An Analysis of the Ending Stocks to Use Ratio in Forecasting Cocoa Prices

by

Brian W. Meinken

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"Facts alone, no matter how numerous or verifiable, do not automatically arrange themselves into an intelligible or truthful picture of the world. It is the task of the human mind to invent a theoretical framework to account for them."

FRANCIS BELLO in the Fortune Series: "Great American Scientists"

If there is one empirical relationship that is familiar to participants in commodity markets it is the one that shows the scatter between the price of a commodity and the ratio of Ending Stocks to Use (ES/USE). This approach is commonly used for commodities such as cocoa, sugar and copper, to name just a few. An example of this ratio for cocoa is illustrated in Figure 1.

This relationship, as well as others similar to it, is usually depicted as a "freehand" curve, convex to the origin, drawn through a scatter in a visually acceptable manner and the viewer is led to believe, if not told bluntly, that the price of a commodity is a function of this ratio.[1] It is unclear how this relation is the result of the interaction of supply and demand for that commodity. Furthermore, when these various relationships are presented by the advocates of this concept, it is suggested or implied that this curve is stable (does not "shift") over time and that this curve is asymptotic to the ordinate or price axis.

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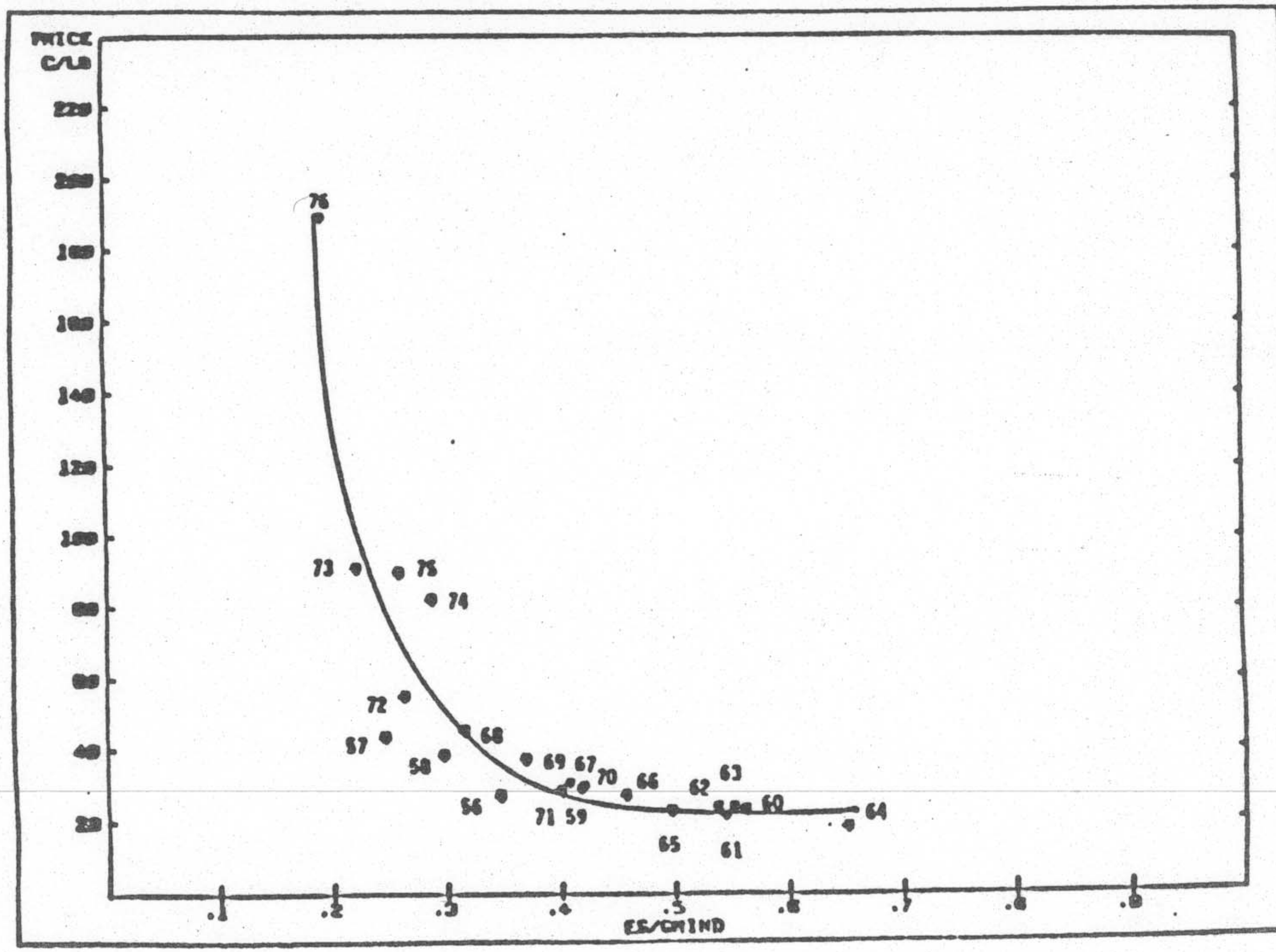
[1] One of a number of variants of this approach exists in which price is related to the ratio of grind (G), or use, divided by supply (S), where grind refers to cocoa beans processed into products and supply is equal to carryover stocks plus the net world crop. Shishko (1967) uses this approach and refers to G/S as a "pressure index."

Figure 1. Cocoa - Price vs. Ending Stocks/Grind Ratio



Use, or should I say misuse, of such relationships as a simple forecaster of cocoa price has occurred for at least two decades, and more recent use of these relationships has been extended to commodities as diverse as corn and orange juice, either to forecast prices directly or for an indication of the direction of price change to be expected over a certain time period. In this paper, I suggest that the preferred approach to forecasting is to work from the underlying structural relations.

Justification and Objectives

The ability to correctly assess supply and demand situations and to properly determine price levels associated with these supply and demand situations is of great importance to the agricultural producer, processor, futures trader, and policymaker, as well as the consumer of the particular product.

While much applied price analysis was performed by the United States Department of Agriculture (USDA) in the 1950's which resulted in such (classic) publications as The Demand and Price Structure for Dairy Products (Rojko, 1957) and The Demand, Supply, and Price Structure for Eggs (Gerra, 1959), recent research with direct applications to price forecasting in commodities such as cocoa has been lacking, to say the least. For example, perhaps the most cited work on the world cocoa market (and probably the most complex) is The Dynamics of the World Cocoa Market (Weymar, 1968) which was published fifteen years ago. Examples of the ES/USE relationship and variants of it can be found in the Commodity Futures Market Guide (Kroll and Shishko, 1973), as well as in USDA Outlook and Situation Reports.

There is still much to be learned about the supply and demand situations that determine the variables ES, USE, and price. However, in recent years, research in price theory has lagged despite the fact that commodity prices have displayed a degree of volatility without precedent. Consequently, the need for more accurate price forecasting, or at least the knowledge of how to approach such forecasting, has never been greater.

