in question. After January C^A remains

constant. The equations are,

$$\text{May} - \text{July:} \qquad c^A = \frac{\displaystyle\sum_{i=t-7}^{t-1} c_i - \sum_{i=t-19}^{t-13} c_i}{\displaystyle\sum_{i=t-7}^{t-13} c_i} \qquad (27)$$

$$\text{August} - \text{January:} \qquad c^A = \frac{\displaystyle\sum_{i=\text{Jan}(1)}^{t-1} c_i - \sum_{i=\text{Jan}(2)}^{t-13} c_i}{\displaystyle\sum_{i=\text{Jan}(2)}^{t-13} c_i} \qquad (28)$$

where,

Jan(1) = Preceding January

Jan(2) = Two January's ago

These equations only represent an approximation of the market's

actual information processing activity, since in the actual

event monthly world consumption data never becomes available

per se, but rather must be estimated from such monthly,

quarterly, and annual grind data as becomes available for

individual countries, and from trade talk about the general

course of consumption in various areas.

Thus, as implied by the notation, equation 25 generates

estimates of the fraction change in consumption for both the

new and the old calendar years, with the seasonal patterns

in d_1 and d_2 each covering 24 month periods (the first

12 months pertaining to the new year forecast, the last

12 months to the old year forecast). The averaging periods

used in calculating P^A and C^A depend on whether it is the

new year or the old year that is being estimated. Figure 5-3

indicates the actual time patterns of d_1, d_2, and b

resulting from a generalized least squares regression

analysis described below, along with smoothed versions of

these regression estimates. The general time patterns of

d_1 and d_2 (which along with an estimate of E^* determine b;

see equation 26b) hypothesized above are confirmed in the

figure. Note that the weight placed on actual consumption

information (i.e. $(1-d_2)$) only begins to increase sharply

after the calendar year being forecast has ended, at which

point the annual grind data for most of the lesser consuming

countries becomes available.

5.2.2 The Data -- Table A-5 in Appendix A of Chapter 4

gives time series for Gill and Duffus' old and new calendar

year consumption forecasts for the 1952-63 period. These

series can be used to generate a series for G^{*n}, the forecast

fraction change in new calendar year consumption. In addi-

tion, the same table gives data for the old, old calendar

year consumption estimates made in August of each year.

As would be expected, each of these estimates does not in
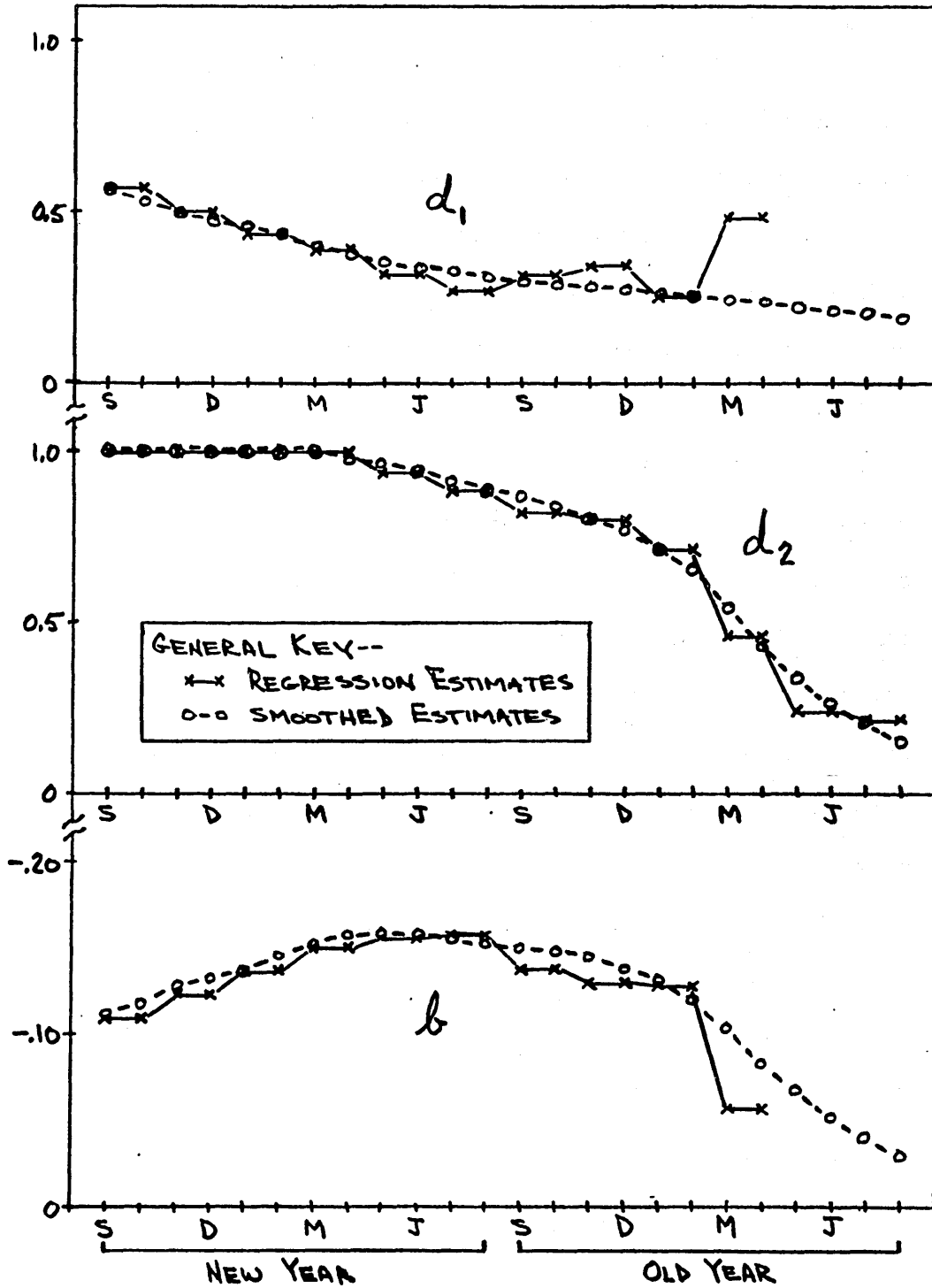
FIGURE 5-3 SEASONAL BEHAVIOR OF CONSUMPTION

FORECAST PARAMETERS

general differ very much from the estimate made for the same

calendar year during the previous August, when most of the

actual consumption data which would ever become available

was already in hand. It therefore would seem a reasonable

approximation to assume that the monthly estimates of old,

old year consumption are linear interpolations between the

given August old, old year estimate, and the estimate made

for the same calendar year in the preceding August. The

resulting monthly series of old, old consumption estimates

can be combined with the existing series of old year

consumption estimates to generate a series for G^{*o}, the

old year estimated fraction change in consumption.

Given these series for G^{*n} and G^{*o}, coupled with

computations of the series for P^A and C^A (using data

described in the last chapter), we are in a position to

estimate the parameters of equation 25. Since the monthly

consumption series starts in January, 1953, the first

observations of the forecast new year fraction change in

consumption which we can include in the regression data

set are those for 1955, and the first old year observa-

tions are those for 1954. The last available new and old

year estimates cover 1963 and 1962 respectively. Thus we

have available for regression 108 new year observations and

108 old year observations, or a total of 216 observations

in all. The data series will be arranged in chronological

order for regression purposes, with the total series of

24 observations for each calendar year (except for 1954

and 1963, which each have only 12 observations) kept in

sequence, as indicated in Table 5-6 below.

Table 5-6   Arrangement of Observations for Regression

Data Points	Year
1 - 12	1954, old year
13 - 24	1955, new year
25 - 36	1955, old year
⋮	⋮
181 - 192	1962, new year
193 - 204	1962, old year
205 - 216	1963, new year

Certain comments on the nature and the quality of the

consumption expectations data are appropriate before we

move on to the regressions discussed in the next section.

As indicated earlier in this section and in Appendix A of

the last chapter, the data for Gill and Duffus' consumption

forecasts is in no small measure constructed data. To

delete the constructed data points, and run regressions on

the remaining observations would represent an arduous and

not necessarily rewarding task. On the other hand, it is

important to note that in keeping the constructed observa-

tions in the regression data set we will to some degree

arrive at hybrid parameter estimates. To the extent that

the data construction procedures employed yield consumption

forecasts similar to those which would have been made by

Gill and Duffus (and this, after all, was the objective in

designing the data construction procedures), the regression
parameter estimates will closely portray Gill and Duffus'
(and by assumption, the market's) forecasting process,
providing that the model has been correctly specified. If
the constructed data differs importantly from the forecasts
which would have been made by Gill and Duffus, then the
regression parameter estimates describe a combination of the
Gill and Duffus and the constructed forecasting procedures.
In either case, the nature of the data construction proce-
dures (interpolation, etc.) is such that we are dealing
with fewer degrees of freedom than indicated by the number
of observations.

5.2.3 Regression Results — The initial regression
results for equation 25 are,

$$G_t^{*n,o} = a_i + b_i P_t^A + (1-d_{2,i}) C^A + e_t \qquad (29)$$

where,

$$a_i = a_1 + \Delta a_i \qquad (29a)$$

$$R^2 = .84 \qquad F(24,191) = 41 \qquad d = 0.18$$

and where the parameters (estimated via the use of appro-
priate bi-monthly indicator variables) are given in Table 5-7.
While the estimated parameter patterns are broadly in line
with the earlier hypotheses, there are certain discrepancies.
The most striking aspect of the above results is the very
high degree of serial correlation in the residuals indicated
by the Durbin-Watson statistic (which corresponds to a serial

Table 5-7: Initial Parameter Estimates

Year	Month	i	Δa_i	b_i	$d_{2,i}$
	Sept., Oct.	1,2	0	-.108 (.018)	0
	Nov., Dec.	3,4	0	-.152 (.022)	0
New	Jan., Feb.	5,6	0	-.203 (.025)	0
Year	Mar., April	7,8	0	-.247 (.028)	0
	May, June	9,10	-.0024 (.0088)	-.254 (.042)	.084 (.106)
	July, August	11,12	-.0107 (.0090)	-.201 (.039)	.357 (.114)
	Sept., Oct.	13,14	-.0137 (.0091)	-.111 (.044)	.548 (.160)
	Nov., Dec.	15,16	-.0231 (.0111)	-.006 (.073)	.807 (.261)
Old	Jan., Feb.	17,18	-.0278 (.0086)	0	.904 (.092)
Year	Mar., April	19,20	-.0295 (.0086)	0	.966 (.092)
	May, June	21,22	-.0277 (.0086)	0	.980 (.092)
	July, August	23,24	-.0282 (.0086)	0	.983 (.092)

Constant term: a_1 = .0227 (.0036)

correlation coefficient of 0.91)[1]. The need to go on to

derive generalized least squares parameter estimates is

manifest. Using the approach outlined in Section 4.5

(with $\rho = .91$), the new regression results are,[2]

$$G_t^{*n,oT} = a_i^T + b_i \, P_t^{A,T} + (1-d_{2,i}) \, C_t^{A,T} + u_t \qquad (30)$$

where,

$$a_i^T = a_1^T + \triangle a_i$$

$$R^2 = .41 \qquad F(26,179) = 4.8 \qquad d = 1.62$$

and where the various transformed variables are defined,

$$X_t^T = X_t - .91X_{t-1} \qquad (31)$$

The parameter estimates are given in columns 1 through 3 of

Table 5-8 and at the bottom of the table. The F ratio is

[1] As is evident from the arrangement of the data matrix indi-
cated in Table 5-6, there are several (nine in all) discon-
tinuities in the data at the transition points from one
calendar year to the next. These discontinuities have been
skipped in calculating the Durbin-Watson statistic, since
the first difference of the error term at these points
does not have its usual significance.

[2] In line with the preceding footnote, the various series of
transformed variables, X^T, defined in equation 31, each skip
one month at the beginning of the data points pertaining to
each successive calendar year. Thus the number of observa-
tions for the generalized least squares regression is
reduced by 10 (one for the beginning of the data, nine
for the transitions between calendar years) from the original
216 observations.

Table 5-8: Regression Estimates and Smoothed Estimates of Consumption Forecast Parameters

i	Mo.	Regression Estimates (Bi-Monthly)			Derived Parameter Estimates (Bi-Monthly)			Smoothed Parameter Estimates (Monthly)			
		(1) a_i (%)	(2) b_i	(3) $1-d_{2,i}$	(4) $d_{2,i}$	(5) G^* (%)	(6) $d_{1,i}$	(7) $d_{2,i}$	(8) $d_{1,i}$	(9) a_i	(10) b_i
1	S	-	-.109	-	1.0	2.77	.56	1.00	.56	2.77	-.111
2	O		(.032)					1.00	.53	2.77	-.119
3	N	-	-.123	-	1.0	2.77	.50	1.00	.50	2.77	-.126
4	D		(.031)					1.00	.48	2.77	-.132
5	J	-	-.138	-	1.0	2.77	.44	1.00	.45	2.77	-.139
6	F		(.030)					1.00	.43	2.77	-.144
7	M	-	-.151	-	1.0	2.77	.39	1.00	.40	2.77	-.152
8	A		(.029)					.98	.38	2.71	-.158
9	M	-.268	-.158	.061	.94	2.67	.32	.96	.35	2.66	-.158
10	J	(.295)	(.027)	(.036)				.94	.33	2.61	-.159
11	J	-.333	-.159	.115	.89	2.75	.27	.92	.32	2.54	-.157
12	A	(.423)	(.027)	(.050)				.89	.31	2.46	-.155
13	S	-.316	-.139	.185	.82	2.98	.32	.86	.30	2.38	-.152
14	O	(.528)	(.028)	(.068)				.83	.29	2.30	-.149
15	N	-.456	-.130	.200	.80	2.88	.34	.80	.28	2.22	-.144
16	D	(.629)	(.033)	(.098)				.76	.27	2.10	-.139
17	J	-.720	-.129	.293	.71	2.89	.26	.70	.26	1.94	-.132
18	F	(.799)	(.047)	(.163)				.64	.25	1.77	-.120
19	M	-1.466	-.059	.542	.46	2.82	.48	.54	.24	1.50	-.103
20	A	(.821)	(.041)	(.152)				.43	.23	1.19	-.083
21	M	-2.142	-	.765	.24	2.63	-	.34	.22	.94	-.068
22	J	(.759)		(.079)				.26	.21	.72	-.053
23	J	-2.304	-	.784	.22	2.14	-	.20	.20	.55	-.040
24	A	(.796)		(.078)				.15	.19	.42	-.030

N E W Y E A R (rows 1–12), O L D Y E A R (rows 13–24)

Regression Constant Term:

$$a_1^T = .242 \text{ \%}$$
$$(.081)$$

Equivalent Basic Constant:

$$a_1 = \frac{a_1^T}{1-\rho} = \frac{.242}{.087} = 2.77\%$$

significant at one percent (with the unadjusted number of degrees of freedom); the Durbin-Watson statistic still indicates serial correlation at the five percent level, although the degree of autocorrelation in the residuals has been significantly reduced (ρ is reduced from .91 to .19) with a corresponding increase in the efficiency of the parameter estim ates. Certain of the parameter estimates,[1] especially the smaller ones, are not signi- ficant at five percent. But all of these are broadly consistent with the hypothesized plausible seasonal patterns and will not be discarded as such. It should be noted that while in equation 29, b was set equal to zero after December in the old year period (see Table 5-7), b is only set equal to zero in May of the old year period in Table 5-8. This reflects the fact that in the initial generalized least squares results (not otherwise reported here) the old year December value of b was still quite large in magnitude, indicating that succeeding monthly average prices should be included in the regression.

The derived parameter estimates in columns 4 through 6 in Table 5-8 are based on the column 1 through 3 estimates coupled with the constant term at the bottom of the table.

---

[1] In particular, $\triangle a_{1-2}$ through $\triangle a_{15-16}$, b_{19-20}, $d_{2,9-10}$, and $d_{2,17-18}$.

The calculation of d_2 in column 4 is straightforward,

given the column 3 estimates. The $\bar{G}^*$ estimates then follow

from equations 30a and 26a. Finally, the d_1 estimates in

column 6 are derived from the b and d_2 estimates via equation

26b and the assumption that E^* equals 0.252, the average

price elasticity indicated in equation 15. The model

specification presented earlier implied that $\bar{G}^*$ should be

a constant, but there is no way in which to incorporate

that specification in the regression model. Nevertheless

the column 5 results support the original hypothesis in that

they indicate only minor variations in $\bar{G}^*$ (which is held

constant in the regression specification only over the first

eight months) until the last two months of the old year

period. By that point the calculation of $\bar{G}^*$ is highly

sensitive to the regression estimate of d_2. The calculated

$\bar{G}^*$ value of 0.0214 for those months would be increased

to 0.0277, the initial $\bar{G}^*$ value, if the d_2 estimate

dropped from 0.22 to 0.17. The initial estimated long

term consumption growth rate of 2.77 percent per annum

is reasonably close to the long term annual growth rate of

2.48 percent estimated in equation 14, and as such seems

plausible.

Columns 7 and 8 indicate smoothed monthly estimates

of d_2 and d_1 drawn through the bi-monthly regression esti-

mates given in columns 4 and 6. The last value of d_1

given by the regression estimates (i.e. the value for March-April of the old year period) is implausibly high, reflecting its high degree of sensitivity to the corresponding regression estimate of b, and has been ignored in obtaining the smoothed d_1 estimates. Column 9 gives the calculated smoothed values of a_i derived from the smoothed d_2 estimates, the use of equation 26a, and the assumption that $\bar{G}^*$ is constant at 0.0277, its initial regression estimate. The calculated smoothed values of b given in column 10 are based on equation 26b, the smoothed estimates of d_1 and d_2, and the assumption that E^* equals 0.252. Figure 5-3, referred to earlier, shows the regression estimates and the smoothed estimates of d_1, d_2, and b. These smoothed estimates will be used in the dynamic silumations of the price-consumption subsystem to be discussed in the next chapter.

