ANALYSIS OF THE UNITED STATES DEMAND FOR GHANIAN COCOA BEANS

by

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CHAPTER 1

INTRODUCTION

The intent of this paper is to determine the characteristics of the demand of United States consumers for Ghanian cocoa beans. Knowledge of the characteristics of this demand is important because cocoa is the major export commodity of Ghana and because the United States is the largest market for Ghanian cocoa beans. This should provide for the policymakers of Ghana a means of deciding which programs to emphasize in order to increase the demand for their cocoa beans in the United States.

In order to determine the characteristics of the demand, we will estimate the demand function and analyze its properties. To estimate the demand function, we will look at the products for which cocoa beans constitute a major ingredient and the factors that determine the demand of these products.

Cocoa

Cocoa is a perennial crop and there are three major varieties of it: Trinitario, Criolla, and Forastero. Most of the cocoa is from the Forastero variety. The seed of the Forastero cocoa has a bitter taste and a dark purple color. There are several kinds of beans that belong to the

Forastero cocoa. They are Cundeamor, Angoleta, Sangretoro, Amelonado, Amazon, and Martina. The Amelonado cocoa is the one that is exported by Ghana.

Cocoa trees grow best in hot, wet, humid climates. The weather conditions during a given year have a significant effect on the amount of cocoa beans produced. Whether or not the trees are infected by disease also has a great effect on the quantity and quality of beans that are produced.

The major diseases of cocoa trees in Ghana are Swollen Shoot, Die-back, and Black Pod. Cocoa trees get the Swollen Shoot disease from wild trees and it is spread among the trees by mealy bugs. After a tree is infected, its shoots, or branches, swell and if the tree is highly infected, it loses its leaves and dies.

Die-back, which is spread by capsid bugs, destroys the cocoa crop although the trees do not usually die. However, the trees die in a year or two if they are highly infected. Black pod disease causes destruction of a large amount of the crop but does not kill the trees.

Besides the diseases described above, other problems that affect cocoa trees are pests like wood termites, thread blights, and root root diseases.

Most of the cocoa in Ghana is grown by small farmers and is harvested during the main harvest period, from October to March, and the mid-harvest period, from May to June.

After the beans are imported into the United States, they are cleaned and roasted. Roasting improves their color, smell, and taste. When the beans are roasted they are broken up and the shells are separated from the nibs. The nibs of different types of cocoa beans are mixed together to improve the flavor of the cocoa. The next stage in processing the beans is grinding. Grinding separates cocoa butter from the rest of the bean. After grinding, there are several types of products that are produced from the bean. They are:

1) Sweet chocolate. Sweet chocolate is made from chocolate liquor, cocoa butter, and flavorings such as salts, spices, and oils. It is dark in color.
2) Baking chocolate. Baking chocolate is made only from ground nibs, and is bitter.
3) Milk chocolate. Milk chocolate is made like sweet chocolate except that part of the chocolate that is needed in making sweet chocolate is replaced by milk. It is lighter in color and sweeter than sweet chocolate.

Cocoa Production and Consumption

Table 1 and Table 2 show that most of the world's cocoa is produced in West Africa and South America, and most of it is consumed in North America and Europe. The United States is the world's largest consumer of cocoa beans and Ghana is one of the world's largest producers.

TABLE 1

WORLD COCOA PRODUCTION

Region	Percentage of Cocoa Produced
West Africa	66%
South America	25%
North America	8%
Asia	1%
World Total	100%

Source: Commodity Yearbook, Commodity Research Bureau.

TABLE 2

WORLD COCOA CONSUMPTION

Region	Percentage of Cocoa Consumed
United States	33%
Europe	60%
Other Countries	7%
World Total	100%

Source: Commodity Yearbook, Commodity Research Bureau.

In Ghana, cocoa is marketed through the Cocoa Marketing Board. The Board exists to sell cocoa beans on the world market and functions to stabilize prices for the producers by paying them a fixed price that is established before the beans are sold. Another function of the Board is to administer the research and development of the cocoa industry in Ghana.

Most of the futures trading in cocoa is done in the New York and London markets. Some futures trading is also done in the Amsterdam and Hamburg markets.

Above we have given a brief description of cocoa as an agricultural product and as an economic product. Next we will attempt to formulate a demand function for cocoa beans by United States consumers.

CHAPTER 2

THE DEMAND EQUATION AND ITS ECONOMIC AND STATISTICAL BASIS

This study covers the years 1956 to 1976 and is based on quarterly time series data. The 84 quarters that are covered give an adequate length of time to observe the cyclical behavior of demand over time. The data ~~is~~ are from the Survey of Current Business and U.S. Imports-General and Consumption.

2.1 Economic Basis

Most of the secondary and finished cocoa products are made from cocoa powder, cocoa butter or chocolate liquor. Analysis of the variables that influence their demand should provide an insight into the demand for cocoa beans; thus the demand for cocoa beans will be a derived demand.