The objectives of this paper are to

1) Determine the exact algebraic relationship between ES, USE, and price from a basic supply-demand-price framework for cocoa.

2) Develop an economic framework to determine the price/demand behavior for cocoa.

Review of Literature

Little or no literature can be found that gives a consistent theoretical foundation from which the researcher can justify the use of these ratios for commodity price forecasting. The FAO "Cocoa Price Model" (1961), which includes the variable ES/G, was the result of the earlier studies of the cocoa price mechanism. That model is as follows:

$$\text{Log } P = 2.013397 - 0.001061Q + 0.00742G - 0.00871005S$$

$$R^2 = 0.79,$$

where:

P = average monthly spot price of Accra beans in New York, cents per 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 grindings in thousands of metric tons, and

S = actual stocks as a percent of a grinding (ES/G).

Although having statistical findings that appear constructive, the model has little merit since it lacks an explicit theoretical foundation. As Weymar (1968) remarks,

> "It is interesting that the authors of the FAO report do not argue for this model on theoretical grounds, but instead, the authors seem 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 changes in the price of cocoa. They do not say why expectations about (say) grind or stocks should have an effect on the price (it is apparently considered self evident) and it is in this sense that they do not provide a theoretical framework for their statistical analysis."

Shishko (1967) developed a "pressure index" for use in forecasting cocoa prices.

$$\text{Pressure Index} = \frac{\text{Demand}}{\text{Supply}} = \frac{\text{World Grindings}}{\text{Stocks + Production}}$$

One would expect price to rise as the index rises, and vice versa. Shishko acknowledges that the index is not a very precise measure of supply and demand, his reason for using it is that in order to develop more precise forecasting equations one would have to determine the true values of the causal variables (stocks, production, etc.).

The relationship P = F (Supply/Grind) is used by Kroll and Shishko (1973) in their text on the commodity futures market. The authors acknowledge that deviations from the estimated line are probably due to the exclusion of some price-influencing forces, but they state that it is reasonable to assume that the price of cocoa depends primarily on the total of supply in relation to the level of consumption prevailing at the start of the season.

Perhaps the most thorough study of the world cocoa economy was that done by Weymar (1968). Due to the depth and complexity of the author's treatment of the subject, a simple summary of this work is impossible. However, Weymar stresses the use of what he terms the "current inventory ratio" (ES/G) in the development of his model of the cocoa economy.

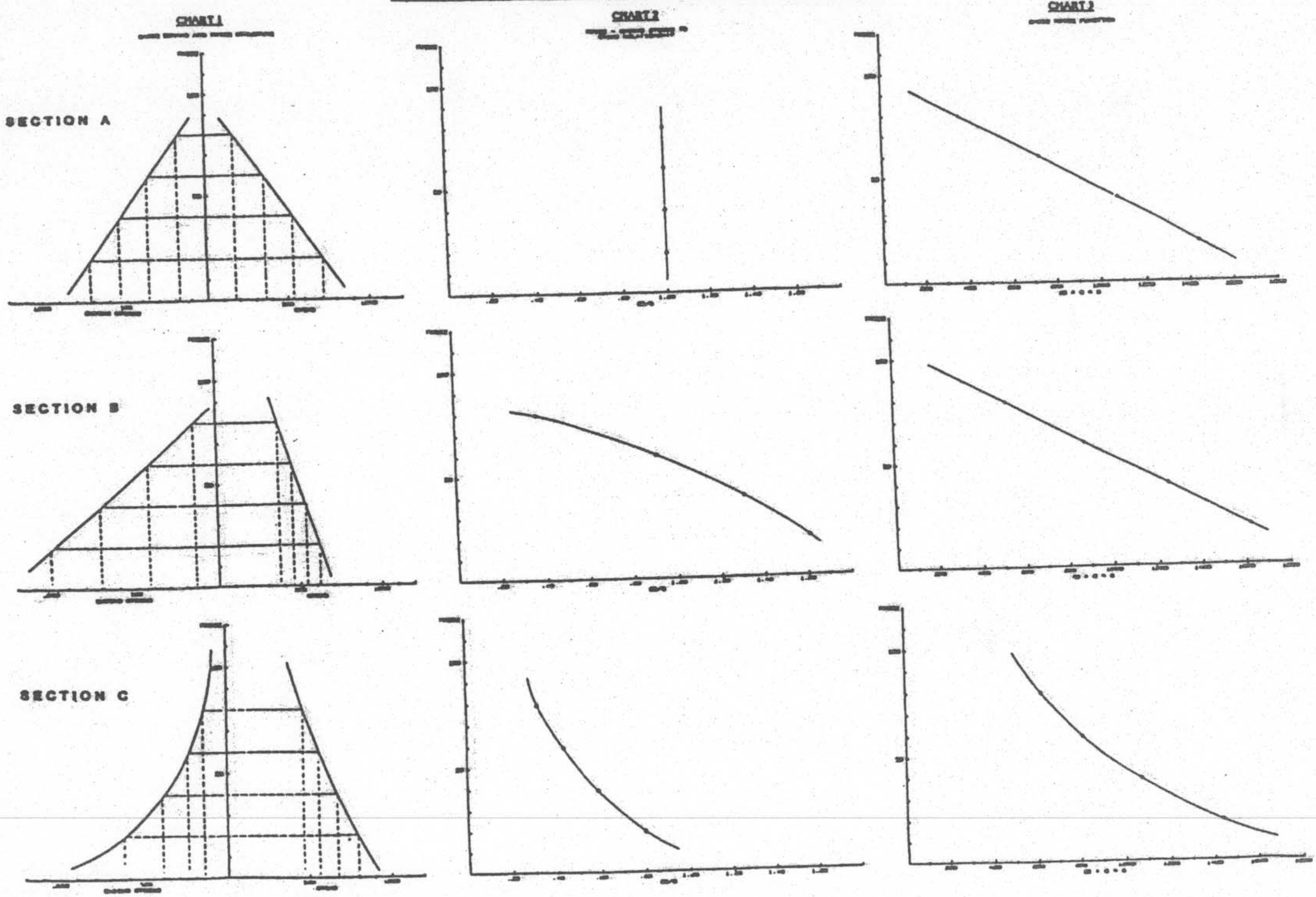
To illustrate or cite any more of these ratios would serve no purpose since they provide little additional information that would justify their predictive use. Admittedly, if there were only one ratio that could be indubitably justified on theoretical grounds, this research would not be necessary. However, as the prior discussion illustrates, a plethora of such relationships exists and at least some kind of explanation appears needed.

In reviewing the literature containing these supposed price predicting relationships, the following questions arose: (1) Is price better predicted by one or a combination of these ratios, or is some other specification preferred? (2) Do all these ratio price functions arise from the same basic underlying structure?