List of References

1) FAO, Agricultural Commodities - Projections for 1970, Rome, 1962.

2) FAO, The Cocoa Situation: Recent Developments and the Outlook for Production and Demand, Rome, 1961.

3) Gill and Duffus Ltd., Cocoa Market Reports (monthly), London.

4) Theil, H., and Nagar, A., "Testing the Independence of Regression Disturbances", American Statistical Association Journal, Vol. 56 (December, 1961), pp. 793-806.

Appendix A -- Additional Data

1.0 Introduction

In order to run the regressions explaining the major

nations' per capita cocoa consumption discussed in Section

5.1.1 and Appendix C, several time series in addition to

those presented in Appendix A of Chapter 4 are required.

In particular, data for the populations, national incomes,

exchange rates, and foreign trade in cocoa products of the

major nations are needed, along with series for the U.S.

and world monthly average sugar prices. These time series

are given in the sections which follow. In addition, the

average population and per capita income growth rates for

the major nations, used in arriving at a plausibility

range for the exogenous growth rate in world cocoa demand

(equation 13 in the chapter text), are calculated in

Sections 2.0 and 3.3, respectively. In Section 6.0 I

comment on the nature and validity of the data given in

this appendix.

2.0 Populations

Table A-1 gives the mid-year populations of the major

consuming nations for the period from 1953 through 1963. The

data through 1962 are taken from the 1963 United Nations

Demographic Yearbook (D-7). The 1963 populations have been

TABLE A-1 POPULATIONS (MILLIONS)

YEAR	US	UK	HOLND	FRANCE	JAPAN	ITALY	GRMNY	SPAIN	TOTAL
1953	160	51	11	43	87	48	49	29	476
1954	163	51	11	43	88	48	50	29	482
1955	166	51	11	43	89	48	50	29	487
1956	169	51	11	44	90	48	51	29	493
1957	172	52	11	44	91	49	51	29	499
1958	175	52	11	45	92	49	52	30	504
1959	178	52	11	45	92	49	53	30	510
1960	181	53	12	46	93	49	53	30	516
1961	184	53	12	46	94	50	54	31	523
1962	187	53	12	47	95	50	55	31	529
1963	190	54	12	48	96	50	56	31	536

derived by extrapolating the 1961-1962 growth rate. The

quarterly aggregate population series (not shown here),

required for the calculation of quarterly series for per

capita cocoa consumption and per capita income, is simply

generated via interpolation between the mid-year population

aggregates. As indicated by the following computation,

the average population growth rate for the aggregated

major consuming nations over the 1953-63 interval was

1.19 percent per annum.

Annual population growth rate

$$\text{EXP (10g)} = \frac{1963 \text{ aggregate population}}{1953 \text{ aggregate population}} = \frac{536 \text{ million}}{476 \text{ million}}$$

or,

$$g = \frac{1}{10} (\ln 536 - \ln 476) = 0.0119$$

3.0 National Income Indicators

As was mentioned in the chapter text, data for the

quarterly rate of national consumption expenditures (in the

national income sense) are more generally available for the

major cocoa consuming nations than are quarterly data for

the various national income or personal income rates. For

this reason, the national income variable used in the regres-

sions explaining aggregate major nation per capita cocoa

consumption is the aggregate per capita national consumption

expenditure rate, stated in dollars and deflated via the

BLS wholesale price index. The subsections which follow present the quarterly consumption rate data for the various nations in terms of local currencies, the exchange rates between local currencies and dollars, and the aggregate expenditures stated in dollars and deflated.

3.1 National Consumption Expenditures -- Table A-2 gives the data, in large measure constructed, for the quarterly consumption expenditures in current local currencies of the eight major nations for the 1956-1963 period. The sources and derivations of these series are the following:

United States. This series, which is not seasonally adjusted, is taken directly from the Survey of Current Business (D-9), the only conversion being from an annual rate to a quarterly rate.

United Kingdom. The U.K. figures are given by the Monthly Digest of Statistics (D-3), and are also not seasonally adjusted.

Netherlands. Quarterly consumption figures for the Netherlands are not available per se. However, the Economic Quarterly Review published by the Amsterdamshe Bank does give a monthly series in the form of index numbers (1953=100) for "household consumption", which is not adjusted for either seasonal variations or fluctuations in the general price level. The quarterly consumption series given for

TABLE A-2 QUARTERLY CONSUMPTION EXPENDITURES, LOCAL CURRENCIES (BILLIONS)

YEAR	Q	US	UK	HOLND	FRANCE	JAPAN	ITALY	GRMNY	SPAIN
1956	1	65.4	3.1	4.3	30.4	1329.0	2408.3	26.0	75.7
	2	65.9	3.4	4.7	31.2	1347.8	2450.3	26.9	78.3
	3	66.7	3.4	4.8	32.0	1363.5	2488.2	27.9	81.2
	4	68.1	3.6	5.2	32.9	1384.8	2522.2	32.7	84.4
1957	1	69.2	3.3	4.8	33.8	1413.8	2556.1	27.0	87.6
	2	69.7	3.5	5.2	34.6	1460.3	2590.0	30.0	90.8
	3	70.9	3.6	5.2	35.6	1500.8	2622.0	30.5	94.1
	4	71.8	3.8	5.4	36.8	1511.0	2652.0	34.5	97.6
1958	1	71.5	3.5	5.0	37.9	1506.0	2682.0	30.0	101.1
	2	72.1	3.7	5.4	39.0	1544.5	2712.0	31.4	104.6
	3	72.9	3.7	5.3	39.9	1562.5	2741.0	32.9	106.5
	4	74.8	4.0	5.6	40.6	1580.0	2769.0	38.1	106.9
1959	1	76.0	3.7	5.2	41.3	1607.0	2797.0	32.7	107.2
	2	77.8	4.0	5.5	42.1	1669.8	2825.0	34.6	107.5
	3	78.3	4.0	5.5	42.9	1699.0	2866.5	36.2	108.1
	4	79.9	4.3	5.9	44.0	1723.0	2921.4	41.7	108.9
1960	1	80.8	3.9	5.4	45.0	1785.3	2976.3	36.1	109.6
	2	82.3	4.2	6.0	46.0	1838.8	3031.3	39.7	110.4
	3	82.4	4.2	6.0	47.0	1917.5	3092.2	39.6	112.8
	4	83.1	4.4	6.4	48.1	1965.3	3159.1	45.9	116.7
1961	1	82.7	4.1	6.0	49.1	1972.5	3225.9	39.9	120.6
	2	83.7	4.4	6.3	50.2	2093.3	3292.8	42.1	124.5
	3	84.5	4.5	6.4	51.5	2187.0	3377.0	43.9	128.6
	4	85.9	4.6	6.7	53.0	2318.5	3478.5	50.8	132.7
1962	1	87.2	4.3	6.2	54.5	2321.3	3580.0	44.4	136.8
	2	88.2	4.7	6.8	56.0	2485.0	3681.5	47.1	140.9
	3	89.2	4.7	6.9	57.4	2535.3	3762.6	47.6	144.3
	4	90.7	4.9	7.4	58.8	2639.0	3823.3	53.1	146.8
1963	1	91.8	4.4	6.9	60.2	2676.8	3884.0	53.0	149.3
	2	92.6	4.9	7.4	61.6	2851.8	3944.7	56.0	151.8
	3	93.7	5.0	7.6	62.9	3062.5	4005.3	57.0	154.3
	4	95.0	5.1	8.0	64.3	3337.5	4066.0	59.0	156.8

the Netherlands in Table A-2 has been generated by averaging

the three monthly consumption index numbers for each quarter,

and multiplying these quarterly averages (divided by 100)

by the average quarterly consumption rate for 1953. The

average index number for the fourth quarter in 1963 has been

estimated based on the assumption that the previous average

relationship between the third and fourth quarter figures

held in that year as well.

France. No quarterly consumption data, nor even any

series closely indicative of quarterly consumption expendi-

tures, appears to be available for France. As a result, the

French quarterly consumption series given in Table A-2

consists of interpolations between the United Nations

figures (D-8) for annual French consumption, except for

the estimates for the last two quarters, which are extra-

polations. The interpolation procedure is based on the assump-

tion that the mid-year consumption rate for each year was

equal to the total annual rate for that year; the quarterly

weighting coefficients used to calculate the initial quarterly

figures are,

Calendar Quarter	Weight on Beginning Mid-year Consumption Rate	Weight on Ending Mid-year Consumption Rate
3	.875	.125
4	.625	.375
1	.375	.625
2	.125	.875

The interpolated figures calculated via these weights are then divided by four in order to convert from an annual rate to a quarterly rate.

It should be noted that this procedure has at least two defects. First, the sum of the resulting quarterly consumption estimates for each year does not necessarily equal the original U.N. figure for that year. Second, the quarterly consumption estimates are in effect seasonally adjusted, since they are based on annual data, and as such cause the aggregate major nations' quarterly consumption series to be a hybrid of adjusted and unadjusted national series.

The 1963 annual French consumption figure, required in the estimation of the last six quarterly figures in Table A-2, is constructed based on the annual French industrial production index published in the I.M.F.'s _International Financial Statistics_ (D-5), and an extrapolation of the relationship which existed between consumption and industrial production in earlier years.

Japan. The Japanese quarterly consumption series comes directly from _Monthly Statistics of Japan_ (D-2), with the only conversion being from an annual rate to a quarterly rate. This series is seasonally adjusted; unadjusted data do not appear to be available. The figures for the last two quarters of 1963 have been constructed by

applying the same percentage increases relative to the second quarter of 1963 as were evident in the Japanese industrial production index published in International Financial Statistics.

Italy. These quarterly figures for consumption expenditures have been constructed in a manner identical in all respects, including both the data sources and the method for estimating 1963 consumption, to that used in deriving the French quarterly consumption series discussed above.

Germany. The German quarterly consumption data through 1962 comes directly from International Financial Statistics, and has not been seasonally adjusted. The 1963 figures have been constructed, based on the German industrial production index published in the same source, and an extrapolation of the relationship between industrial production and consumption expenditures which existed in the previous years.

Spain. The Spanish quarterly consumption estimates are again based on the same interpolation procedure as was used in generating the French figures, with the annual consumption figures coming from the United Nations Yearbook of National Accounts Statistics (D-8) through 1960. For 1961 and 1962, the annual consumption estimates are constructed based on IMF (D-5) data for national income, coupled with an extension of the average consumption-income ratio which

held in earlier years. Finally, the 1963 consumption esti-
mate has been derived from the IMF industrial production
series, and an extrapolation of the earlier relationship
between consumption and industrial production.

3.2 Exchange Rates -- Table A-3 gives the quarterly
average official dollar exchange rates for the various
major nation local currencies, taken from International
Financial Statistics.

3.3 Aggregate Consumption Expenditures -- Table A-4
shows the major nations' quarterly consumption expenditures
converted to dollars via the various official exchange rates,
and summed to give the aggregate major nations' consumption
expenditures in current dollars. The final column in
Table A-4 gives the aggregate per capita consumption expen-
ditures, deflated via the BLS wholesale price index. The
following computation yields an average growth rate in
deflated aggregate per capita consumption expenditures of
0.90 percent per quarter.

Quarterly per capita consumption growth rate

$$\text{EXP } (28\ g) = \frac{1963 \text{ first quarter per capita consumption}}{1956 \text{ first quarter per capita consumption}} = \frac{.279}{.217}$$

or,

$$g = \frac{1}{28} (\ln .279 - \ln .217) = .0090$$

TABLE A-3   EXCHANGE RATES (LOCAL CURRENCIES PER DOLLAR)

YEAR	Q	US	UK	HOLND	FRNCE	JAPAN	ITALY	GRMNY	SPAIN
1956	1	1.0	.36	3.80	3.50	360.0	624.9	4.20	38.95
	2	1.0	.36	3.80	3.50	360.0	624.9	4.20	38.95
	3	1.0	.36	3.80	3.50	360.0	624.9	4.20	38.95
	4	1.0	.36	3.80	3.50	360.0	624.9	4.20	38.95
1957	1	1.0	.36	3.80	3.50	360.0	624.9	4.20	38.95
	2	1.0	.36	3.80	3.50	360.0	624.9	4.20	42.00
	3	1.0	.36	3.80	3.62	360.0	624.9	4.20	42.00
	4	1.0	.36	3.80	3.97	360.0	624.9	4.20	42.00
1958	1	1.0	.36	3.80	4.20	360.0	624.9	4.20	42.00
	2	1.0	.36	3.80	4.20	360.0	624.9	4.20	42.00
	3	1.0	.36	3.80	4.20	360.0	624.9	4.20	42.00
	4	1.0	.36	3.80	4.20	360.0	624.9	4.20	42.00
1959	1	1.0	.36	3.80	4.90	360.0	624.9	4.20	42.00
	2	1.0	.36	3.80	4.90	360.0	624.9	4.20	42.00
	3	1.0	.36	3.80	4.90	360.0	624.9	4.20	48.00
	4	1.0	.36	3.80	4.90	360.0	624.9	4.20	60.00
1960	1	1.0	.36	3.80	4.90	360.0	620.9	4.20	60.00
	2	1.0	.36	3.80	4.90	360.0	620.9	4.20	60.00
	3	1.0	.36	3.80	4.90	360.0	620.9	4.20	60.00
	4	1.0	.36	3.80	4.90	360.0	620.9	4.20	60.00
1961	1	1.0	.36	3.73	4.90	360.0	620.9	4.13	60.00
	2	1.0	.36	3.60	4.90	360.0	620.9	4.00	60.00
	3	1.0	.36	3.60	4.90	360.0	620.9	4.00	60.00
	4	1.0	.36	3.60	4.90	360.0	620.9	4.00	60.00
1962	1	1.0	.36	3.60	4.90	360.0	620.9	4.00	60.00
	2	1.0	.36	3.60	4.90	360.0	620.9	4.00	60.00
	3	1.0	.36	3.60	4.90	360.0	620.9	4.00	60.00
	4	1.0	.36	3.60	4.90	360.0	620.9	4.00	60.00
1963	1	1.0	.36	3.60	4.90	360.0	620.9	4.00	60.00
	2	1.0	.36	3.60	4.90	360.0	620.9	4.00	60.00
	3	1.0	.36	3.60	4.90	360.0	620.9	4.00	60.00
	4	1.0	.36	3.60	4.90	360.0	620.9	4.00	60.00

TABLE A-4 QUARTERLY DOLLAR CONSUMPTION EXPENDITURES (BILLIONS)

YEAR	Q	US	UK	HLND	FRNC	JAPN	ITLY	GRMY	SPN	TOTAL	PER-CAP ($/HEAD)
1956	1	65.4	8.8	1.1	8.7	3.7	3.9	6.2	1.9	99.8	217
	2	65.9	9.4	1.2	8.9	3.7	3.9	6.4	2.0	101.6	217
	3	66.7	9.6	1.3	9.2	3.8	4.0	6.6	2.1	103.2	218
	4	68.1	10.1	1.4	9.4	3.8	4.0	7.8	2.2	106.8	223
1957	1	69.2	9.1	1.3	9.6	3.9	4.1	6.4	2.2	105.9	218
	2	69.7	9.8	1.4	9.9	4.1	4.1	7.1	2.2	108.3	222
	3	70.9	10.1	1.4	9.8	4.2	4.2	7.3	2.2	110.1	223
	4	71.8	10.7	1.4	9.3	4.2	4.2	8.2	2.3	112.2	227
1958	1	71.5	9.7	1.3	9.0	4.2	4.3	7.1	2.4	109.6	219
	2	72.1	10.3	1.4	9.3	4.3	4.3	7.5	2.5	111.7	223
	3	72.9	10.5	1.4	9.5	4.3	4.4	7.8	2.8	113.3	226
	4	74.8	11.3	1.5	9.7	4.4	4.4	9.1	2.5	117.6	233
1959	1	76.0	10.3	1.4	8.4	4.5	4.5	7.8	2.6	115.3	227
	2	77.8	11.1	1.4	8.6	4.6	4.5	8.2	2.6	118.9	233
	3	78.3	11.2	1.5	8.8	4.7	4.6	8.6	2.3	119.9	235
	4	79.9	12.0	1.6	9.0	4.8	4.7	9.9	1.8	123.6	243
1960	1	80.8	10.8	1.4	9.2	5.0	4.8	8.6	1.8	122.5	239
	2	82.3	11.6	1.6	9.4	5.1	4.9	9.5	1.8	126.1	245
	3	82.4	11.7	1.6	9.6	5.3	5.0	9.4	1.9	126.9	246
	4	83.1	12.3	1.7	9.8	5.5	5.1	10.9	1.9	130.3	252
1961	1	82.7	11.4	1.6	10.0	5.5	5.2	9.7	2.0	128.1	246
	2	83.7	12.2	1.7	10.2	5.8	5.3	10.5	2.1	131.6	254
	3	84.5	12.5	1.8	10.5	6.1	5.4	11.0	2.1	133.9	258
	4	85.9	12.9	1.9	10.8	6.4	5.6	12.7	2.2	138.5	266
1962	1	87.2	12.0	1.7	11.1	6.4	5.8	11.1	2.3	137.6	262
	2	88.2	13.0	1.9	11.4	6.9	5.9	11.8	2.3	141.5	270
	3	89.2	13.1	1.9	11.7	7.0	6.1	11.9	2.4	143.3	271
	4	90.7	13.6	2.1	12.0	7.3	6.2	13.3	2.4	147.6	279
1963	1	91.8	12.4	1.9	12.3	7.4	6.3	13.3	2.5	147.9	279
	2	92.6	13.6	2.1	12.6	7.9	6.4	14.0	2.5	151.7	286
	3	93.7	13.9	2.1	12.8	8.5	6.5	14.3	2.6	154.4	289
	4	95.0	14.4	2.2	13.1	9.3	6.5	14.8	2.6	157.9	295

4.0 Major Nations' Foreign Trade in Cocoa Products

In order to gain a measure of total cocoa consumption
in the aggregated major nations, it is necessary that we
add to their aggregate grind an estimate of their aggregate
net imports of cocoa products, converted into bean equi-
valents. This presents two problems, one arising from the
joint product nature of cocoa butter and cocoa powder,
the other stemming from the nature of the available data.