The theory that provides the background for the analysis of the demand is the economic theory of demand. The law of demand states that ~~if~~ a decrease (increase) in the price of a product causes an increase (decrease) in the quantity of the product that is demanded, when other factors remain the same, ~~then the product is 'normal'.~~ "Other factors" are variables such as income, population, tastes, prices of other products and expectations of future prices. ~~It is assumed throughout this paper that cocoa is a~~

~~normal good.~~

2.2 Statistical Basis

The demand function for cocoa beans will be estimated by using a linear regression model that is based on the statistical theory of linear models. A regression model defines a statistical relationship between one variable and another variable or a set of variables.

We hypothesize that model 1.0 below specifies a regression relationship for the quantity of cocoa beans imported into the United States.

Model 1.0

$$Q_i = \beta_0 + \beta_1 I - \beta_2 PCB - \beta_3 PS + \beta_4 FQ + \beta_5 SQ + \beta_6 TQ + \varepsilon_i$$

Where

Q_i = the square root of the quantity of cocoa beans imported into the United States from Ghana (not per capita)

I = The per capita personal income of the United States (not deflated values)

PCB = The deflated wholesale price of cocoa beans from Ghana on the New York market

PS = The deflated wholesale price of refined sugar in the United States

FQ = 1, if first quarter
0, otherwise

SQ = 1, if second quarter
0, otherwise

TQ = 1, if third quarter
0, otherwise

ε_i are independent normal random variables with mean 0 and variance σ^2, $i = 1, 2, \ldots, n$

The assumptions of model 1.0 are

1. ε_i has a normal distribution with mean 0
2. ε_i has constant variance (homoskedasticity)
3. $Cov(\varepsilon_i, \varepsilon_j) = 0$ (nonautocorrelation)
4. No exact linear relationship between the independent variables I, PCB, PS, FQ, SQ, TQ (nonmulticollinearity).

In order to estimate model 1.0 we will use the method of least squares. Let

$$U = \sum_{i=1}^{84}(Q_i - (\beta_0 + \beta_1 I - \beta_2 PCB - \beta_3 PS + \beta_4 FQ + \beta_5 SQ + \beta_6 TQ))^2.$$

U represents the sum of squares of ε_i in model 1.0. ε_i is the variation in the demand for cocoa that is not explained by the independent variables. The method of least squares estimates model 1.0 by finding the values of β_i, $i = 0, 1, 2, \ldots, 6$ that minimize U. For a multiple regression model these values are

$$\hat{\beta} = (x'x)^{-1}(x'y)$$

Where

$\hat{\beta}$ is a vector which estimates the regression parameters β_i, $1 = 0, 1, 2, \ldots, 6$

x refers to the independent variables

y refers to the dependent variable Q_i.

The Gauss-Markov Theorem tells us that $\hat{\beta}$ is a vector of best linear unbiased estimators.[1] $\hat{\beta}$ is linear since the parameters are linear combinations of the observed values of Q_t. They are unbiased since the expected value of $\hat{\beta} = \beta$. They are called "best" because they have variances that are no larger than the variances of other linear unbiased estimators of the vector β of the parameters. The properties of unbiasedness and minimum variance are important because they tell us that $\hat{\beta}$ gives us the most precise estimate among similar estimators.

When model 1.0 is estimated the result is

$$\hat{Q}_{1e} = 3839.6 + 240.88I - 522000.0PCB - 354100.0PS + 1325.7FQ + 1617.15SQ + 507.65TQ.$$

In the next section we will take an indepth look at the independent variables in order to show why they are used to specify the demand equation.

2.3 Independent Variables

Price of cocoa beans. Cocoa beans are the major ingredient in cocoa powder, cocoa butter, and chocolate liquor. The price of cocoa beans directly affects the price of these products and thus their demand which in turn affects the demand for cocoa beans.

The price of cocoa beans from Ghana is used because when manufacturers are deciding from whom to buy their

[1] Alexander M. Mood, Frank A. Graybill, and Duane C. Boes, Introduction to the Theory of Statistics (New York: McGraw-Hill, Inc., 1950), p. 500.

beans, price is an important variable in determining whom the beans will be bought from. Since cocoa is a normal good, the relationship between the demand for cocoa beans and their price is an inverse one.

Price of sugar. Sugar is another major ingredient which is used in most secondary and finished cocoa products. Its price therefore influences the demand for these products and thus the demand for cocoa beans.

If manufacturers are not in a position to set prices for cocoa products we can assume that an increase in the price of sugar would cause a decrease in the quantity of cocoa beans demanded, since it would increase the cost of manufacturing cocoa products and thereby their prices. The demand for cocoa beans is therefore inversely related to the price of sugar. Both the price of sugar and the price of cocoa beans are deflated to remove the effects of inflation.

Income. The amount of cocoa products that consumers are able and willing to buy is determined to a large extent by the level of their income. According to economic theory the higher the level of personal income in the United States is, the greater the demand for cocoa products should be. Therefore the demand for cocoa beans and the level of personal income in the United States have a direct relationship. Personal per capita income is used to remove the effects of changes in population on the level of income.