Conceptual Framework

The cocoa market can be characterized by two demand functions -- one for current use and one for stocks -- with supplies predetermined. Figure 3, comprised of three sections, illustrates geometrically how supply and demand interact to determine price within the restraints imposed by the identity between stocks, use and production. Figure 3 is divided into three charts each having three sections, prefixed A, B, or C. Chart 1-A illustrates the two basic demand functions for

FIGURE 3 - BASIC COCOA PRICE RELATIONSHIPS



cocoa under the assumptions that both are identical and linear. Chart 2-A shows the resulting price-ES/G relationship, while Chart 3-A illustrates the derived "Basic Price Function."

We note the following: (1) Given Chart 1-A, or the equations representing Chart 1-A, one can derive Charts 2-A, 3-A. Given only Chart 2-A or 3-A, the other charts cannot be derived from it. Clearly, Chart 1-A provides all the necessary information to generate any relationship between price and any other variable, or combination of variables, in the system. On these grounds, we describe Chart 1-A as the Basic Demand and Price Structure.

However, from an empirical standpoint, Section A does not generate a price-ES/G relationship, or a "pressure index," even vaguely resembling those shown in Figure 1. Thus, in Section B, the ending stocks demand function is modified to make it more elastic than the grind function. Charts 2-B and 3-B follow from 1-B. The relationship is inverse, but concave to the origin. Finally, by modifying the ending stocks function to make it curvilinear in Section C, while retaining the more elastic concept, we arrive at relationships that are consistent with both theory and observation.

Algebraic Derivation of the Various Price Relationships

Using Section B as an example, the "Basic Price Function" shown in Chart 3-B can be derived from the demand function in 1-B as follows:

Let	G	= 700.00	- 4.00	P	(grind demand)
	ES	= 1,285.71	- 14.2857	P	(stock demand)
	G+ES	= S.			(identity)

then, rearranging the demand functions given

$$G + 4.00P = 700.00$$

$$ES + 14.286P = 1{,}285.71$$

adding and setting the result equal to S

$$S + 18.286P = 1{,}985.71$$

or

$$18.286P = 1{,}985.71 - S$$

$$P = \frac{1985.71}{18.286} - \frac{1}{18.286} S$$

$$P = 108.592 - 0.05475\ S$$

Price - Ending Stocks/Grind Relationship. Price will vary with the ratio ES/G providing the two demand functions are not identical. The exact nature of the relationship, of course, depends on the structure of two demand curves and can be either positive or negative depending on the nature of the first derivatives with respect to price. The relationship will be negative if $\frac{DES}{dp} > \frac{dG.}{dp}$

The price-ES/G relationship shown in 2-B is derived algebraically as follows:

Given:

$$\frac{ES}{G} = \frac{1{,}285.71 - 14.2857\ P}{700.0 - 4.0\ P}$$

Solving for ES/G as a function of P,

$$\frac{ES}{G} = 3.571 \quad \frac{- 1{,}213.99}{- 4.0P + 700.0}$$

which is rewritten to place P in its "dependent" position.

$$P = \frac{-700.0 - \frac{1{,}213.99}{ES/G - 3.571}}{-4.0}$$

At this juncture, it should be intuitively clear that if the two basic behavorial equations, the grind demand function and the Ending Stocks demand function, shift over time then the other relationships (Charts 2-B and 3-B) must also shift. The same is true for both Sections A and C.

Further Observations on the P-ES/G Relation

As indicated earlier, advocates of this relationship assume that the function is asymptotic to the price axis. However, it is conceivable that under certain circumstances, particularly low levels of supply, this relationship can bend back on itself such that two values of price could be associated with one value of the ratio. Figure 4 illustrates this possibility.

Mathematically, the P-ES/G curve is

1) negative as long as $\frac{dES}{dP} > \frac{dG}{dp}$

2) a vertical straight line as long as $\frac{dES}{dp} = \frac{dG}{dp}$

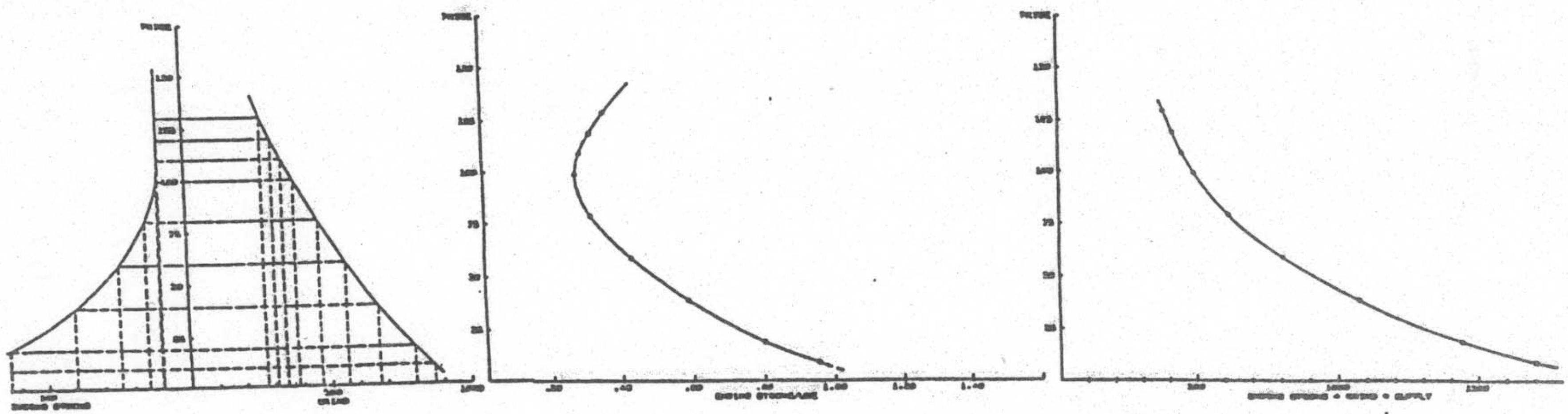
3) positive as long as $\frac{dES}{dp} < \frac{dG}{dp}$; and, while not illustrated,

4) asymptotic to the price axis as long as $\frac{dES}{dp} > \frac{dG}{dp}$ and approaches $\frac{dG}{dp}$ as a limit.