Under average conditions, one pound of cocoa beans
yields 0.43 pounds of powder (10 - 12 percent fat content),
0.38 pounds of butter, and 0.19 pounds of waste. Put
another way, 2.34 pounds of beans are required to produce
one pound of powder, and 2.62 pounds of beans yield one
pound of butter. But as the following example indicates,
these multipliers cannot be used to convert product imports
into their bean equivalents without risking a significant
overstatement of the original amount of beans used in manu-
facturing the imported products.

Original Bean Grind	Products Yielded and Imported	Product-Bean Multiplier	Estimated Bean Equivalent of Product Imports
100 lb.	43 lb. powder	2.34	100 lb.
	38 lb. butter	2.62	100 lb.
100 lb.			200 lb.

We shall resolve this problem somewhat arbitrarily by dividing
the above multipliers by two, yielding a powder multiplier of

1.17, and a butter multiplier of 1.31. The use of these multipliers in estimating the bean equivalents of products trade only yields accurate estimates if the products are traded in their physically natural ratio. In all other cases, the estimated bean equivalents represent approximations, with the accuracy of these approximations declining as the actually traded products ratio differs increasingly from the natural ratio. Table A-5 gives the estimated bean equivalents of the aggregate annual net powder and butter imports of the major nations over the 1956-1963 interval, based on FAO cocoa data (D-4).

The third product category covered by the FAO data and included in Table A-5 is "chocolate and chocolate products". The rather broad definition of this category makes it particularly difficult to estimate the bean equivalent of the corresponding FAO trade figures, since there are included products ranging from milk crumb, which is very low in chocolate content, to dark chocolate, one pound of which contains the equivalent of as much as 0.7 pounds of cocoa beans. In order to calculate the bean equivalent of trade in this category, I have used a multiplier of 0.5 pounds of beans per pound of chocolate and chocolate products, on the assumption that a major portion of the indicated

Table A-5: Cocoa Bean Equivalents of Aggregate Major Nations' Product Imports

(in thousands of metric tons unless otherwise indicated; negative numbers represent net exports)

	1956	1957	1958	1959	1960	1961	1962	1963
Cocoa butter	110	-3,200	- 2,780	- 970	900	-3,130	- 5,630	- 870
Cocoa powder	7,690	5,010	- 1,010	16,650	6,140	- 830	- 7,230	-2,490
Chocolate and chocolate products	-4,790	-5,920	- 6,850	- 6,020	-4,450	430	- 4,170	-5,710
Total (metric tons)	3,010	-4,110	-10,640	9,660	2,590	-3,530	-17,030	-9,070
Total (long tons)	2,950	-4,030	-10,430	9,470	2,540	-3,460	-16,690	-8,890

tonnages involved dark chocolate.[1]

The annual series for the bean equivalents of the major nations' net product imports can be broken into a quarterly series on the assumption that these imports followed the same seasonal pattern within each year as was exhibited by the aggregate grind (see Table A-1 in Appendix A of Chapter 4). Given the crude nature of the procedures used in generating Table A-5, it is perhaps encouraging that the estimated bean equivalents of aggregate net product imports are small relative to the total grind figures (the largest bean equivalent in magnitude is equal to less that two percent of the corresponding grind figure).

5.0 Sugar Prices

Table A-6 gives the monthly average price series for U.S. spot raw sugar and for world spot raw sugar, as determined by the New York Coffee and Sugar Exchange, and published in the Lamborn Sugar Market Reports (D-6).

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[1] The FAO figures for U.K. imports of chocolate products seem primarily to consist of milk crumb imports from Ireland, having a bean equivalent by weight of less than ten percent. In order to adjust for this distortion, I have netted the chocolate product export figures for Ireland against the U.K. import figures.

TABLE A-6   SUGAR PRICES

U.S. RAW SUGAR PRICES

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEPT	OCT	NOV	DEC
1953	5.54	5.66	5.83	5.88	5.85	5.87	5.91	5.90	5.91	5.90	5.65	5.55
1954	5.54	5.56	5.68	5.69	5.60	5.65	5.69	5.59	5.48	5.46	5.65	5.46
1955	5.46	5.44	5.34	5.32	5.45	5.52	5.51	5.52	5.50	5.36	5.47	5.33
1956	5.38	5.38	5.45	5.52	5.53	5.50	5.61	5.60	5.59	5.79	5.83	5.87
1957	5.84	5.60	5.68	5.64	5.87	6.02	5.95	5.63	5.67	5.71	5.62	5.65
1958	5.65	5.65	5.53	5.71	5.79	5.77	5.78	5.78	5.87	5.97	5.85	5.94
1959	5.65	5.49	5.34	5.42	5.80	5.81	5.79	5.87	6.01	6.05	5.94	5.67
1960	5.39	5.50	5.61	5.67	5.59	5.75	5.98	5.97	6.09	6.02	6.03	5.96
1961	5.77	5.70	5.62	5.62	5.84	5.86	5.76	5.44	5.43	5.57	5.67	5.77
1962	5.82	5.75	5.80	5.81	5.81	5.82	5.76	5.92	5.80	5.89	5.82	5.91
1963	6.07	6.17	6.42	7.64	10.46	8.07	7.32	6.02	6.82	8.80	8.71	8.16

WORLD RAW SUGAR PRICES

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEPT	OCT	NOV	DEC
1953	3.55	3.52	3.27	3.38	3.65	3.62	3.60	3.53	3.29	3.15	3.10	3.27
1954	3.30	3.39	3.28	3.36	3.32	3.27	3.13	3.18	3.21	3.25	3.26	3.19
1955	3.17	3.17	3.22	3.31	3.38	3.26	3.22	3.22	3.27	3.28	3.19	3.16
1956	3.26	3.28	3.34	3.31	3.36	3.36	3.40	3.34	3.24	3.24	3.92	4.77
1957	5.83	5.80	6.17	6.46	6.02	6.12	5.27	4.13	4.55	4.03	3.63	3.87
1958	3.74	3.55	3.42	3.45	3.47	3.42	3.50	3.46	3.48	3.41	3.42	3.64
1959	3.27	3.11	3.05	2.88	2.94	2.81	2.66	2.78	3.09	3.10	2.96	3.00
1960	2.97	3.02	3.05	3.04	3.05	2.97	3.26	3.31	3.25	3.25	3.25	3.25
1961	3.03	2.97	2.97	3.14	3.35	3.20	3.05	2.80	2.69	2.73	2.53	2.46
1962	2.30	2.36	2.65	2.69	2.61	2.63	2.92	3.24	3.18	3.28	3.65	4.29
1963	5.41	6.06	6.62	7.65	10.36	9.92	9.05	6.63	7.63	10.67	11.63	10.36

6.0 Comments on the Data

The data presented in the preceding sections are needed for pursuing the indirect approach toward estimating the world cocoa consumption function, described in Section 5.1.1. These time series are marred by several flaws:

a) The quarterly consumption expenditures series for three of the major cocoa consuming nations (France, Italy, and Spain) are derived from annual data via interpolation, and as such only provide rough approximations of the actual quarterly movements in the consumption expenditures of these countries.

b) Several of the data points for national consumption expenditures late in the period studied are constructed, based on available data for industrial production, which construction procedure is less than ideal.

c) The aggregate major nations' quarterly consumption expenditures series is a hybrid of seasonally adjusted and seasonally unadjusted series.

d) The exchange rates used to state aggregate consumption expenditures in dollars are the official exchange rates, and as such do not necessarily accurately reflect the intercountry differentials in the costs of cocoa beans or of cocoa products.

e) Because of the joint product nature of cocoa butter and cocoa powder, and because of the conglomeration of items

included in the "chocolate and chocolate products" category,
the estimated cocoa bean equivalents of the major nations'
trade in cocoa products represent rough approximations at
best.

f) The raw sugar price series used are only loosely
related to the actual sugar price series for several of the
countries included in the aggregate.

The basic conclusion suggested by these qualifications
taken as a whole is that in attempting to estimate the
structure that determines world cocoa consumption, there is
apparently no useful middle ground between a direct estimation
of the world cocoa consumption function such as that discussed
in Section 5.1.3, and a detailed disaggregated approach
involving the separate estimation of the consumption func-
tions of the major consuming nations and of subgroups of
the lesser consuming nations. From the point of view of
obtaining a detailed understanding of the determinants of
world consumption, there is no question but that the
disaggregated approach is the more appropriate of the two.
On the other hand, the more limited objective of the consump-
tion study undertaken in this chapter is to obtain an esti-
mate of the aggregate world cocoa consumption function
useful for studying the price-consumption dynamics of the
world cocoa industry. Even in this context the disaggre-
gated approach is preferable, as it comes closer to describing

the actual mechanism which generates aggregate consumption.
The reasons for my choosing the direct estimation alterna-
tive in the face of this preference are twofold: (a) the
disaggregated approach would involve an unwarrented amount
of time in the absense of a clear indication that there
exists no acceptable alternative, and (b) the direct esti-
mation approach pursued in the chapter text in fact seems
to explain variations in world consumption reasonably well.

List of Data Sources

D-1 Amsterdamische Bank, Economic Quarterly Review, Amsterdam.

D-2 Bureau of Statistics, Office of the Prime Minister, Monthly Statistics of Japan, Tokyo.

D-3 Central Statistical Office, Monthly Digest of Statistics, London.

D-4 FAO, Cocoa Statistics, Rome.

D-5 International Monetary Fund, International Financial Statistics, Washington.

D-6 Lamborn and Company, Sugar Market Report, New York.

D-7 United Nations, Demographic Yearbook, New York.

D-8 _____, Yearbook of National Accounts and Statistics, New York.

D-9 U.S. Department of Commerce, Survey of Current Business, Washington.

Appendix B -- The Relationship between the Equations for Quarterly and Monthly Consumption

Equation 5 in the text of the chapter, repeated here as equation B-1 without superscripts and with a specific representative lag structure, embodies the basic hypothesis used in the chapter regarding the form of the cocoa consumption function.

$$\ln q_t = k + d_1(g_1 P_{t-1} + g_2 P_{t-2}) + d_2 y_t + d_3 t \qquad (B-1)$$

or,

$$q_t = EXP\left[k + d_1(g_1 P_{t-1} + g_2 P_{t-2}) + d_2 y_t + d_3 t\right] \quad (B-2)$$

which has the linear approximation,

$$q_t = 1 + k + d_1(g_1 P_{t-1} + g_2 P_{t-2}) + d_2 y_t + d_3 t \qquad (B-3)$$

where,

$$
\begin{aligned}
q &= \text{Aggregate monthly per capita cocoa consumption} \\
y &= \text{Aggregate monthly per capita cocoa income} \\
P &= \text{Cocoa price} \\
t &= \text{Time, in months}
\end{aligned}
$$

Then quarterly consumption can be written,

$$Q_T = q_{3T+1} + q_{3T} + q_{3T-1} \qquad (B-4)$$

or,

$$Q_T = 3\left[1 + k + b_1(c_1 P_{3T} + c_2 P_{3T-1} + c_3 P_{3T-2}) + b_2 Y_T + b_3 T\right] \qquad (B-5)$$

where,

$$Y_T = y_{3T+1} + y_{3T} + y_{3T-1} \qquad (B-6)$$

and,

$$b_1 = d_1$$

$$c_1 = g_1 / 3$$

$$c_2 = (g_1 + g_2) / 3$$

$$c_3 = g_2 / 3 \tag{B-7}$$

$$b_2 = d_2$$

$$b_3 = 3\, d_3$$

where,

Q = Aggregate quarterly per capita cocoa consumption

Y = Aggregate quarterly per capita cocoa income

T = Time, in quarters

But the expression in brackets in equation B-5 is a

linear approximation to the exponential having the bracketed

term minus 1 as the exponent, so that the logarithm of

quarterly consumption can be approximated,

$$\ln Q_t = a + b_1 \left(c_1 P_{3T} + c_2 P_{3T-1} + c_3 P_{3T-2} \right) + b_2 Y_T + b_3 T \tag{B-8}$$

where,

$$a = k + \ln 3 \tag{B-9}$$

which is the form of equation 7 in the chapter text.

Appendix C -- Indirect Estimation Regression Results

Table C-1 gives the detailed indirect estimation regression results using the two price lag distributions (wide and narrow), with each distribution tested using several different average lags. These results as well as the Table C-2 results were referred to in Section 5.1.2. Table C-2 gives the indirect estimation regression results using the wide price lag distribution with an average lag of seven months, with the two sugar prices included together and individually, and with time and income included individually.

Table C-1: Indirect Estimation Results for Various Average Lags Using Both Distributions

Coefficients

Price Lag Distributions	Average Lag (Months)	Constant	2nd Q.	3rd Q.	4th Q.	Price	Income	Time	R^2
	5	-1.012 (0.365)	-.110 (.024)	-.190 (.024)	.023 (.027)	-.0110 (.0016)	0.781 (1.861)	-.00059 (.00429)	.8900
	6	-1.021 (0.350)	-.108 (.024)	-.191 (.023)	.014 (.026)	-.0111 (.0016)	0.878 (1.782)	-.00089 (.00411)	.8972
Narrow	7	-1.075 (0.344)	-.111 (.024)	-.186 (.023)	.004 (.025)	-.0110 (.0015)	1.191 (1.756)	-.00168 (.00407)	.8973
	8	-1.160 (0.348)	-.112 (.024)	-.175 (.024)	-.002 (.026)	-.0107 (.0016)	1.621 (1.781)	-.00272 (.00413)	.8914
	9	-1.289 (0.366)	-.107 (.026)	-.167 (.026)	.002 (.028)	-.0101 (.0016)	2.223 (1.877)	-.00409 (.00437)	.8756
	5	-1.000 (0.367)	-.114 (.024)	-.189 (.024)	.020 (.027)	-.0112 (.0017)	0.759 (1.862)	-.00062 (.00429)	.8900
	6	-.0988 (0.346)	-.110 (.023)	-.188 (.023)	.014 (.025)	-.0114 (.0016)	0.756 (1.756)	-.00074 (.00405)	.9006
Wide	7	-1.038 (0.340)	-.109 (.023)	-.183 (.023)	.007 (.025)	-.0113 (.0015)	1.036 (1.731)	-.00144 (.00400)	.9011
	8	-1.137 (0.347)	-.108 (.024)	-.175 (.024)	.003 (.026)	-.0109 (.0016)	1.528 (1.774)	-.00260 (.00411)	.8929
	9	-1.281 (0.362)	-.106 (.026)	-.169 (.026)	.005 (.028)	-.0103 (.0016)	2.219 (1.856)	-.00416 (.00432)	.8781

Table C-2:   Regression Results Including Sugar Prices, and Including Time and Income Separately

<div align="center">Coefficients</div>

| Constant	2nd Q.	3rd Q.	4th Q.	Price	Sugar #7	Sugar #8	Income	Time	R^2
-0.996	-.106	-.180	.009	-.0117	.0241	.0011	0.098	.00042	.9056
(0.351)	(.024)	(.025)	(.027)	(.0017)	(.0458)	(.0132)	(2.075)	(.00450)	
-0.999	-.106	-.179	.010	-.0117	.0273	xxxx	0.052	.00047	.9056
(0.341)	(.023)	(.023)	(.025)	(.0016)	(.0257)	xxxx	(1.960)	(.00438)	
-0.990	-.108	-.184	.005	-.0113	xxxx	.0068	0.620	-.00038	.9044
(0.345)	(.023)	(.023)	(.025)	(.0015)	xxxx	(.0075)	(1.796)	(.00418)	
-0.838	-.106	-.181	.013	-.0118	xxxx	xxxx	xxxx	.00087	.8997
(0.062)	(.022)	(.022)	(.023)	(.0013)	xxxx	xxxx	xxxx	(.00102)	
-0.926	-.107	-.182	.010	-.0115	xxxx	xxxx	0.433	xxxx	.9006
(0.138)	(.022)	(.022)	(.023)	(.0014)	xxxx	xxxx	(0.441)	xxxx	

Chapter 6

Dynamic Characteristics of the Price-Consumption Subsystem

6.0 Introduction

In Chapter 1, I defined the price-consumption subsystem

as the system of equations which generates intermediate

term movements in the price and consumption rate of cocoa in

response to annual variations in cocoa production (or better,

monthly variations in cocoa sales and production forecasts).