Most analysts who have used this relationship to forecast cocoa price have assumed 4 (asymptotic to the price axis), perhaps without being aware of it. That is, they "draw" the curve in a manner asymptotic

FIGURE 4

BACKWARD BENDING RELATIONSHIP



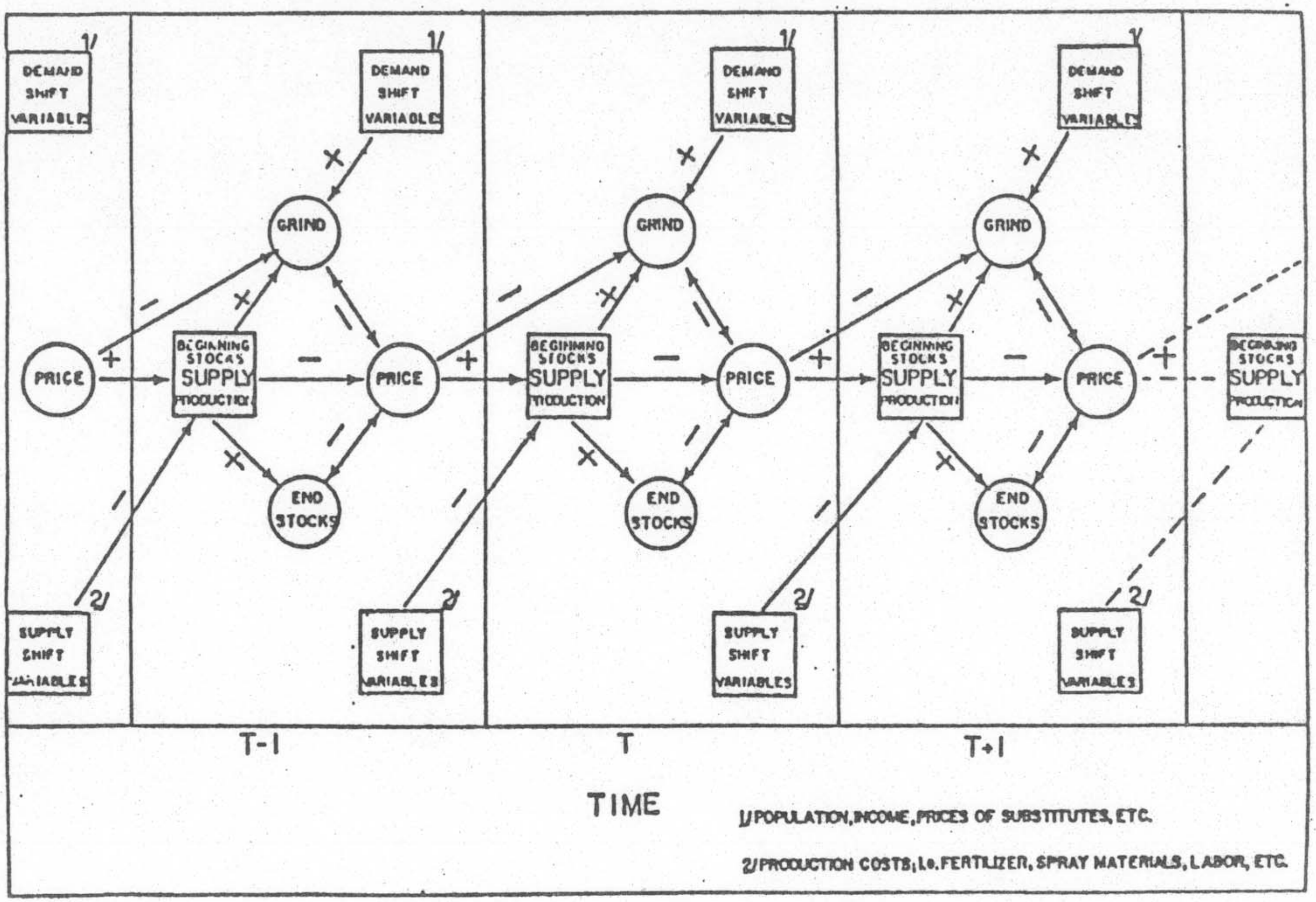
to the price axis. However, conceptually, two different prices could be associated with only one value of ES/G. Consequently, decisions made by either the hedger or the speculator based on this relationship could be costly should they predict the incorrect price as their objective.

Simplified Model of the World Cocoa Economy

The cocoa economy behaves in a manner similar to that illustrated in Figure 5. Price, grind, and ending stocks are jointly and simultaneously determined by the level of supply and the levels of the demand shift variables. Although the simultaneous equations approach to forecasting agricultural supply-demand-price behavior is still a matter of debate, there are certain instances when a simultaneous specification may be preferred to alternative models. One situation is when total quantity available for harvest is predetermined with current prices relative to harvesting cost. A second situation in which a simultaneous specification would be preferred is when total production is assumed to be predetermined, but allocation among different uses is not. One of the more often cited examples of the second case is Meinken's (1955) model of the wheat sector. Both carrying stocks and production of wheat were predetermined and total supply is allocated to four uses (domestic human food, domestic livestock feed, net exports, and year-end stocks.

The model used in this paper is also of the second category. The factors that "shift" or alter the demand for grind are assumed to be principally two in number: last year's price (P-1) and time (T). These demand shift variables are shown as single pointed arrows in Figure 5. "Time" is a trend variable (1 is equal to 1956, 2 is equal to 1957,

Figure 5. Cocoa - Simplified Demand-Supply-Price Structure



etc.) and is intended to allow primarily for world population and income growth. Consequently, the grind demand function is as follows:

$$(1)\ G = a + bP + cP - 1 + dT$$

With respect to the ending stocks demand function, the only demand shift factor is time. However, in theory -- and probably in practice as well -- this is an oversimplification, as storage demand is known to be influenced by expectations concerning future supplies and prices as well as the cost of storage (i.e., interest rates, warehouse costs, etc.). However, the purpose of this paper is not to build the perfect model, if indeed such a model can be developed, but to illustrate the basic underlying relationship among the important variables. Therefore, we have assumed that as the (cocoa) industry expands over time, higher levels of stocks -- both pipeline and speculative -- will be carried by the trade. Summarizing this,

$$(2)\ ES = a' + b'P + c'T$$

based on the assumption of linearity and additivity. In addition to the above demand equations, we have the following identity:

$$(3)\quad G + ES = Supply$$

where supply (S) equals beginning stocks (on October 1 for cocoa) plus production and is assumed to be predetermined or known.

These three equations are the "structural" equations. The first two are classic demand functions, while the third is an identity. Given the values of the "known" variables (S, T, and P-1) and estimates of the coefficients a, b, c, d, a', b', c', the values of price, grind, and ending stocks can be forecast.

Analysis and Results for Cocoa
Regression Models for Cocoa Ending Stocks and Grind

The first set of equations in Table 1 show the results of fitting linear equations to the data by the method of ordinary least squares (OLS). The grind equation confirms much that is already known; current price has only a slight negative effect on the current marketing year's grind, but last year's price exerts a very strong negative effect. A very strong time trend is also present, equal to approximately 40.8 thousand metric tons per year.

The ending stocks equation has a modest R^2, although both the price and time variables have large t ratios. Based on the discussion in the preceding section and a priori knowledge about the price-ES/G relationship, a linear-additive model is not a satisfactory mathematical form of this function. Consequently, the final 3-equation model contains a curvilinear specification of the ending stocks function.

Since the 3-equation system is comprised of both linear and curvilinear equations, a simple direct mathematical solution is difficult. The system, however, may be solved readily by means of graphic techniques. The benefit of this method is not only ease of estimation, a must for participants in the cocoa trade who lack computer facilities or who have limited knowledge of econometric methods, but also that it readily displays the shifts in demand as they occur as well as the form these functions take.[2]

The first step in the graphic solution for any particular year is to substitute values of the independent variables for that year into

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[2] For a more detailed discussion of the application of graphic analysis in econometrics and for simultaneous equations in particular, the reader is referred to Waugh (1957).

Table 1. Cocoa - Statistical Results

							R^2
Linear							
	Grind =	1040.6 - 0.464 Price	-	4.356 1-P	+	40.874 Time	.982
t-value		(-.67613)		(-6.1623)		(28.4418)	
	ES =	799.1 - 9.196 Price	+	10.974 Time			.799
t-value		(-8.156)		(3.541)			
Curvilinear							
Log	Grind =	6.898 + 0.074 Log Price	-	0.147 Log P-1	+	0.231 Log Time	.910
t-value		(1.217)		(-2.271)		(12.126)	
Log	ES =	8.971 - 0.869 Log Price	+	0.212 Log Time			.925
t-value		(-12.774)		(7.368)			
Final Cocoa Model							
	Grind =	1040.6 - .464 Price	-	4.356 1-P	+	40.874 Time	.982
Log	ES =	8.971 - 0.869 Log Price	+	0.212 Log Time			.925
	Grind + ES = Supply						

the behavioral equations (i.e., equations (1) and (2)) and then combine these values with the constants as follows.

$$G = 1040.5632 - 0.46353 (P) - 4.3556 (Pt-1) + 40.874 (T)$$

$$\text{Log } ES = 819712 - 0.8691 (\log P) + 0.2115 (\text{Log } T)$$

Then select a series of values of (deflated) prices and compute the associated values of G and ES from the above equations. Plot these points and connect by the appropriate lines (linear for the grind, smooth curve for ES).

Add the computed values of G and ES for each level of price. This variable is supply. Then, plot price against supply and connect with a smooth curve. This is the basic price function for the given year.

To obtain the equilibrium solution first take the indicated supply and read the associated price from the ordinate. To obtain the equilibrium solution for G and ES, draw a horizontal line through the equilibrium price and where this line intersects the G and ES functions, draw perpendicular lines that intersect their respective scales.

Based on the data in Annex 1, Figures 6 through 8 illustrate this procedure for 1960-61 and 1974-75 for all the conceptual relationships discussed in the preceding section. The reader will note the following: (1) the exceptionally close correspondence between the observed (actual) and computed values; (2) the fact that all the functional relationships shift; and (3) that only the grind function is linear.

The statistical results shown in Figures 9 and 10 were based again on the data contained in Annex 1 for the marketing years 1956-57 through 1975-76. The reasons for choosing this time period are twofold. First, this was a time span that saw cocoa prices reach a post-World War