Figure 6-1 repeats the structure of the price-consumption

subsystem from Figure 1-1, and indicates the points where

the influences which will here be considered exogenous drive

the subsystem.[1] In the two preceding chapters I obtained

estimates of the three basic equations which comprise the

subsystem, namely those determining the cocoa price, world

cocoa consumption, and forecasts of old and new calendar

year consumption, all on a monthly basis. In this chapter

I shall first indicate the way in which these estimated

equations fit together to provide a model suitable for

---

[1]To the extent that current planting is influenced by recent
cocoa prices, the level of cocoa trees and in turn the
current production rate, sales rate, and production expec-
tations are not in fact exogenous in the long run. But
these variables can be considered as being exogenous in an
examination of intermediate term price and consumption
dynamics due to the long distributed lag (having an average
lag time of some 10 years) in the maturing of cocoa trees.
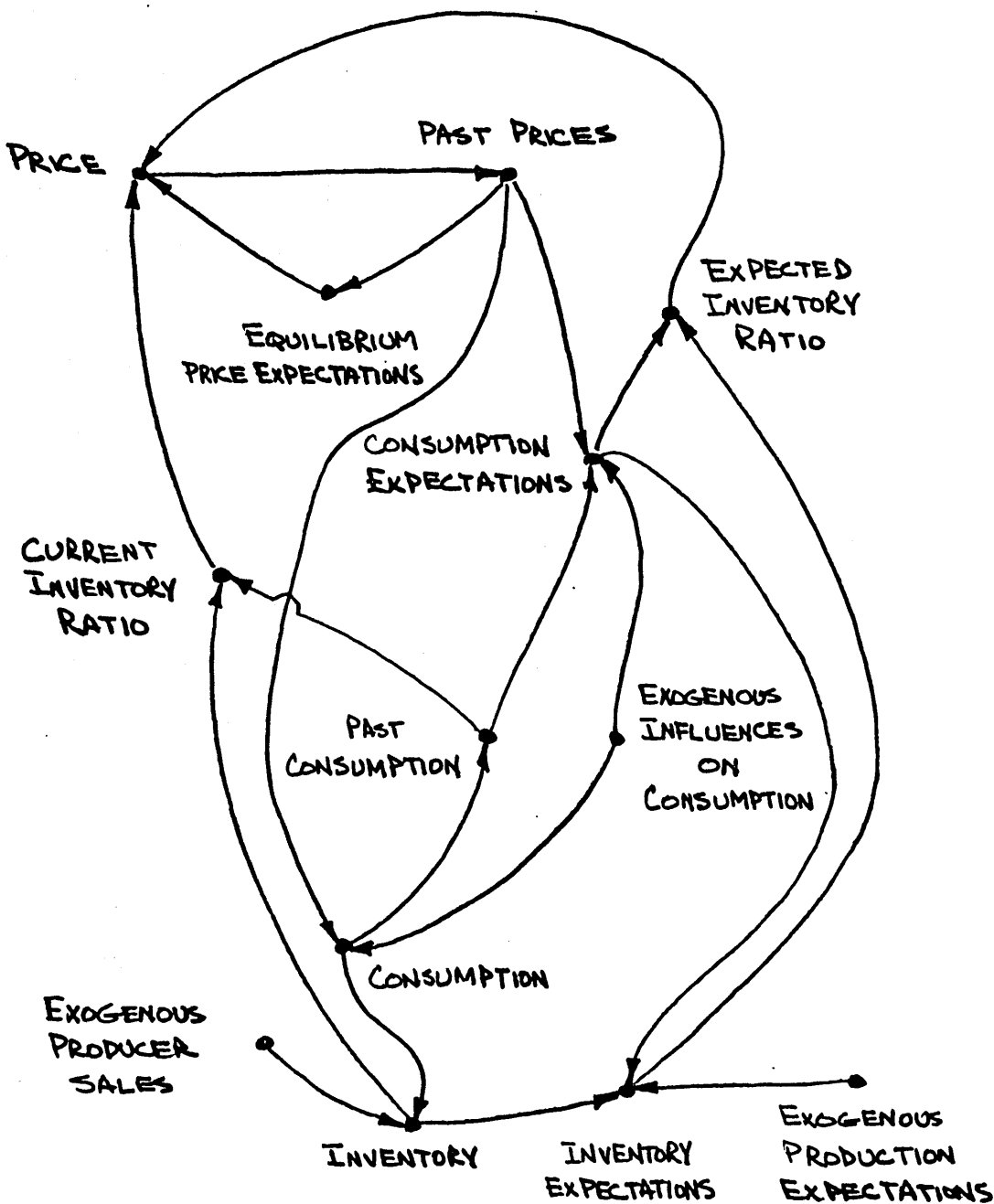
FIGURE 6-1 THE PRICE-CONSUMPTION SUBSYSTEM

generating simulations of the dynamic behavior of the actual
price-consumption subsystem. We shall then be in a position
to study the dynamic response of the model (and by inference,
the response of the actual subsystem) to various time patterns
in the exogenous variables. There are two broad benefits
to be gained from pursuing such a course.

First, observation of the model's response to the actual
exogenous influences (or estimates thereof) over a given
interval provides a qualitative test of the validity of the
complete set of equations comprising the estimated subsystem.
The simplest and perhaps most meaningful form of this test
involves an instructed comparison of the responses of the
actual and estimated subsystems to the given exogenous time
series. For example, in the context of Figure 6-1, we have
monthly data for the exogenous production variables (sales
and crop expectations), and for the exogenous influence on
consumption, over the 11 year period from September, 1952,
through August, 1963. These time series can be used to
drive the estimated subsystem, yielding a dynamic simulation
of the actual subsystem's behavior over the specified inter-
val. Comparisons can then be made between the simulated
and actual behavior of the observable variables (i.e. price,
consumption, inventories, etc.).

To be useful in judging the validity of the estimated
subsystem, these comparisons between simulated and actual

output should focus on those output characteristics which most clearly reflect the "natural"[1] dynamic behavior generated by the subsystem's structure. The primary such output characteristics are the phase relations between the various exogenous and endogenous variables, as well as the amplitudes of the endogenous variables. The greater the similarity between the corresponding phase and amplitude characteristics of the simulated and actual responses, the more likely it is that the estimated subsystem is a valid representation of the actual subsystem. This test is qualitative in the sense that to my knowledge there exist no meaningful formal tests of such similarity along the lines of statistical hypothesis tests.[2] The test provides information beyond the usual statistical tests on the individual equations comprising the

---

[1]The "natural" behavior characteristics of a dynamic system are, in the case of a linear system of differential equations, the time-related characteristics of the homogeneous solution of the system. These consist of such periodicities and real exponential time constants as are embodied in the homogeneous solution, which in turn determine the phase and amplitude characteristics of the system's response to a given exogenous input.

[2]One obvious quantitative measure of output similarity is the correlation coefficient between corresponding actual and simulated time series (e.g. the correlation coefficient between the actual and simulated price series). If this is quite high, say greater than 0.9, it does provide a tangible indication of similarity. But if it is low, it may only reflect a relatively minor phase difference between the actual and simulated responses, or it may reflect a fundamental error in the estimated subsystem. It is in this respect that a qualitative comparison of phase and amplitude characteristics provides a richer and more meaningful test.

subsystem in that it deals with the complete set of inter-

relations between the subsystem variables.[1]

For example, conventional hypothesis testing procedures

might indicate a statistically significant relation whereby

current consumption is a function of current price, when in

fact consumption is a function of a distributed lagged

version of price, with an average lag time of several

months. Such a situation might arise if price plays a very

important role in determining consumption, and if the price

series is highly autocorrelated (both of these stipulations

hold in the case of cocoa). While conventional hypothesis

testing procedures might accept the no-lag relation, a

comparison of actual behavior with the simulated behavior

generated by the estimated subsystem would show noticeable

phase and amplitude differences.[2]

Confirmation that the estimated equation structure

provides an acceptable representation of the actual set of

relations opens the door to the second benefit to be gained

from studying the dynamic behavior of the estimated price-

---

[1]On the other hand, insofar as the simulation covers the same
period used to generate the equation estimates, the test is
not as informative as it otherwise might be.

[2]Forrester (1; p. 104, p. 118) makes a similar point regarding
the omission of explanatory variables, as opposed to the mis-
specification of included explanatory variables. It can be
argued that any specification error in an individual
estimated equation will show up in the form of serially
correlated residuals, and that in this sense simulation does
not contribute any new information. All that can be said
is that simulation provides an additional indication of the
importance of any specification errors in the individual equa-
tion estimates.

consumption subsystem. This benefit takes the form of an

increased understanding of the natural dynamic behavior of

the actual subsystem, which understanding can be used, if

certain requirements are met, to predict the dynamic

characteristics of the subsystem's response to wide ranges

of behavior in the exogenous variables.[1]

Any non-trivial system of differential equations (or

its difference equation approximation), when driven by a

given exogenous random time series (noise), will tend to

"filter" the broad spectrum of periodic components which

comprise the noise series[2] in such a way that the compo-

nents at some periodicities are amplified more or attenuated

less than the components at other periodicities. If the

filtering process for a particular system is quite selective,

such that the components within a relatively narrow range of

periodicities are amplified much more than components out-

side of that range, then the system is said to have a natural

period.[3] Because of the selective filtering process, the

---

[1] Many good references exist on the basic theory of linear and non-linear systems. I have found the text by Mason and Zimmerman (2; especially Chapters 6-8) to be quite useful.

[2] The noise spectrum is given in terms of component frequencies by the Laplace transform of the noise time series. Since the period of a spectral component is merely the inverse of its frequency, the further transformation required to give the spectrum in terms of component periods is trivial. Discussions of noise are in-cluded in Forrester (1; pp. 412-415) and Mason and Zimmerman (2; pp. 269-287).

[3] In terms of the homogeneous solution of a system of linear differential equations, the natural period of the system is the period of any relatively undamped periodic term in the solution. Thus it is possible, even likely given a complex system structure, for a system to have more than one natural period.

noise driven response of a naturally periodic system will itself show the natural period of the system in the sense that the time intervals between successive major peaks and troughs will remain fairly constant.

If a system is linear, the nature of its filtering process is independent of the dynamic characteristics of its exogenous variables (e.g. the variance of a noise series). On the other hand, as a system becomes increasingly non-linear, its filtering characteristics become increasingly dependent on the nature of its exogenous input. Thus the degree of non-linearity of a system limits the degree to which one can generalize about the characteristic response of a system to broad classes of exogenous disturbances. By driving the estimated price-consumption subsystem with various test inputs we shall be able to determine the degree to which it is approximately linear, and within the limits of this approximation, to determine the characteristics of the subsystem's filtering process. These characteristics are of interest because they contribute to a fuller under-standing of the observed behavior generated by the actual cocoa price-consumption subsystem.

6.1 The Estimated Subsystem

The subsystem structure indicated in Figure 6-1 is centered around the three basic equations estimated in the

preceding chapters, namely the equations defining price,

consumption, and consumption expectations. The remainder

of the subsystem's structure is implied by the nature of

the three estimated equations. Once we have specified the

subsystem's structure, then we can drive it with various

sets of initial conditions and exogenous inputs and study

the resulting dynamic behavior of the endogenous variables.

<u>6.1.1 Price Equation</u> -- The basic price formulation

is given by equation 56 (coupled with equation 57 and put

in the format of equation 45) in Chapter 4, and is repeated

here for convenience together with its subsidiary relationships:

$$\ln(\frac{\bar{P}}{P_t}) = .508 + .0092h_t + .0209Z_t + .5241\ln Y_t^{*ht} - 25.7\sum_i a_i^* (\frac{\Delta\bar{P}}{P}) \quad (1)$$

$$Z_t = \sum_h c_h + (\sum_h d_h) \ln Y_t + (\sum_h e_h) \ln Y_t^{*ht} \quad (2)$$

$$
\begin{aligned}
h_t &= \text{12 in September} \\
h_t &= \text{11 in October} \\
&\vdots \\
h_t &= \text{1 in August}
\end{aligned}
\quad (3)
$$

where,

P	=	Real spot Accra in New York
h	=	Horizon interval
Z	=	Variable defined in equation 15, Chapter 4
Y	=	Current inventory ratio
Y^{*h}	=	Expected inventory ratio at end of horizon interval, h
$\frac{\Delta\bar{P}}{P}$	=	Group averages of lagged fraction price rate of change
$\bar{P}$	=	Postwar average P, 35.2 cents per pound
a^*	=	Lag weighting coefficients given in Table 4-4
$\left.\begin{array}{c}c_h \\ d_h \\ e_h\end{array}\right\}$	=	Seasonal coefficients given in Table 4-2

The inventory ratios, along with the corresponding inventory

levels, were defined in Appendix A of Chapter 4,

$$Y_t = \frac{I_t}{\sum_{i=t-11}^{t} c_t} \tag{4}$$

$$I_t = I_{t-1} + .99\, s_t - c_t \tag{5}$$

$$Y_t^{*ht} = \frac{I_t^{*ht}}{c_t^*} \tag{6}$$

$$I_t^{*ht} = I_t^{nb} + .99\, s_t^* - c_t^* \tag{7}$$

$$I_t^{nb} = I_{t-1}^{nb} + .99\, s_t^{no} - c_t^o \tag{8}$$

$$s^{no} = 0.907\, o_t^o + 0.093\, o_t^n \tag{9}$$

where,

I	=	Current inventory
c	=	Monthly consumption rate
s	=	Monthly producer sales rate
I^{*h}	=	Inventory expected at end of horizon interval, h
c^*	=	Expected consumption over new crop year
s^*	=	Sales expected over new crop year
I^{nb}	=	Estimated normal inventory, beginning of current crop year
s^{no}	=	Estimated normal sales, old crop year
c^o	=	Actual consumption, old crop year
o^o	=	Actual production, old crop year
o^n	=	Actual production, new crop year

6.1.2 Consumption Equation -- Equation 15 in Chapter 5

gives the linear exponential growth format of the monthly

consumption rate,

$$\ln c_t = k_i - .00720\ P_t^L + .00206\ t \tag{10}$$

where,

c = Monthly consumption rate

P^L = Lagged prices, using lag coefficients given in Figure 5-4

t = Time, in months

k_i = Seasonal constants given in Table 5-4

The alternative format which seems more effectively to

represent the exogenous time related influences on consump-

tion for the 1952-63 interval is given by equation 18 in

Chapter 5,

$$\ln c_t = k_i - .00670\ P_t^L - .000518\ t + .0000198\ t^2 \tag{11}$$

where,

k_i = Seasonal constants given in Table 5-4

6.1.3 Consumption Expectations Equations -- As indi-

cated by equations A-5 and A-6 in Appendix A of Chapter 4,

consumption expectations for the new crop year (used in

equation 7, above) can be derived from the consumption

expectations for the old and new calendar years,

$$c_t^* = (f_{4,t}^{*o})(c_t^{*o}) + (\overline{f}_{1-3})(c_t^{*n}) \tag{12}$$

$$f_{4,t}^{*o} = (w_t^o)(f_4^o) + (1-w_t^o)(\overline{f}_4) \tag{13}$$

where,

c^* = Expected new crop year consumption

c^{*o} = Estimated old calendar year consumption

c^{*n} = Expected new calendar year consumption

f_4^{*o} = Estimated fraction of old calendar year grind ground in fourth quarter

f_4^o = Actual fraction of old calendar year grind ground in fourth quarter

$\overline{f}_{1-3}$ = Average fraction of calendar year grind ground in first three quarters (= .731)

$\overline{f}_4$ = Average fraction of calendar year grind ground in fourth quarter (= .269)

w^{*o} = Weighting function described in Figure 6-2
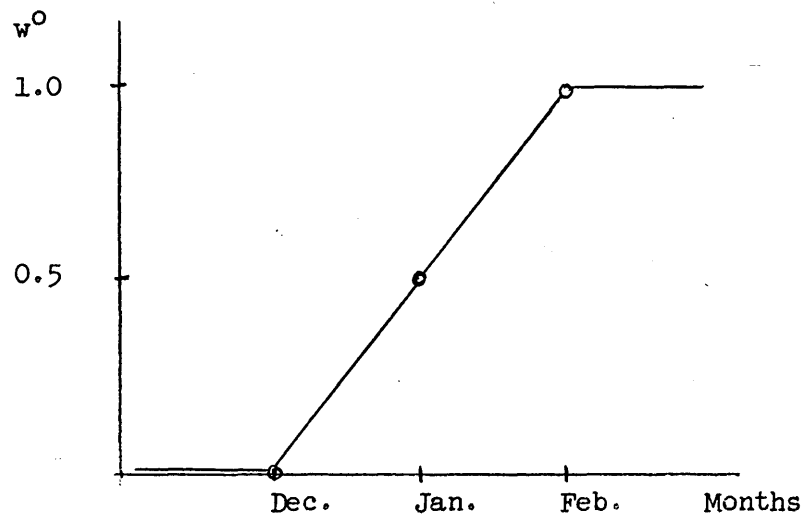
Figure 6-2: Weighting Function

In Chapter 4 we had available from historical data the actual
quarterly grind fractions, and used these in generating the
series of new crop year consumption forecasts, even though
these fractions were not yet knowable as such to the trade
at the times at which the forecasts were supposed to have
been made. The assumption made there was that the trade is
generally able to make reasonably close estimates of these
fractions. Here, where we will be using the equations to
generate sequential dynamic simulations, we are modifying
this procedure somewhat by initially using the average
quarterly grind fractions, and then, using the weighting
function indicated in Figure 6-2, phasing into the actual
old year fourth quarter grind fraction after it becomes
available.

The calendar year consumption estimates depend on
one another and on the fraction consumption change estimates
as discussed in Chapter 5.

$$c_t^{*n} = (1 + G_t^{*n})(c_t^{*o}) \tag{14}$$

$$c_t^{*o} = (1 + G_t^{*o})(c_t^{*oo}) \tag{15}$$

$$c_t^{*oo} = (w_t^{oo})(c_t^{oo}) + (1 - w_t^{oo})(c_L^{*o}) \tag{16}$$

$$w_t^{oo} = (13 - h_t) / 12 \tag{17}$$

where,

c^{*n} = Expected new calendar year consumption

c^{*o} = Estimated old calendar year consumption

c^{*oo} = Estimated old, old calendar year consumption

c^{oo} = Actual old, old calendar year consumption

c_L^{*o} = Old calendar year consumption estimate made in preceding August

G^{*n} = Expected fraction change in new calendar year consumption

G^{*o} = Estimated fraction change in old calendar year consumption

w^{oo} = Weighting function

h = Horizon interval (see equation 3)

The old calendar year consumption estimate made in the preceding August (c_L^{*o}) is the last old year estimate of consumption covering what is now the old, old year. Equations 16 and 17 generate an old, old year consumption estimate which smoothly shifts from c_L^{*o} at the beginning of the crop year, to the actual old, old consumption figure at the end of the crop year, reflecting the assumption that by the end of the crop year the existing estimate of calendar year consumption two years back will be reasonably accurate.

The fraction consumption change estimates are then
given by equations 25 and 26 in Chapter 5,

$$G_t^{*n,o} = d_{2,i}\overline{G}^* + d_{2,i}(1-d_{1,i})E^*P_t^A + (1-d_{2,i})c_t^A \qquad (18)$$

where,

$G^{*n,o}$ = Expected fraction changes in new and old calendar year consumption

P^A = Relevant average fraction change in price

c^A = Relevant average fraction change in consumption

$\left.\begin{array}{c}d_1\\d_2\end{array}\right\}$ = Weighting coefficients given in Table 5-8

$\overline{G}^*$ = Estimated average consumption growth rate (= .0277)

E^* = Estimated average price elasticity of consumption (= -.252)

6.2 Response of the Estimated Subsystem to the Actual Exogenous Series

In order to use the estimated price-consumption subsystem to simulate cocoa market behavior over the September, 1952, through August, 1963, period, we will need estimates of the initial conditions describing the state of the subsystem at the beginning of the simulation, along with data for the exogenous inputs to the subsystem.

6.2.1 Exogenous Inputs -- We have available data for the three exogenous inputs indicated in Figure 6-1:

a) Producer sales -- This time series enters into the system in equation 5, and is given in Table A-4 in Appendix A of Chapter 4.

b) <u>New crop production (or sales) forecasts</u> --

Given in Table A-6 of the same appendix, these forecasts

are used in equation 7.

c) <u>Exogenous demand influences</u> -- The two estima-

ted versions of the monthly cocoa consumption function

(equations 10 and 11) contain two different estimates of the

exogenous demand influences over the period in question,

one involving linear exponential growth, the other non-

linear exponential growth.

6.2.2 <u>Initial Conditions</u> -- The following initial

conditions are required by the subsystem equations:

a) P_{t-i}, the 81 past monthly average real spot Accra

prices (running from December, 1945, through August, 1952)

some or all of which are needed in calculating $\frac{\Delta \bar{P}}{\bar{P}}$ in

equation 1, P^L in equations 10 and 11, and P^A in equation 18.

These will be set equal to the corresponding actual histori-

cal prices.

b) c_{t-i}, the 11 past values of monthly consumption

running from October, 1951, through August, 1952, required

in equation 4 and for the calculation of f_4^o in equation 13

and of c^A in equation 18. Using the above price data we

can calculate initial estimates of these monthly consumption

rates via equation 10. The final monthly estimates will then

be set equal to these initial estimates adjusted via a multi-

plier such that the summed final estimates (plus a similar

estimate for September, 1952 consumption) equal 726,000 tons, the

estimated total consumption level for the fourth quarter of 1951

and the first three quarters of 1952. The 726,000 ton estimate

is based on the actual consumption figures for 1951 and 1952

(750,000 and 717,000 tons, respectively), and the assumption

that both of these years followed the normal seasonal pattern

whereby 26.9 percent of annual consumption is consumed in the

fourth quarter (i.e. (.269) (750) + (.731) (717) = 726).

c) I_1, the world inventory level at the end of September,

1952, used in equation 5. This will be set equal to the 257,000

ton derived in Section 2.3 of Appendix A of Chapter 4.

d) I_1^{nb}, the normal beginning inventory level for the 1951-

52 crop year, used in equation 8. This will be set equal to

301,000 tons, which via equation 8 yields an I^{nb} value of

257,000 tons (the I_1 value) during the 1952-53 crop year. The

argument for assuming that I^{nb} equals I_1 during that crop year

was given in Section 3.3 of Appendix A, Chapter 4.

e) c_i^{*oo}, the old, old year estimate of calendar 1951

consumption, required by equation 15. As mentioned above,

actual 1951 consumption totalled 750,000 tons. If, as would be

the obvious assumption, this figure is used as the simulated

old, old year estimate of 1951 consumption, the initial

simulated forecasts of 1952 and 1953 consumption generated

by equations 14 and 15 are 785,000 tons and 805,000 tons, respec-

tively, which forecasts compare with the corresponding Gill and

Duffus forecasts (constructed) of 675,000 tons for both years

(see Table A-5 in Appendix A of Chapter 4). The problem as

indicated by the historical notes in the appendix of Chapter 2, is that the consumption forecasts made by Gill and Duffus (and the cocoa trade in general) in late 1952 and early 1953 were distorted by the vagaries of control and decontrol of confectionary consumption in the United Kingdom during the Korean War period, and by the apparent effects of the war itself on cocoa consumption. Put another way, the basic assumption embodied in equation 18 (i.e. the assumed absense of structural shifts in demand) was violated during this period.[1] We are faced with three alternatives: (1) set the c^{*oo} value for 1951 at 750,000 tons, the actual 1951 consumption level; (2) reduce the c^{*oo} value for 1951 to a point yielding initial simulated forecasts of 1952 and 1953 consumption close to the actual forecasts of 675,000 tons; (3) start the simulation at a later point. We shall reject the first alternative on the grounds that it represents an obvious distortion of the actual situation, since it yields initial consumption forecasts for 1952 and 1953 over 100,000 tons in excess of the corresponding forecasts indicated by the data. Instead, we shall choose the second alternative, and in so doing shall in a sense be choosing at least an approximation of the third alternative as well.

---

[1] No consumption forecasts from 1952 and the first three quarters of 1953 were included in the regressions on which equation 18 is based.

The C^{*oo} value to be used for 1951 will be 630,000

tons, yielding initial forecasts for 1952 and 1953 consump-

tion of 662,000 and 677,000 tons respectively. The reason

why this specification (or the specification of any other

broadly reasonable initial condition(s)) provides at least

a close approximation of starting the simulation at some

point later than September, 1952, arises from the feedback

nature of the price-consumption subsystem. The subsystem is

basically a feedback control mechanism, the function of

which is to keep consumption in line with producer sales.

If the estimated subsystem is a reasonable representation

of its actual counterpart, then it will generate simulated

behavior (i.e. price, inventory, etc. behavior) similar to

observed actual behavior when driven with the observed

data for the exogenous variables. Distortions in the initial

conditions will lead to temporary distortions early in the

simulation, but the feedback control process should lead to

a convergence on the actual behavior pattern if the model

is reasonably accurate. The rapidity of this convergence

increases with the degree of damping in the subsystem's

characteristic dynamic behavior.

6.2.3 The Simulations -- Figure 6-3a shows the simulated

behavior generated by the estimated price-consumption subsystem

incorporating the linear exponential growth version of the

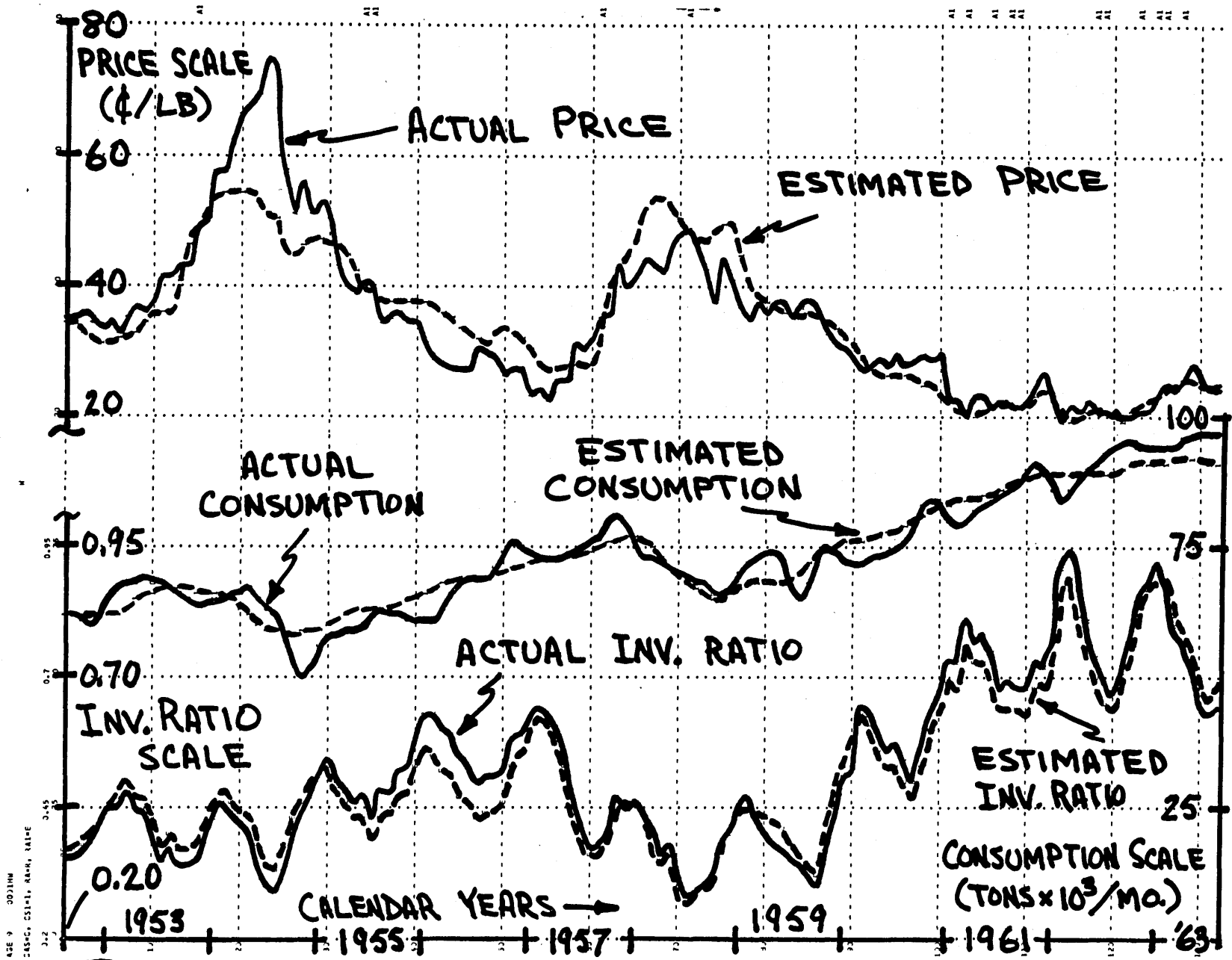monthly cocoa consumption function (equation 10). The simulated

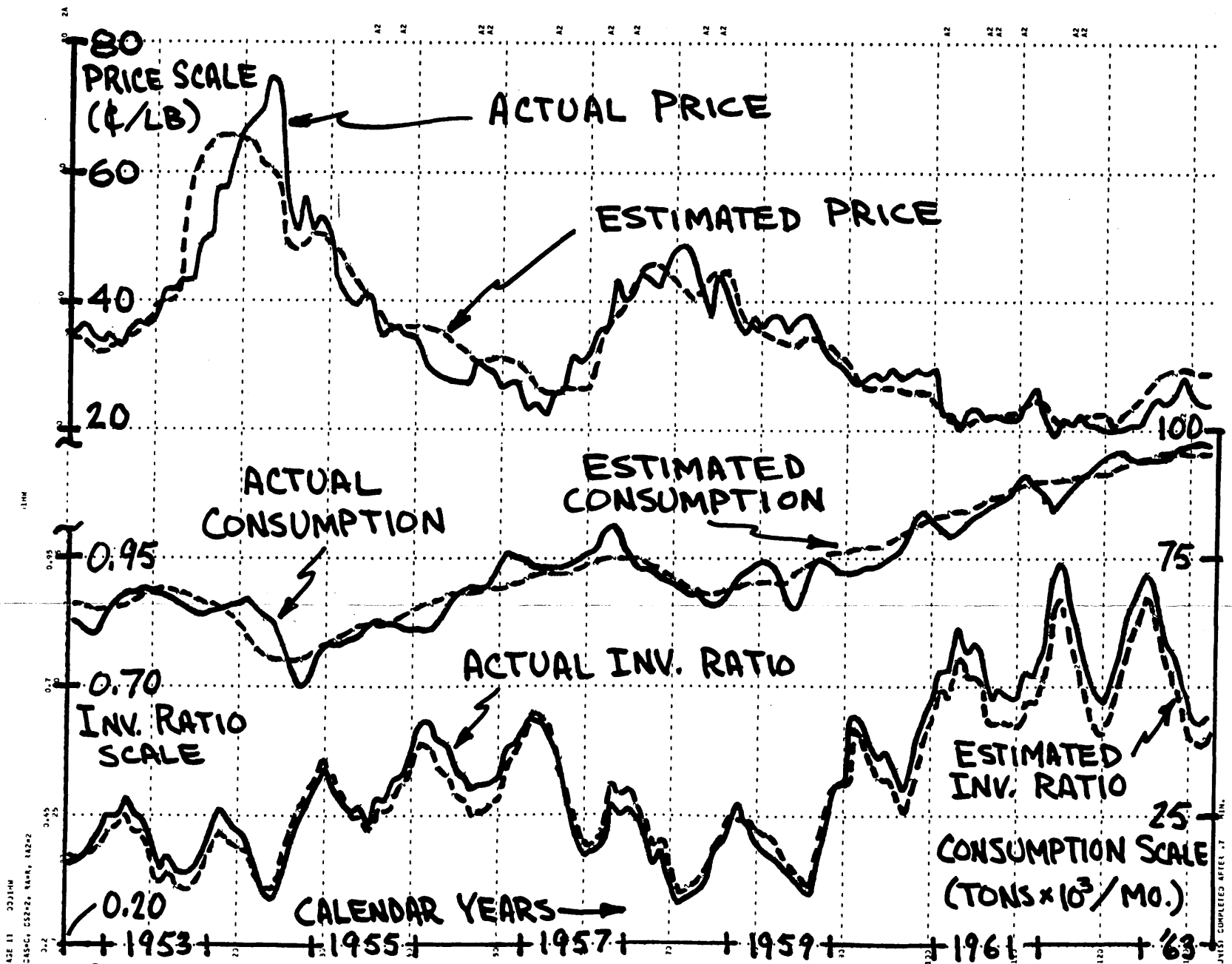FIGURE 6-3a -- ACTUAL VS. SIMULATED VARIABLES, LINEAR GROWTH

FIGURE 6-3b -- ACTUAL VS. SIMULATED VARIABLES, NONLINEAR GROWTH

variables shown, along with the corresponding actual data, are price, the current inventory ratio, and seasonally adjusted monthly consumption, with the seasonal adjustments made along the lines indicated in the footnote to Table 5-4. Two protracted periods involving noticeable discrepancies between simulated and actual behavior are evident in Figure 6-3a. During the period from September, 1952 (the start of the simulation), to February, 1955, the simulated price level is consistently lower than the actual price level. Then, starting in August, 1955, and running through February, 1959, there is a persistent tendency for the simulated price to be relatively high.

The relatively low simulated prices during the earlier period can be traced largely to the temporarily high actual consumption rate associated with decontrol in the United Kingdom in early 1953. This exogenously caused actual consumption bulge is not well represented by the linear exponential growth version of the consumption equation, as evidenced by the series of positive consumption residuals (i.e. actual consumption minus estimated consumption) during the early portion of Figure 5-2a. The relatively low simulated consumption rate early in the simulation leads not only to a relatively high early simulated current inventory ratio, but also, via consumption expectations, to a relatively high simulated expected inventory ratio. Both of these deviations contribute to the tendency for the simulated price

to remain below the actual price.

The discrepancy between simulated and actual behavior becomes particularly noticeable when, in March, 1954, simulated consumption begins its sharp decline in response to the earlier price increase, two months before the beginning of the corresponding decline in actual consumption. The unusually long lag in the actual consumption response to the 1953-54 price rise was attributed at the time to the continued and unusual increase in U.K. cocoa demand as an aftermath of decontrol (see the Chapter 2 appendix). If this interpretation is correct, the deviation between simulated and actual behavior in 1954 and early 1955 continues to reflect a poor portrayal of exogenous demand influences. An alternative interpretation, representing a qualification on the validity of the estimated price-consumption subsystem, is that the seven month average lag in the estimated price effect on consumption is too short, at least for this interval in the cocoa market's history. In any case, the relatively early decline in simulated consumption causes the simulated price to reach its peak at 55 cents per pound in March, 1954, which compares with the actual price peak of 74 cents per pound reached in July.

As a result of the relatively early and low simulated price peak, simulated consumption during late 1954 and early 1955 rises substantially above actual consumption, causing

a rapid closing and eventually a reversal of the gap between the simulated and actual current inventory ratios. By the middle of 1955 the discrepancy between simulated and actual behavior arising from the early misrepresentation of the exogenous demand influences appears to have run its course.

The second period of protracted deviation between actual and simulated behavior, wherein the simulated price persistently remains above the actual price, begins in the second half of 1955, and runs into early 1959. This error pattern can again, and somewhat more clearly, be ascribed to the poor estimate of exogenous demand influences embodied in the linear growth version of the consumption equation. Simulated consumption during most of this interval remains at or above the actual consumption rate, despite the existence of simulated prices in excess of actual prices. As before, evidence of misrepresentation of the exogenous demand influences is provided by the residuals (now predominantly negative) during the 1955-59 period shown in Figure 5-2a.