Figure 6. Cocoa - Basic Demand and Price Structure

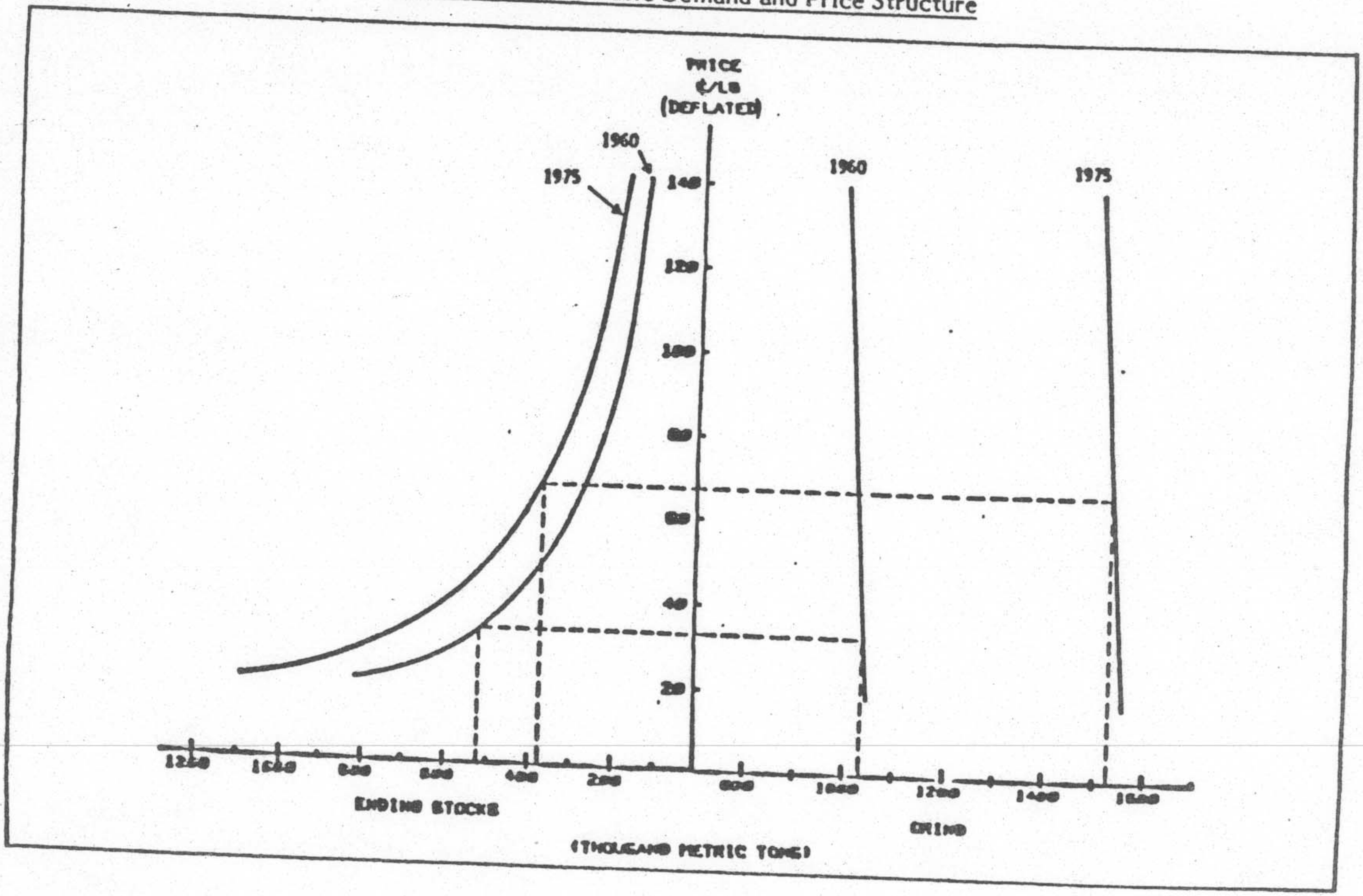


Figure 7. Cocoa - Basic Price Function

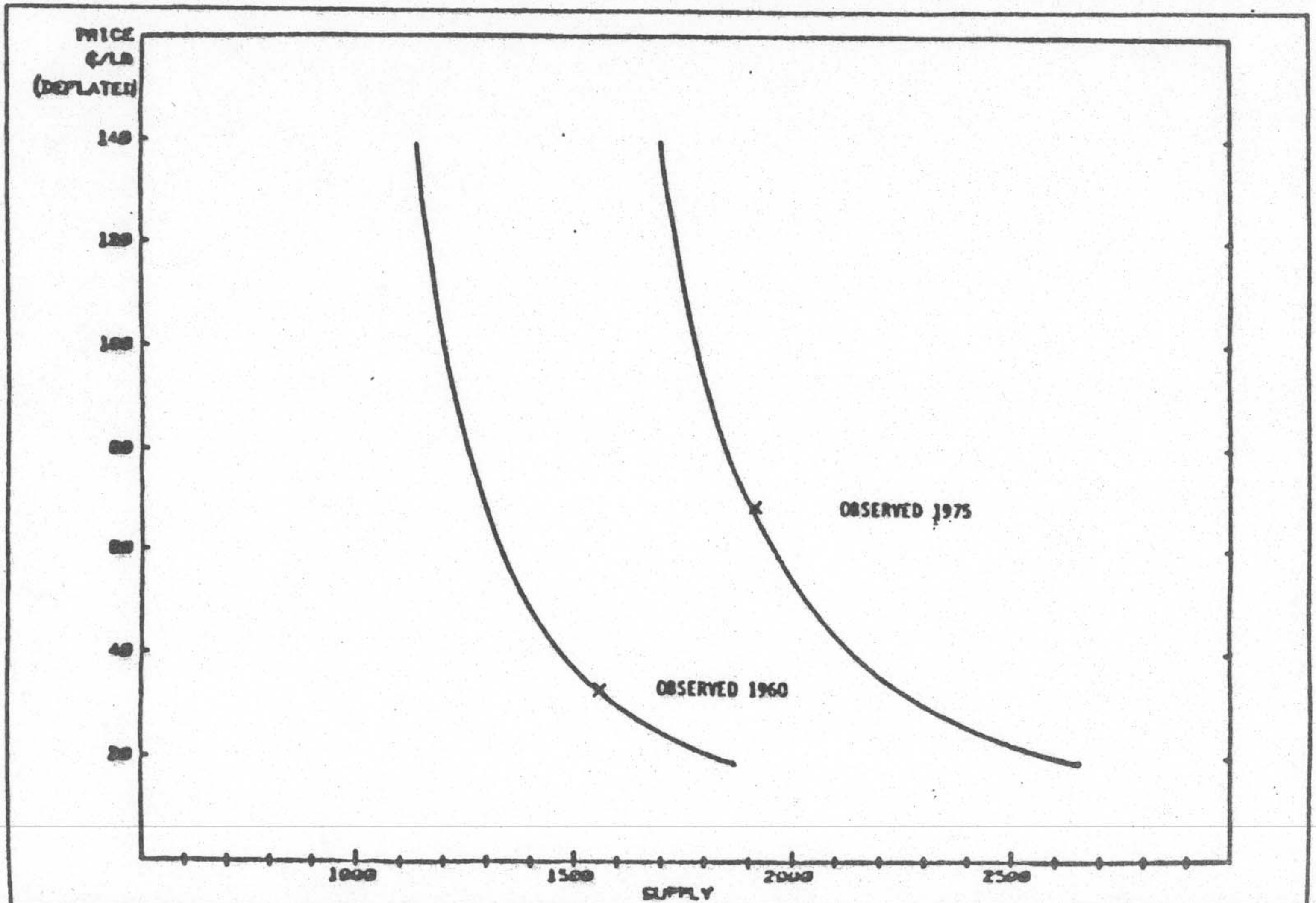


Figure 8. Cocoa - Price vs. Ending Stocks to Grind Ratio