The role played by the defects in the linear exponential growth version of the cocoa consumption function is made clearer by a comparison of Figures 6-3a and 6-3b, where the latter shows the behavior of the estimated subsystem incorporating the non-linear consumption equation (equation 11). The higher early simulated consumption rate (which more closely

approximates the effect of decontrol in the U.K.) leads to
higher early simulated prices. The simulated price rises
more rapidly than the actual price in the fall of 1953 for
two reasons: (1) the initial simulated forecast of 1954
consumption (made in September, 1953) is some 30,000 tons in
excess of the corresponding actual forecast; and (2) as
indicated in Figure 4-4b, the regression price estimate
tends to lead the actual price during most of the 1953-54
bull market, so that even if the simulated current and
expected inventory ratios were exactly in line with the
actual data, the simulated price would tend to rise earlier
than the actual price during this period. The relatively
early simulated price rise (coupled perhaps with a too
short specification of the price-consumption time lag) leads
again to a relatively early decline in consumption and con-
sumption expectations, and in turn to an early and somewhat
low price peak (66 cents per pound in January, 1954, versus
74 cents per pound in July). After this initial distortion
(which in any case is not as severe as the distortion in
the first simulation) has run its course, the behavior of the
estimated price-consumption subsystem rather closely approxi-
mates that of its actual counterpart. The only exception
occurs near the end of the simulation, when there is a ten-
dency for the simulated current inventory ratio to remain
somewhat low, and for the price to remain a bit high.

Even given the discrepancies noted above, the most
striking qualitative characteristic of the simulated
behavior patterns shown in Figures 6-3a and 6-3b, especially
the latter, is the degree of similarity between these simu-
lated patterns and the corresponding actual behavior patterns.
The general similarity between the simulated and actual
variations in consumption is required by the basic feedback
control nature of the price-consumption subsystem, and is
not to be taken as an important indication of the validity
of the estimated subsystem. Any persistent tendency for
simulated consumption to exceed actual consumption would lead
to a decline in the simulated inventory level relative to
the actual level (since the producer sales rates flowing into
both inventories are identical), which would cause a rela-
tive price increase and in turn a reduction in simulated
consumption toward the actual consumption level. The converse
of this process also pertains. The interesting and meaning-
ful fact is that the similarity in the simulated and actual
consumption patterns is accompanied by simulated price and
inventory behavior which is also largely similar to the
corresponding actual variations. Within the qualifications
provided by the above noted discrepancies, the general
qualitative similarity between the simulated and actual
behavior patterns provides additional evidence, beyond that
provided by the statistical tests on the individual equations,

of the relative validity of the combined estimated re-
lationships as a description of the actual cocoa price-con-
sumption subsystem.

6.2.4 The Sales-Consumption Cross-Covariance Function --
The above qualitative comparisons between the simulated and
actual behavior patterns concentrated on certain intervals
within the total eleven year data period, during which inter-
vals various differences between the two behavior patterns
were particularly evident. It would be useful if we could
devise a comparison procedure which would at the same time
be both less qualitative, and more general, in the sense of
referring to the whole data period rather than only certain
intervals within the period.

One comparative measure shedding additional light
on the degree of similarity (or lack of it) between the
simulated and actual behavior averaged over the total data
period is the cross-covariance function between the exo-
genous producer sales rate (the flow of cocoa into the
system) and the endogenous monthly consumption rate (the
flow of cocoa out of the system), evaluated at shift times
such that consumption is lagged relative to sales. This
function is defined,

$$F(L) = \frac{1}{n-L} \sum_{t=1}^{n-L} (s_t - \bar{s})(c_{t+L} - \bar{c}) \qquad (19)$$

where, $L \geq 0$ $n = 132$

and where,

     t = Time, in months ($t=1$ in September, 1952)

     L = Shift time, in months

     s = Monthly producer sales

     c = Monthly consumption rate

Figure 6-4 shows the actual and simulated cross-covariance functions for positive shift times up to 40 months, where the simulated consumption rate is that shown in Figure 6-3b (i.e. seasonally adjusted consumption generated using the non-linear version of demand growth), and where the exogenous sales rate has also been seasonally adjusted.[1]

As has already been observed, the price-consumption subsystem is a feedback control system, the function of which is to keep consumption in line with producer sales. The sales-consumption cross-covariance function for relatively small positive shift times indicates the nature of the average consumption response to short term variations in sales.[2]

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[1] Using the average seasonal sales pattern indicated in Table 6-1 presented in the next section.

[2] Implicit in this statement is the assumption that the relationship between sales and production expectations is time invariant, since crop expectations also influence consumption via their effects on the cocoa price.

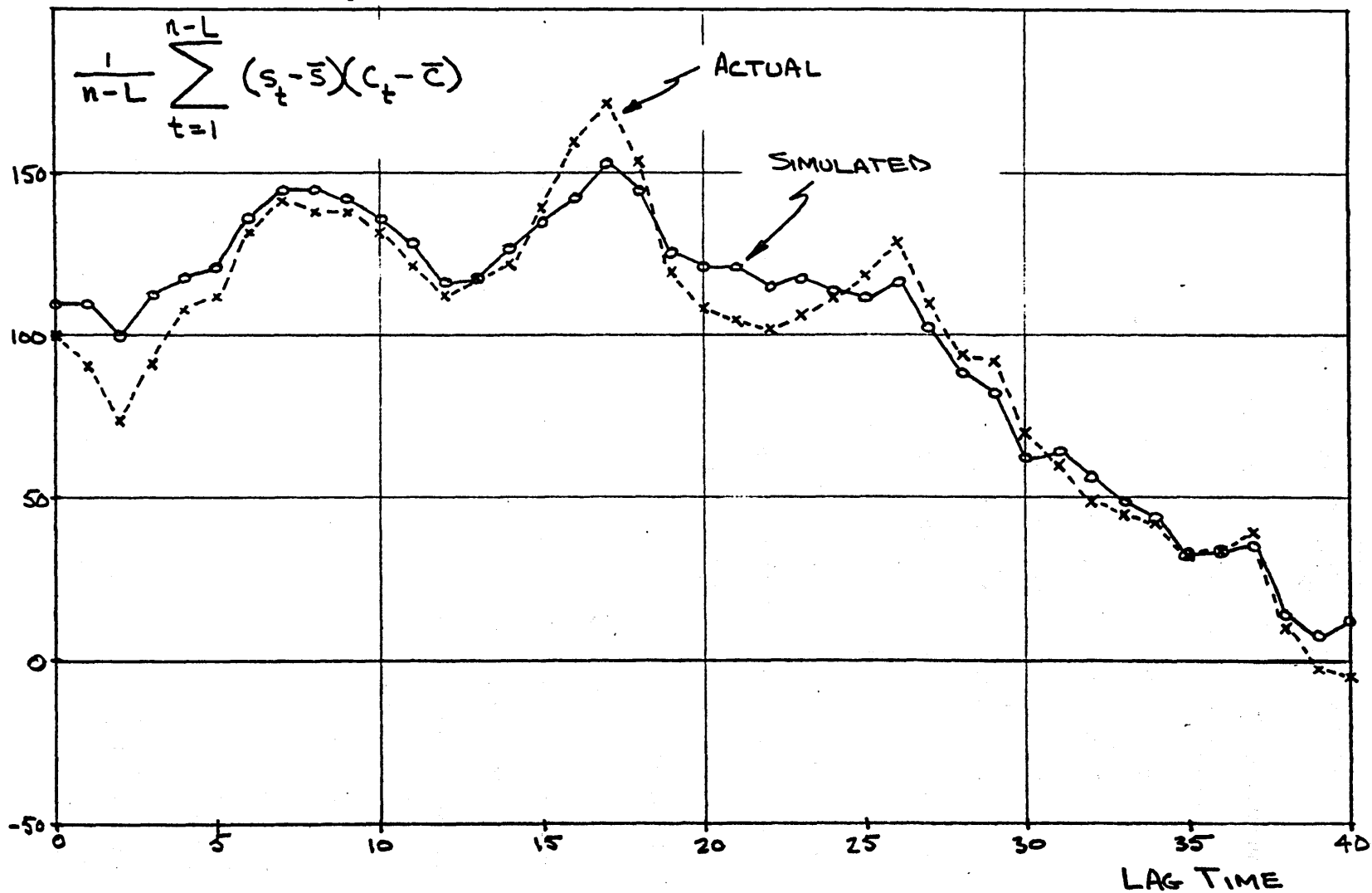$$\frac{1}{n-L}\sum_{t=1}^{n-L}(s_t-\bar{s})(c_t-\bar{c})$$

FIGURE 6-4   SIMULATED VS. ACTUAL CROSS-CORRELATION FUNCTIONS

In particular, the timing of the peak in the function is indicative of the overall lag incurred in the consumption adjustment process. As indicated in Figure 6-4, the simu- lated and actual sales-consumption cross-covariance functions are highly similar in their shapes and in the timing of their peaks (indicating an average adjustment lag of approximately 17 months), thus providing a further confirmation of the rela- tive validity of the estimated price-consumption subsystem.

6.3 Natural Dynamic Characteristics of the Subsystem

With the essential validity of the price-consumption subsystem model established, we are now in a position to move on to an investigation of the dynamic properties of the model and, by inference, of the actual subsystem. The general pro- cedure to be followed will be to establish a steady state growth pattern in the exogenous production variables (i.e. sales and production forecasts) and in consumption, which in turn will generate corresponding steady state behavior in the endogenous variables. We can then perturb the system with various specific deviations from steady state in the exogenous variables, with these deviations chosen so as to indicate the subsystem's dynamic properties of interest.

6.3.1 Steady State Exogenous Inputs -- One plausible long term growth pattern in production and consumption is that of linear exponential growth, such as that specified in equation

10 for consumption. Accordingly, equation 10 will be used in

the dynamic simulations in this section,[1] so that the exogenous

growth rate (for both consumption and production) will be set

at 2.472 percent per annum.

The initial crop size will (arbitrarily) be set at 800,000

tons, and the sales pattern for each crop will follow the 1952-

1963 average seasonal sales pattern indicated in Table 6-1.

Finally, new crop sales expectations will be assumed to make

a smooth transition during the early part of each crop year,

from an extrapolated version of the previous crop, to the

actual value of the current crop.

Table 6-1   Average Seasonal Sales Pattern
              (fraction of each crop sold per month)

Forward Sales		Sales Within Crop Year			
		October	.099	April	.054
August	.042	November	.130	May	.057
September	.051	December	.129	June	.038
		January	.129	July	.037
		February	.105	August	.030
		March	.084	September	.015

[1]It is true that the equation 11 format for consumption yields a
better simulated response to the actual production series over
the 1952-63 interval than does the equation 10 format. But ap-
parently this primarily reflects a better representation of the
exogenous consumption influences over that interval, since the
endogenous relationship involved (i.e. the price influence on
consumption) is virtually unchanged between the two formats.

September - January: $\quad S_t^* = (1-.2i)(1+\bar{G}) O_t^o + (.2i) O_t^n \quad$ (20a)

February - August: $\quad S_t^* = O_t^n \quad$ (20b)

where,

$$
\begin{aligned}
i &= 1 \text{ in September} \\
i &= 2 \text{ in October} \\
&\vdots \\
i &= 5 \text{ in January}
\end{aligned}
$$

(20c)

and where,

$S^* \quad = \quad$ Expected sales, new crop year

$O^o \quad = \quad$ Actual production, old crop year

$O^n \quad = \quad$ Actual production, new crop year

$\bar{G} \quad = \quad$ Growth rate (= .02472)

6.3.2 Steady State Initial Conditions

-- The following set of initial conditions is such that if the above described exogenous growth trends in consumption and production are not disturbed, the price and the current and expected inventory ratios will remain approximately constant (apart from seasonal variations). The initial price and all past prices are equal to 31 cents per pound.[1] Any past monthly consumption rates needed for the calculation of other initial values (such as the value of C^{*oo} used in equation 15) are calculated from equation 10, with the price set at 31 cents. Finally, the initial values of the inventory level (I) and the normal beginning inventory (I^{nb}) are both set at 400,000 tons. While these

---

[1]This is the price level at which the first year's consumption rate is in approximate equilibrium with the specified initial crop size of 800,000 tons.

initial values are not perfect in the sense of not giving rise
to any early price and inventory deviations from the normal sea-
sonal patterns, such deviations as do occur are minor.

6.3.3 Gain Curve and Linearity -- As was suggested in
the chapter introduction, one of the fundamental descriptive
characteristics of a dynamic system is the degree to which it
tends to filter selectively various exogenous input periodi-
cities by amplifying some more than others. The filtering
characteristics of a system are of interest because they provide
a compact and meaningful generalization about the manner in which
the system is likely to respond to various classes of exogenous
disturbances, including both deterministic and stochastic
variations.

One quantitative measure of the filtering characteristics
of a system is provided by the "gain" function between two
variables in the system, one exogenous and called the input
variable, the other endogenous and called the output variable.
Various methods can be used to calculate such a gain curve,
including analytical solution in the case of relatively simple
linear systems. The method which we shall use is to set the
input variable equal to a sine wave with a specific amplitude,
and to measure the amplitude of the resulting output fluctu-
ations for various input periods. The gain function is then
defined:

$$G(T, A_I) = \frac{A_O(T, A_I)}{A_I} \qquad (21)$$

where,

G   =   Gain

T   =   Period of input sine wave

A_I =   Amplitude of input sine wave

A_O =   Amplitude of output fluctuations

If the system is linear the gain function is insensitive to variations in the input amplitude, and equation 21 can be rewritten,

$$G(T) = \frac{A_O(T)}{A_I} \qquad (22)$$

which holds for all values of A_I. The degree of linearity of a system can thus be determined by finding the degree to which the gain curve between two of the system's variables shifts for differing values of A_I. The greater the linearity of a system, the more one can generalize about its characteristic responses to broad classes of exogenous disturbances.

In calculating the filtering characteristics of the price-consumption subsystem we shall drive the subsystem via the monthly consumption rate by adding to the endogenously deter-mined consumption rate a sinusoidel component having a peak-to-trough amplitude equal to 10 percent of the trend consump-tion rate. That is, equation 10 will be modified in the following manner,

$$c_t = c_t^n + (A_I/2) \text{ SINE } (\frac{2\pi t}{T}) \; c_t^x \tag{23}$$

$$A_I = 0.10 \tag{23a}$$

$$c^n = \text{EXP } (a_i - .00720 \; P_t^L + .00206t) \tag{24}$$

$$c_t^x = \text{EXP } (a_i - .00720 \; \bar{P} + .00206t) \tag{25}$$

where,

c = Monthly world consumption rate

c^n = Endogenous consumption rate

c^x = Exogenous consumption trend

P^L = Lagged price

t = Time, in months

a_i = Seasonal constants

T = Input period

A_I = Input amplitude

$\bar{P}$ = Postwar average price level (= 35.2 cents per pound)

The output variable used in calculating the gain function will be the price logarithm. A separate simulation will be run for each of several input periods covering a broad range of periodicities, with the length of each simulation equal to six times the input period. The output amplitude will then be defined as the difference between the average of the six peak values of the price logarithm minus the average of the six trough values.

$$A_o = \overline{\ln P_P} - \overline{\ln P_T} \tag{26}$$

where,

A_o = Output amplitude

$\overline{\ln P_P}$ = Average peak price logarithm

$\overline{\ln P_T}$ = Average trough price logarithm

Figure 6-5 shows the variation of the gain thus defined, as a function of the input period. In the range of relatively short periods, the estimated price-consumption subsystem shows a tendency to filter out or suppress very short periods (roughly 24 months or less) and to some degree to amplify selectively periods in the 54 to 63 month range. Over the full range of periodicities, there is a marked tendency to amplify periods approximately 108 months or nine years in length. At periods greater than 14 years (168 months) the gain reaches a plateau[1]·at approximately 4.0. The essential linearity (in logarithms) of the estimated subsystem is evidenced by the fact that when A_I is increased from 0.10 to 0.20 (see equation 23), there is no noticeable shift in the gain curve, despite the fact that at the peak gain with the larger input amplitude, the price level varies from troughs of 17 cents per pound, to peaks of 57 cents per pound, covering most of the price range observed in the cocoa market since World War II.

6.3.4 Short Term Noise Response -- The tendency for the estimated subsystem to suppress very short period disturbances is indicated in Figure 6-6a, which shows the subsystem's response to a random exogenous consumption term. In particular,

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[1]For very long exogenous sine waves in consumption, the subsystem has time to make virtually complete adjustments to the alternating peaks and troughs in the exogenous consumption term. Given the price elasticity of demand of roughly -.25, 10 percent peak-to-trough variations in the exogenous consumption term are thus accompanied by approximately 40 percent variations in the price level. The semi-constant elasticity of demand explains why I chose the price logarithm rather than the price itself as the output variable.

-356-

$$GAIN = \frac{A_0}{A_I} \; ; \; FOR \; A_I = .10 \; AND \; .20$$
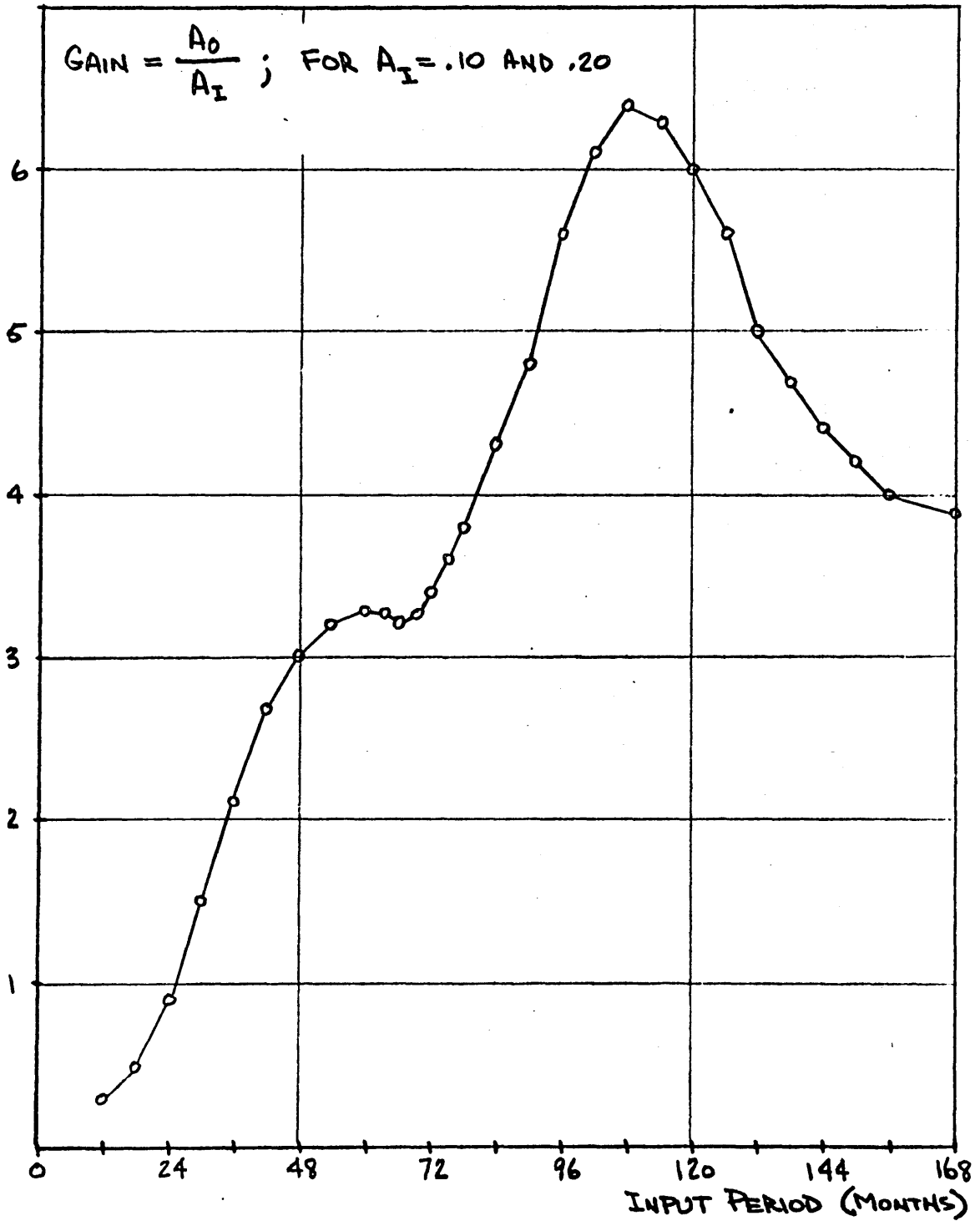
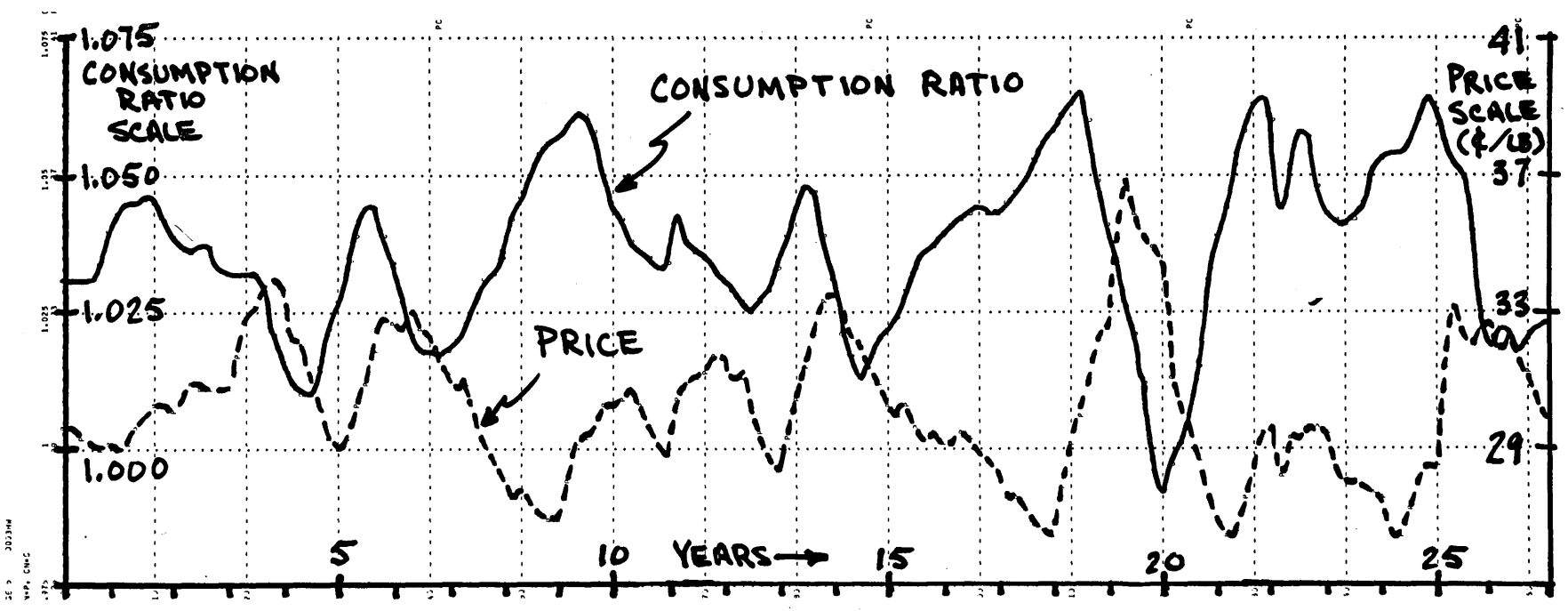INPUT PERIOD (MONTHS)

FIGURE 6-5   GAIN CURVE

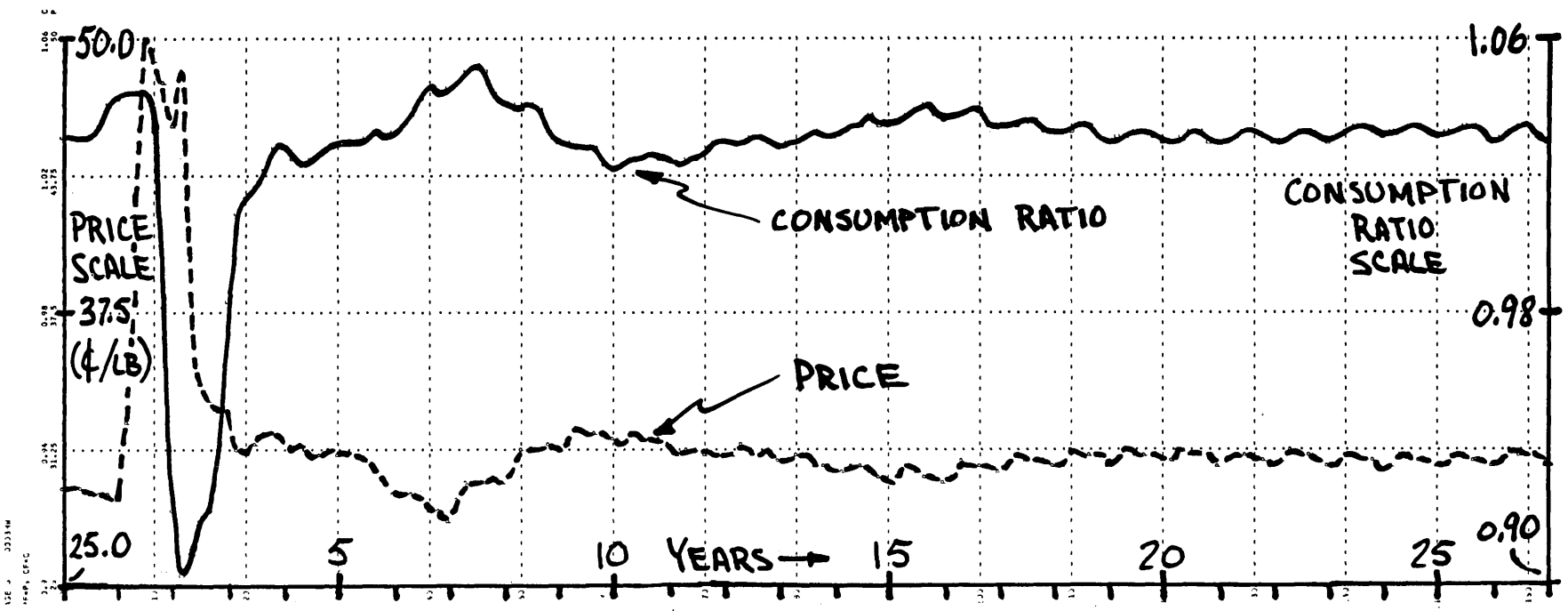FIGURE 6-6a -- HIGH FREQUENCY NOISE RESPONSE

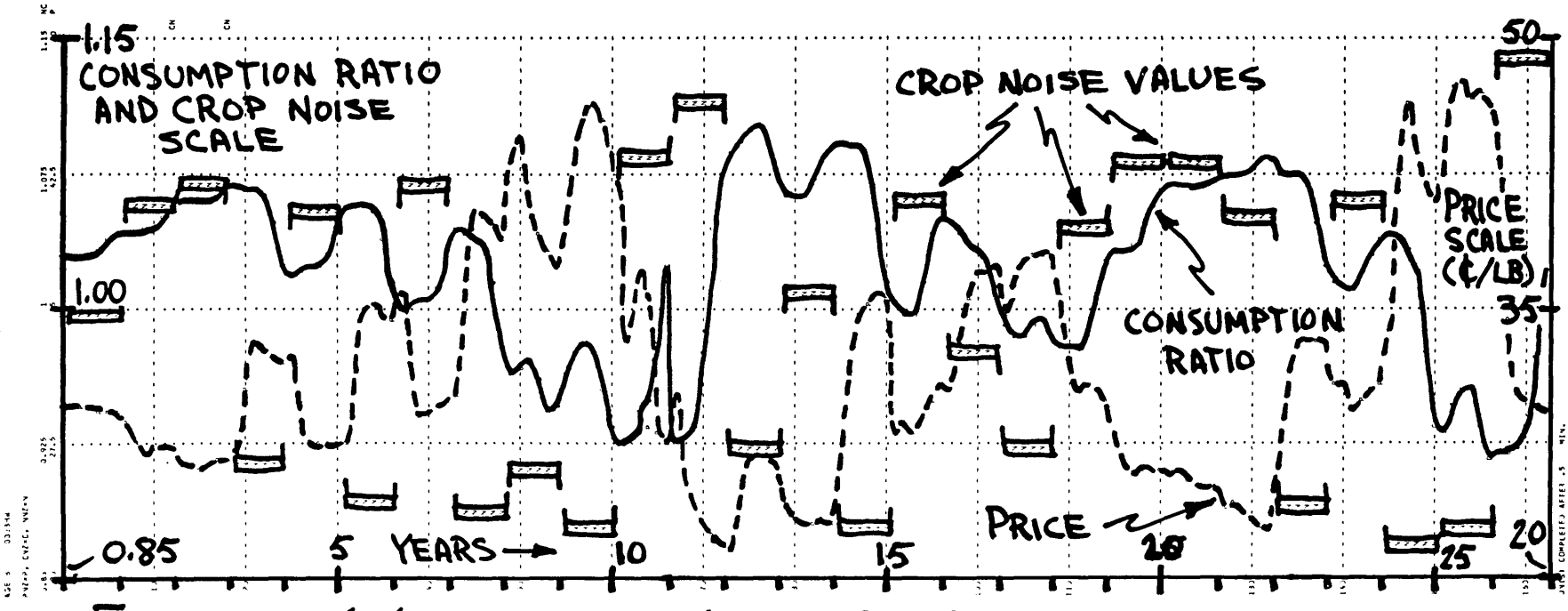

FIGURE 6-6b -- CROP FAILURE RESPONSE

FIGURE 6-6c -- CROP NOISE RESPONSE

the sinusoidal multiplier in equation 23 has been replaced

by a random variable having a continuous rectangular distri-

bution ranging from -0.20 to +0.20, and taking on a new inde-

pendent value every three months.[1]

The two variables shown in Figure 6-6a are the price and

the ratio of the endogenous monthly consumption rate (equation

24) to the trend consumption rate (equation 25)[2] -- hereafter

referred to as the consumption ratio. These variables show

very little evidence of periods short of roughly 24 months

or greater than about 60 months. Shorter periods are not

evident because of the subsystem's low gain in that region.

Longer periods do not show up because of the high degree of

short term variability in the exogenous noise series (reflec-

ting the three month sampling interval), which is such that the

exogenous disturbance contains very little power[3] in the 108

month periodic range selectively amplified by the subsystem.

---

[1]The 40 percent range in the quarterly consumption noise distri-
bution is unrealistically large. But given the effective linearity
of the subsystem, especially over the range of behavior shown
in Figure 6-6a, the only effect which a reduction in the noise
distribution's range would have would be a reduction in the ampli-
tude of the response fluctuations. There would be no change in
the periodicities evidenced in the figure.

[2]This ratio has a steady state value of roughly 1.03, which reflects
the simulated steady state price level of 31 cents per pound,
versus the postwar average price of 35.2 cents used in calculating
the trend consumption rate.

[3]See Forrester (1; p. 412) for a discussion of the power content
of sampled white noise.

The general tendency of the subsystem severely to dampen short term noise such as that used to generate Figure 6-6a is indicated by the fact that the noise variations, which cause quarterly exogenous consumption variations covering a 40 percent range, feedback to cause endogenous consumption fluctuations varying over only a six percent range.

The mechanism which generates the observed fluctuations is that which was hypothesized in Chapter 1. That is, an exogenous random increase in consumption causes a price increase (via a reduction in the current and expected inventory ratios), which feeds back, after a delay, to cause a decline in consumption. The consumption decline brings with it a price decline which is only imperfectly discounted in the consumption (and inventory ratio) forecasts. The price continues to decline until, after a delay, the new lower price level causes consumption to form a trough and begin to increase again, thus starting the second cycle. While the consumption forecast mechanism does not perfectly discount past price effects on future consumption, it does come reasonably close to doing so, as evidenced by the high degree of damping indicated in Figure 6-6a.

6.3.5 Crop Failure Response -- The tendency of the estimated subsystem to propagate long term (roughly nine year) fluctuations is evidenced in Figure 6-6b, which shows the price and consumption ratio response to a single 20 percent crop

failure taking place in the second simulated year. In all other respects, the exogenous inputs to the system are the steady state inputs defined in section 6.3.1.

The price peak associated with the crop failure itself (occurring in the second crop year) is followed by a second, highly diminished peak some eight years later. The first price trough occurs in the seventh year, while the second comes about nine years thereafter. The basic causal mechanism which gives rise to these long period fluctuations is the positive feedback loop linking thepast average price rate of change, long term price expectations, and the current price (see Figure 6-1, the last term in equation 1, and Figure 4-6). For example, in Figure 6-6b, the crop failure causes a sharp increase in the price level, which brings with it an increase in long term equilibrium price expectations. Then, after production returns to its normal growth pattern, the price falls, but it initially (during the third year) stops short of its steady state level in part because of the new higher equilibrium price expectation. Two influences now induce the prolonged price decline which continues through the seventh year. First, with the price above its steady state level, consumption falls significantly short of production, and the current and expected inventory ratios rise. Second, with prices having declined for over a year, equilibrium price expectations also begin to fall. The fall in equilibrium expectations causes the price decline to continue,

which feeds back, eventually lowering equilibrium expectations to a point below the steady state price level. The price trough is formed when consumption becomes so high as to cause an inventory decline sharp enough to offset the effects of the continued decline in equilibrium expectations. With the price trend reversed, equilibrium expectations reach their low point and then begin to climb, and the second half of the cycle begins. While the long period response to a single pulse shown in Figure 6-6b appears highly damped, the gain curve (Figure 6-5) indicates that the system will amplify any persistent disturbances having periodicities of approximately nine years.

6.3.6 Crop Noise Response -- Figure 6-6c indicates the price and consumption ratio response of the estimated subsystem when random variations in crop size are added to the consumption noise described in section 6.3.4. The crop sizes used in generating Figure 6-6c have been generated by multiplying the exponential trend value for each successive crop by a random number drawn (independently from year to year) from a rectangular distribution ranging from 0.85 to 1.15. The crop noise values are shown in the figure in order to indicate the degree to which the price and consumption patterns represent responses to specific noise values.

The tendency of the subsystem selectively to amplify the

input noise spectrum at periods near 108 months[1] is marked.

The period between the first two major price troughs,

occurring in the third and thirteenth years, is 116 months.

The third major trough (in the 22nd year) follows the

second by 116 months as well. The three major price peaks

(in the 10th, 18th, and 26th years) are spaced at intervals

of 96 months and 92 months.

One of the more interesting aspects of Figure 6-6c

is its portrayal of the combined influences, exogenous and

endogenous, on each of the subsystem's variables. Each

major price peak is associated with a short crop, each

trough with a large crop. If we were to imagine a typical

series of cocoa market letters accompanying the time series

shown in the figure, each major price movement would be

completely ascribed to the corresponding crop movement.

On the other hand, while one would be hard pressed to identify

a nine year periodicity in the crop noise series, such a

component is quite evident in the series for the endogenous

variables. The timing of the major peaks and troughs is in

fact largely determined by the subsystem's structure, as

well as by the exogenous variations. The crop failure in

the 10th year coincides with a major price peak, while that

---

[1]The crop noise series has much more spectral power near
108 weeks than does the consumption noise series, reflec-
ting the 12 month crop sampling time versus the three month
sampling time used in generating the consumption noise.

in the 23rd year only serves to complete a price trough,

precisely because of the timing of these failures relative

to the phasing of the endogenously propagated cycles.