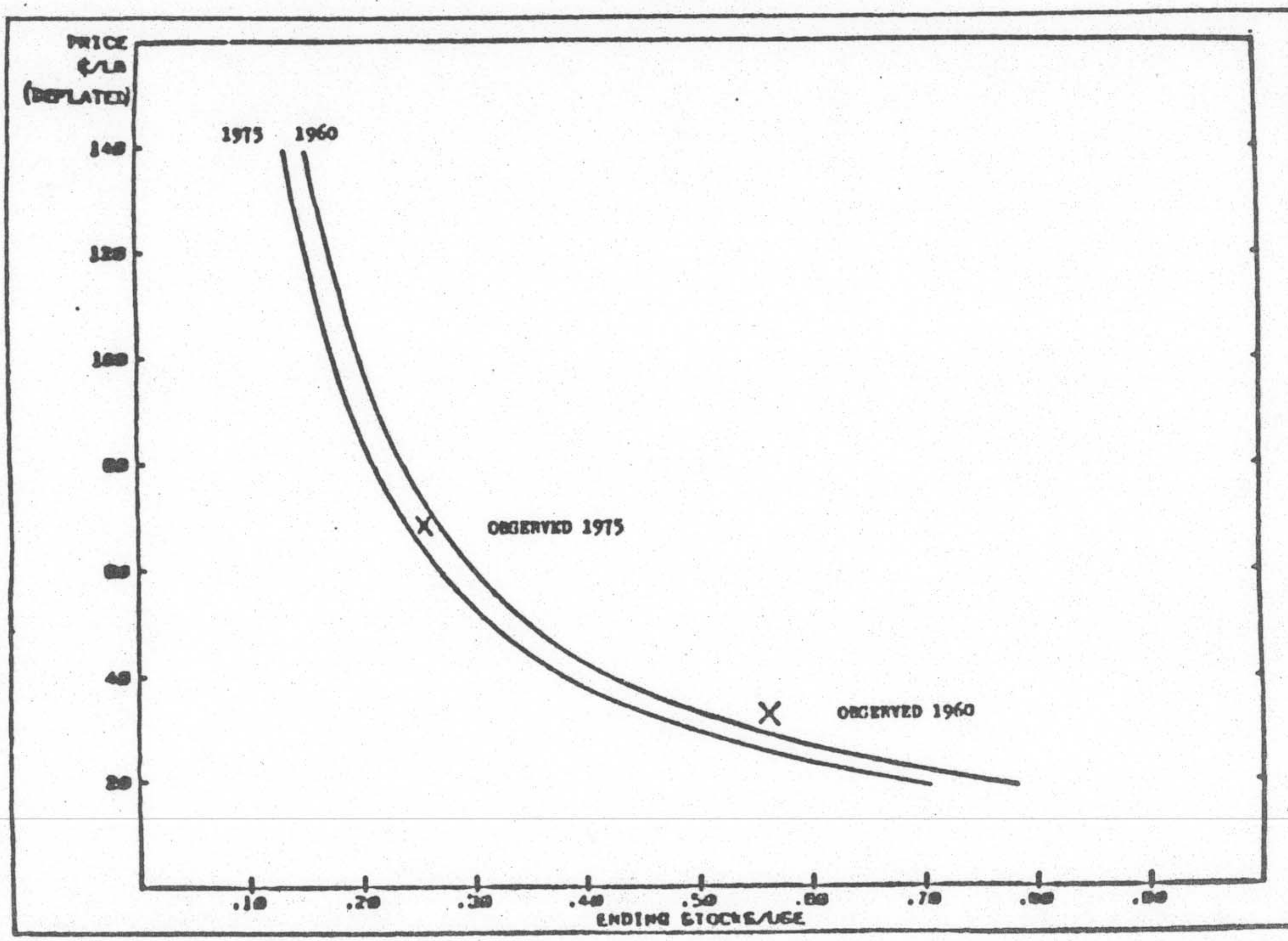


Figure 9 Cocoa - Simultaneous Forecasts of Ending Stocks and Grind

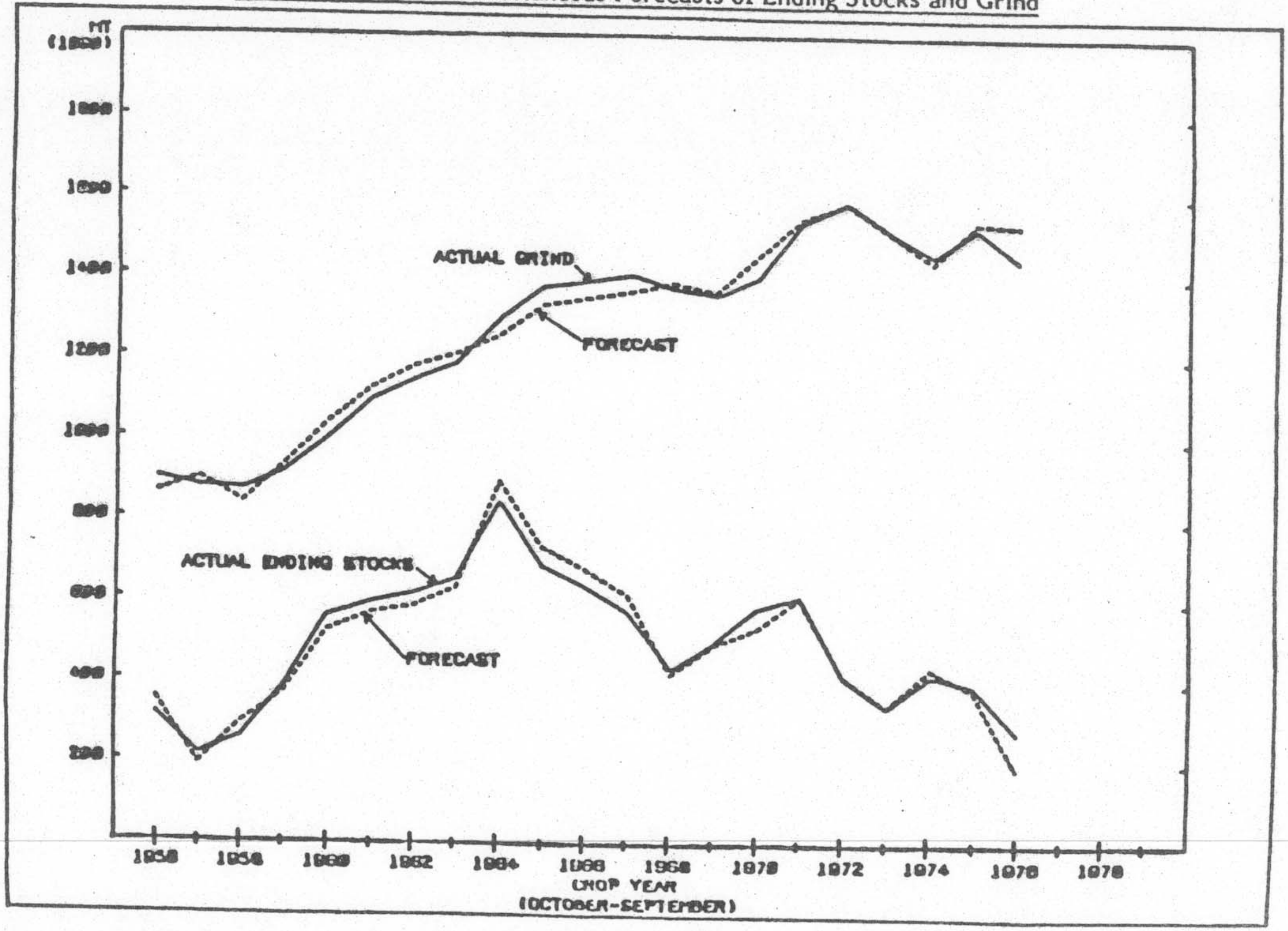
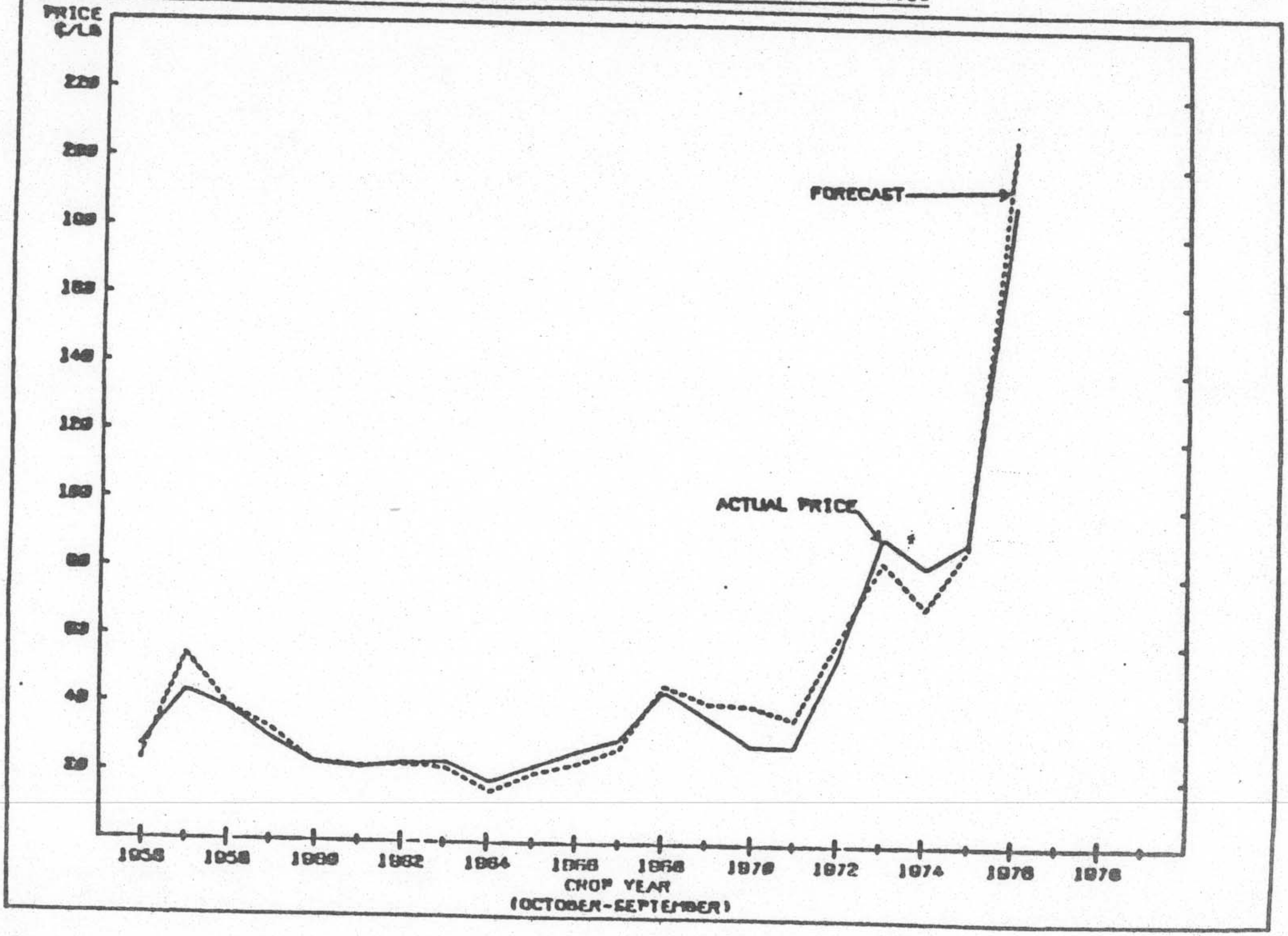


Figure 10 Cocoa - Simultaneous Forecast of Price



II low of 11.63 cents per pound in July of 1965. Second, the high cash price of over 250 cents per pound in 1977, or for that matter the season average price of 189 cents in 1976-77, would have been difficult to foresee based on a simple ES/USE forecast for that year. Prior to the record high prices seen in 1976-77, the previous high season average cash price occurred during the 1973-74 season and was 91.2 cents per pound. If one were to refer back to Figure 1, one would observe that the previous high occurred when the ES/USE ratio totaled 22.35 percent. In order for one to attempt to forecast the 1976-77 season average price of 189 cents per pound, one would have to draw virtually a vertical line, or in other words, have known in advance that the ER/USE ratio would lie on the more inelastic segment of the ES/USE curve. However, even if one knew this beforehand, his forecast of an ES/USE lower than that seen in 1973-74 would imply a forecast of price in 1976-77 ranging anywhere from the previous season average high of 90 cents to infinity! Clearly, this would not be an exact forecast. Also included in our results in Figures 11 and 12 are the forecasts for ES, G and price for the 1976-77 season, which was outside our sample period. As can be seen, the forecast of ending stocks was below the actual, while the grind was somewhat overestimated. This is most probably due to the presence of autocorrelation. However, the forecast of the season average price at 207 cents per pound, although 18 cents above the actual, must still be considered a respectable forecast considering the historical data.

Conclusions and Recommendations

In sum, the simplistic approach of relating cocoa prices, or any commodity price for that matter, to the ratio of ES to G or USE is unacceptable from an econometric viewpoint and naive. Although there is no denying a high correlation between these variables, this should be expected since all three are simultaneously determined and, by definition, are dependent upon each other. Consequently, a high correlation between price and ending stocks does not imply that prices are determined by a stocks-use ratio.

Furthermore, arguments that state that one ratio is preferred to another (i.e., the ES/USE is a better forecaster of price than USE/S lacks merit since they all result from the same basic underlying structure. In addition, simple scatters of price versus ES/USE, USE/S, or even ES/S provide little indication about the actual operation of the forces that determine price. This is evidenced by the fact that it is possible to go from the demand functions and the basic price functions to the above mentioned relationships, but it is not possible to do the reverse.

The problems encountered in using these relationships largely result from the highly inelastic character of the ES function at low levels of stocks. Consequently, any attempt to study commodity markets and forecast prices must concentrate heavily on the demand for stocks, for this is where most price volatility will arise. Unfortunately, it is also in the area of stocks where poor statistical results may arise due to data errors. This is due to the fact that for most commodities, ending stocks are treated as a residual product. For example, it is not uncommon for historical cocoa data to be revised considerably, and due to the nature of the stocks function, a change of large magnitude can greatly affect forecasts of price, particularly if errors occur at low levels of supply.[3]

[3]For a more thorough discussion of the demand for storage the reader is referred to Labys (1973).

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Annex 1. Historical Cocoa Data

Cocoa Season Oct-Sept	Beginning Stocks	Net World Crop	Total Availability	Seasonal Grindings	Ending Stocks	ES/Grindings (%)	Grindings Supply	Price**
	------------	------------	------------ thousand metric	tons ------------		------------	------------	
1956-57	308	902	1,210	898	312	34.74	74.21	27.4
1957-58	312	778	1,090	875	215	24.57	80.28	43.8
1958-59	215	914	1,129	870	259	29.77	77.06	38.5
1959-60	259	1,042	1,301	916	385	42.03	70.41	30.0
1960-61	385	1,177	1,562	1,000	562	56.20	64.02	23.4
1961-62	562	1,129	1,691	1,095	596	54.43	64.75	21.9
1962-63	596	1,164	1,760	1,144	616	53.85	65.00	24.0
1963-64	616	1,222	1,838	1,184	654	55.24	64.42	24.1
1964-65	654	1,493	2,147	1,297	845	65.15	60.41	18.4
1965-66	845	1,214	2,059	1,374	685	49.85	66.73	23.0
1966-67	685	1,337	2,022	1,387	635	45.78	68.60	27.5
1967-68	635	1,340	1,975	1,403	572	40.77	71.04	30.9
1968-69	572	1,230	1,802	1,369	433	31.63	72.97	45.2
1969-70	433	1,421	1,854	1,354	500	36.93	73.03	37.4
1970-71	500	1,484	1,984	1,399	585	41.82	70.51	29.2
1971-72	585	1,567	2,152	1,536	616	40.10	71.38	29.0
1972-73	616	1,383	1,999	1,583	416	26.28	79.19	55.5
1973-74	416	1,434	1,850	1,512	338	22.35	81.73	91.2
1974-75	338	1,434	1,872	1,452	420	28.93	77.56	82.5
1975-76	420	1,497	1,917	1,523	394	25.87	79.45	90.3
1976-77	394	1,326	1,720	1,442	278	19.28		

*Source: Gill & Duffus Groups "Cocoa Market Report"
**Spot Accra, New York (¢/lb.)