6.4 Conclusions and Qualifications

The initial basic conclusions suggested by the simu-

lations discussed in the last two sections are straight-

forward: (a) the estimated price-consumption subsystem

appears to be a reasonably valid representation of the

actual subsystem; and, (b) the subsystem tends selectively

to amplify the periodicities near nine years in length,

and sharply to attenuate input periodicities under two

years in length.

But the primary conclusion to be drawn requires our

going back to review the assumptions made in defining the

price-consumption subsystem in Chapter 1 and in the intro-

duction to this chapter. We said there that the world

cocoa production rate (and its derived variables, crop

forecasts and producer sales) could be considered exogenous

relative to the defined subsystem because of the long delay

entailed in price effects on production. That assumption

now appears questionable[1] in view of the relatively long,

---

[1]There is no issue here as to whether or not cocoa production
can be considered as exogenous for statistical estimation
purposes; clearly it can. The question is whether it can be
considered to be exogenous in simulations of cocoa price
and consumption dynamics.

nine year natural period of the estimated subsystem.

With cocoa trees beginning to yield at a commercial rate

after four to seven years, and with the likelihood of the

existence of some shorter term, non-planting price effects

on production (e.g. the use of insect sprays and/or

fertilizers), the possibility of significant coupling

between the price-consumption subsystem and the price-pro-

duction subsystem exists. To the extent that such coupling

does exist, the price-consumption subsystem's behavioral

properties which we have investigated will not necessarily

be evidenced as behavioral properties of the total system

We have in this important sense only studied a partial

version of the dynamics of the overall cocoa industry.

List of References

1) Forrester, J.W., Industrial Dynamics, MIT Press and Wiley,

   New York, 1961.

2) Mason, S.J., and Zimmerman, H.J., Electronic Circuits,

   Signals, and Systems, Wiley, New York, 1960.

Chapter 7

Summary and Conclusions

7.0 Introduction

It is appropriate, in bringing the thesis to a close,
that we review the more important points made in the pre-
ceding chapters, and bring into clearer focus the primary con-
clusions which have been drawn.

7.1 Summary

In the order of their earlier presentation, the major
topics discussed in the thesis are:

Price-Consumption Subsystem   In Chapter 1, I define
as the cocoa price-consumption subsystem the set of rela-
tionships between variables which determines the cocoa price
and consumption response to annual variations in world pro-
duction. The endogenous variables specifically discussed,
coupled with their respective determining relationships, are:
(1) the spot price stated as a function of current inven-
tories, the expected time pattern of future inventories, and
long run equilibrium price expectations; (2) the consump-
tion rate, determined by lagged prices, incomes, populations,
and trends in tastes; (3) consumption expectations, derived
from recent changes in prices and consumption, and estimates
of the long run trend in consumption; (4) the current inventory

level, being the time integral of cocoa producer sales minus
consumption; and (5) inventory expectations, determined by
the current inventory level, expected consumption, and
expected producer sales. I hypothesize that primarily be-
cause of the lag in the price effect on consumption, the
structure of the price-consumption subsystem may itself give
rise to fluctuations in its variables. Any such fluctuations
would become increasingly damped, the more accurately and
rapidly consumption expectations discount the influence
of past prices on future consumption.

Market History Chapter 2 reviews the more significant
events which transpired in the cocoa market over the 1952-
1963 interval specifically studied in the thesis. In the
appendix to Chapter 2, I present excerpts from cocoa market
letters and reports covering this period on a monthly basis.
The highlights of the historical discussion are: (1) the
manner in which decontrol of confectionary consumption in
the United Kingdom, followed by short African crops, led
to the 1953-1954 bull market; (2) the role played by the
1957 Bahia withholding action in the 1957-1958 bull market;
and (3) the apparent close linkage between the weekly main
crop cocoa purchases made by the marketing board in Ghana, and
the market's forecasts of the size of the Ghanaian crop.

Commodity Price Theory In Chapter 3, I develop a
theory explaining the determination of general commodity spot

price behavior. The theory is a synthesis of long term

partial equilibrium analysis, supply of storage theory, and

Muth's rational expectations hypothesis, and is in part

based on an earlier contribution by Samuelson.

Price Mechanism The commodity price theory developed

in Chapter 3 receives empirical support in Chapter 4, where

I estimate the equation which generates monthly average spot

cocoa prices. The estimated relation, which allows for

variable aggregate long term price expectations stated as

a function of the long run price trend, includes generally

plausible coefficients and explains the major portion of

price variations over the 1952-1963 period.

Cocoa Data The regressions carried out in Chapter 4

require monthly time series for several world cocoa variables,

including grindings, producer sales, current inventories,

market forecasts of production and grindings, and expected

year-end inventories. There exist no published (or unpub-

lished, to my knowledge) versions of any of these time series.

Appendix A of Chapter 2 presents the data required for the

construction of such series, and gives the constructed series

for current and forecast grindings and sales (production).

Consumption and Consumption Expectations In order to

complete the estimated model of the cocoa price-consumption

subsystem, the price equation estimated in Chapter 4 must be

coupled with estimates of the relationships generating world

consumption (grindings) and consumption expectations.
These estimates are derived in Chapter 5.

Price-Consumption Dynamics The dynamic simulations generated in Chapter 6 using the estimated price-consumption subsystem serve two purposes. First, an investigation of the subsystem's response to historical data for the exogenous inputs provides a somewhat different (and in this sense, additional) test of the validity of the individual subsystem equations than that provided by conventional hypothesis testing procedures. Then, with the validity of the estimated subsystem generally confirmed, further simulations incorporating various test inputs serve to identify the subsystem's natural dynamic characteristics.

7.2 Conclusions

The primary conclusions drawn in the thesis relate to two areas: (1) the general theory of commodity prices; and (2) the specific characteristics of the cocoa price-consumption subsystem. In the sections which follow I shall review these conclusions, and set them in their broader contexts.

7.2.1 Commodity Price Theory-- The static framework of traditional microeconomic theory has never provided a very satisfying explanation of short and intermediate term price behavior. The supply-demand equilibrium notion,

Price

Market Supply Curve

Short Term Demand Curve

O   Quantity
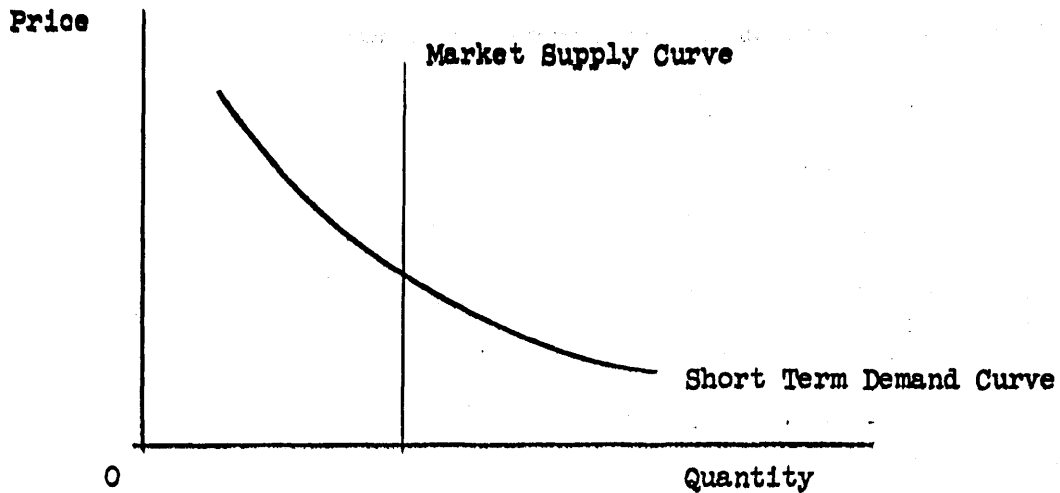
Figure 7-1: Short Term Static Equilibrium

arising from the assumption that producer profits and consumer

utilities are maximized in a competitive context, serves

rather well to explain long term price levels. But the same

equilibrating mechanism does not realistically account for

shorter term price movements.

The conventional static-theoretic explanation of (say)

monthly price levels makes use of the "market supply" concept,

illustrated in Figure 7-1. The short term price level is

that price which will bring the short term consumption rate

into equilibrium with the predetermined, price inelastic

short term supply rate. That is, the short run "market

supply" is what it is (and therefore the market supply curve

in Figure 7-1 is vertical), and the price moves to whatever

level is necessary to ensure that that supply is consumed.

Both of the basic concepts involved, the short term demand function and the market supply rate, leave a good deal to be desired in terms of providing a useful model of actual commodity market behavior. For any given commodity the current price level may have little or no influence on the current consumption rate, so that a graphic portrayal of the short term demand function would itself have to be represented as a vertical line (i.e. on the conventional Marshallian axes). In this case the short term equilibrium price level is either nonexistant or indeterminate. Even worse, the concept of a market supply rate is tautological at best, and as such has no explanatory value. The concept seems to arise from a combination of the observation that the instantaneous production rate of a commodity is not in general influenced by current or even recent prices, coupled with the definition that instantaneous demand and instantaneous supply must be in equilibrium in the sense that whatever is currently being consumed is also currently being supplied from some source. There in fact exists no counterpart to the theoretical market supply concept, in the sense of a supply rate demanding instantaneous consumption and thereby determining the current price level.

The obvious omission from the static framework is the consideration of the roles played by inventories and expecta-

tions, both inherently dynamic concepts. It is the explicit consideration of these variables that leads to the commodity price theory evolved in Chapter 3. The development of this theory involves the synthesis of three basic concepts:

1) The Long Term Equilibrium Price Level. For any commodity industry, there exist various exogenous influences which give rise to long term trends in demand. Population growth and long term per capita income trends provide examples. The long term equilibrium price level, then, is that price which keeps the long term trend in production in line with the exogenously determined long term trend in consumption.

2) Supply of Storage Theory. The size of the total inventory of a given commodity which will be carried at any point in time by the aggregate of current and potential storers depends on the aggregate price expectations of those storers. The more they expect the price to increase, the more coverage (measured in time units) of expected aggregate consumption they will be willing to carry in inventories. The converse holds. The current aggregate expected price rate of change can then be stated as a function of the current aggregate inventory level, since the current inventory level is predetermined by past consumption and production, and must, by definition, be stored.

3) <u>Muth's Rational Expectations Hypothesis</u>. Muth's
hypothesis is that actual expectations regarding the
state of an economic variable at some point in the
future are the same as would be predicted by the best
available and relevant economic theory.

The synthesis of these concepts takes the following
lines. First, the supply of storage function for the commodity
in question can be written,

$$\frac{dP^*_t}{dh} = f^* (Y_t) \tag{1}$$

where,

$$\frac{dP^*}{dh} =$$ Current price rate of change expectation
for the time increment from t to t+dh

$$Y =$$ Current inventory ratio (i.e. current
coverage, measured in time units)

and where the function has the general shape indicated in
Figure 7-2. Using Muth's rational expectations hypothesis,
the expected price rate of change for any future point in
time can be written in terms of the corresponding expected
inventory ratio,

$$\frac{dP^{*h}_t}{dh} = f^* (Y^{*h}_t) \tag{2}$$

where,

$$\frac{dP^{*h}}{dh} =$$ Current price rate of change expectation
for the time increment from t+h to t+h + dh

$$Y^{*h} =$$ Current inventory ratio expectation for
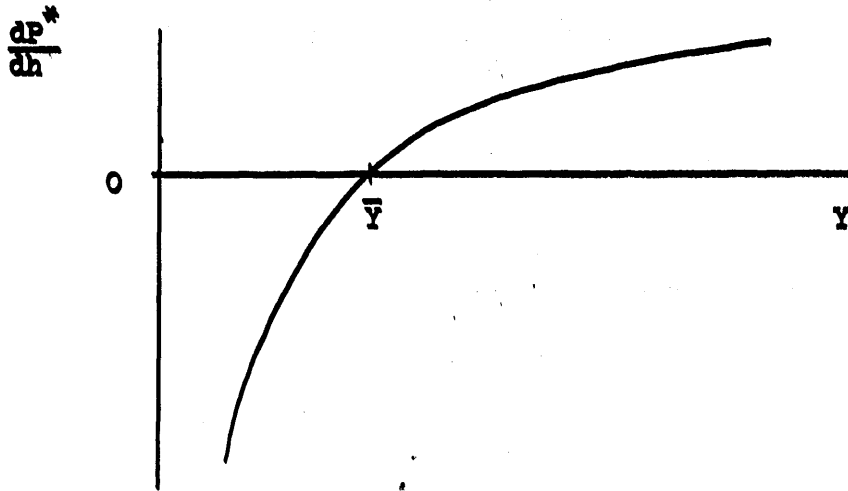time t+h

$$\frac{dP^*}{dh}$$

Figure 7-2: Supply of Storage Curve

Now the existence of forces tending to maintain a
long term equilibrium price level implies the existence
(again using the rational expectations hypothesis) of long
term equilibrium (or "normal") price expectations. In turn,
the expectation that there exists some long term equilibrium
price level further implies the existence of an expected
equilibrium inventory ratio, namely the ratio for which the
expected price rate of change is zero (i.e. $\bar{Y}$ in Figure 7-2),
since any other expected equilibrium inventory ratio would
imply a non-constant expected equilibrium price. Thus for
some horizon point in the indefinite future, the aggregate
price and inventory ratio expectations are equal to their
respective equilibrium levels. Using equation 2, the total
expected price change over the indefinite horizon interval

can be written in terms of the expected behavior of the inventory ratio during that interval,

$$P_t^{*\infty} - P_t = \int_0^\infty f^* (Y_t^{*h}) \, dh \qquad (3)$$

where,

$P^{*\infty}$ = Expected equilibrium price level

P = Current price

Y^{*h} = Current inventory level expectation for time t+h

Equation 3 can be rewritten, <u>stating the current price level as a function of long run equilibrium price expectations and the expected future behavior of the inventory ratio.</u>

$$P_t = P_t^{*\infty} - \int_0^\infty f^* (Y_t^{*h}) \, dh \qquad (4)$$

This is the fundamental result of Chapter 3.

As a practical matter, inventory ratio expectations are likely to be relatively well defined for fairly short horizon intervals, reflecting relatively well defined consumption and production expectations. Then, beyond the usual consumption and production forecast horizons, the aggregate inventory ratio expectations probably increasingly take the form of a gradual approach toward equilibrium. Long term equilibrium price expectations, in turn, are likely to be determined by past prices (both their level and their trend)

and by any information which becomes available indicating fundamental structural changes in supply or demand.

7.2.2 Cocoa Price-Consumption Dynamics. The thesis suggests two basic conclusions with regard to the characteristic cocoa price and consumption dynamics generated by the structure of the cocoa industry system.

First, if the cocoa price-consumption subsystem (see Figure 6-1) is considered as an entity, with variations in production related variables taken as exogenous, then this subsystem shows a marked tendency to suppress any periodic input components having periods of roughly two years or less, and selectively to amplify input periodicities roughly nine years in length. The nine year natural period primarily reflects the manner in which the cocoa market apparently forms its long term equilibrium price expectations, namely to extrapolate the long term price trend.

The second and more important conclusion is that the study of the cocoa price-consumption subsystem undertaken in the thesis only represents a partial dynamic equilibrium analysis, in the sense that there are likely to exist significant coupling effects between the economic forces generated by this subsystem, and the forces generated by the related price-production subsystem. The primary price effect on production comes via variations in the planting of new cocoa trees. Since cocoa trees begin to bear at a commercial

rate at an age of four to seven years, and reach full
maturity roughly 18 years after having been planted, the
average gestation delay is about 11 years. A very rough
first approximation of the dynamic behavior likely to be
generated by the price-production subsystem can be gained
by viewing this subsystem as a simple cobweb mechanism with
a lag time of 11 years. Thus a period of high prices would
be followed 11 years later by a period of high production
and low prices, which in turn would bring on a second period
of high prices after a second 11 year interval. The indi-
cated natural period of 22 years would be shortened,
possibly markedly, by any short term price effects on pro-
duction such as variations in the use of fertilizers and
sprays, and/or variations in the cultivation and harvesting
of marginal cocoa acreage.

The natural period of the price-production feedback
loop(s) would not have to be much less than 22 years to ensure
a significant degree of coupling between the price-pro-
duction and price-consumption subsystems, with the likely
result that the dynamic characteristics of the total
cocoa industry system would not be the same as those of the
price-consumption subsystem. It is in this sense that the
Chapter 6 discussion of price-consumption dynamics repre-
sents only a partial dynamic equilibrium analysis.

Biographical Note

F. Helmut Weymar was born on November 24, 1936, in Jamaica, New York. After graduating from Pingry School in Hillside, New Jersey, he entered Massachusetts Institute of Technology, where he received his S.B. in Business and Engineering Administration in June, 1958. During his last undergraduate semester he served as a member of the faculty of Browne and Nichols School in Cambridge. Upon graduation, Mr. Weymar was married to the former Caroline B. Seager.

In the fall of 1958, Mr. Weymar became assistant to the Head of the Department of Electrical Engineering at MIT, in which capacity he served for one year. In September, 1959, he began his graduate program at MIT, which led to his receiving his Ph.D. in Industrial Economics in February, 1965. During the course of his graduate studies he served as a research assistant and teaching assistant in the Industrial Dynamics Research Group in MIT's School of Industrial Management. Since July, 1963, Mr. Weymar has been employed by the James O. Welch Division of the National Biscuit Company, working in the area of commodity procurement.

Mr. Weymar was a contributor to Marketing and the Computor (Prentice-Hall, 1963) and Problems in Industrial Dynamics (MIT Press, 1963).