Quarters. The indicator variables FQ, SQ, and TQ are placed in the model for an exploratory reason. We would like to find out if the time of the year is significantly related to the demand for cocoa beans from Ghana.

There are several other variables that influence demand. They are tastes of consumers, prices of competing products, price expectations of United States manufacturers, and the ability of manufacturers to store cocoa beans. These variables are omitted in this analysis because of the lack of data in some cases and the desire to simplify the analysis in others.

We have defined the demand function and have given its economic and statistical basis. In the next chapter we will determine if model 1.1 is adequate for specifying a demand relationship for cocoa beans.

CHAPTER 3

ADEQUACY OF THE MODEL

Before drawing inferences from the estimated model, we will examine it to determine if

1) it satisfies assumptions (1) through (4) of a linear regression model, and
2) it specifies a regression relationship between the demand for cocoa beans and the set of independent variables that is correct.

3.1 Assumptions

Let

$$e_i = Q_{1i} - \hat{Q}_{1i},\ i = 1, 2, \ldots, 84.$$

e_i is called the residual term in the estimated model and is an estimate of the normal random variable ε_i. Since assumptions (1) through (3) are about ε_i, we will analyze the residuals to determine if the model meets these assumptions. Assumption (4) involves the relationship among the independent variables, therefore we will use a procedure that is not directly based on the residuals when we look at that assumption.

Normality. Assumption (1) states that the error terms, ε_i, of model 1.0 have a normal distribution with zero mean.

If this assumption is not met, the least squares estimators are still best linear unbiased estimators, but for a small sample size it prevents us from using tests of statistical hypotheses and confidence intervals which are based on the fact that the parameters β_i, i = 0, 1,...6 are normally distributed.[2]

We will use a normal plot of the residuals to test the assumption of normality of the error terms. A normal plot of e_i will be almost linear if ε_i is distributed normally. Figure 1 shows that the normal plot of e_i is almost linear which means that our assumption of normality of the error terms, ε_i is realistic.

<u>Homoskedasticity</u>. For the assumption of homoskedasticity to hold we must have $var(\varepsilon_i) = \sigma_i^2$, i = 1, 2,...,n. When this assumption does not hold, the error terms are said to be heteroskedastic. That is, $var(\varepsilon_i) = \sigma_i^2$. When heteroskedasticity exists, the least squares estimators are still unbiased, but they do not have minimum variance. Therefore with heteroskedasticity we get confidence intervals and acceptance regions of tests of statistical hypotheses that are larger or smaller than the correct ones since in this case the estimate of the variance of $\hat{\beta}$, $S^2(\hat{\beta})$ is biased.

Since the existence of heteroskedasticity means that the error terms, ε_i, vary systematically with the level of the independent variables, scatter plots of e_i against the

[2]Ibid., p. 490.

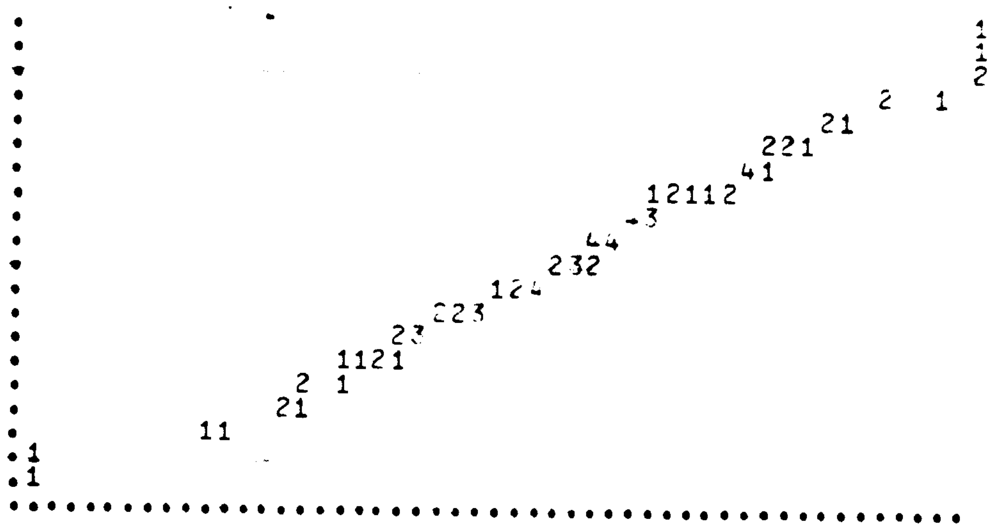

Figure 1. Normal plot of the residuals.

independent variables can point out cases where the error terms may not be constant.

Figures 2 through 4 show the scatter plots of e_i against I, PCB, and PS respectively. Scatter plots of e_i against I and PCB show no pattern that would indicate systematic variation of ε_i with these variables. The plot of e_i against PS is not as clear-cut. Most of the points in Figure 4 are concentrated at low levels of PS.

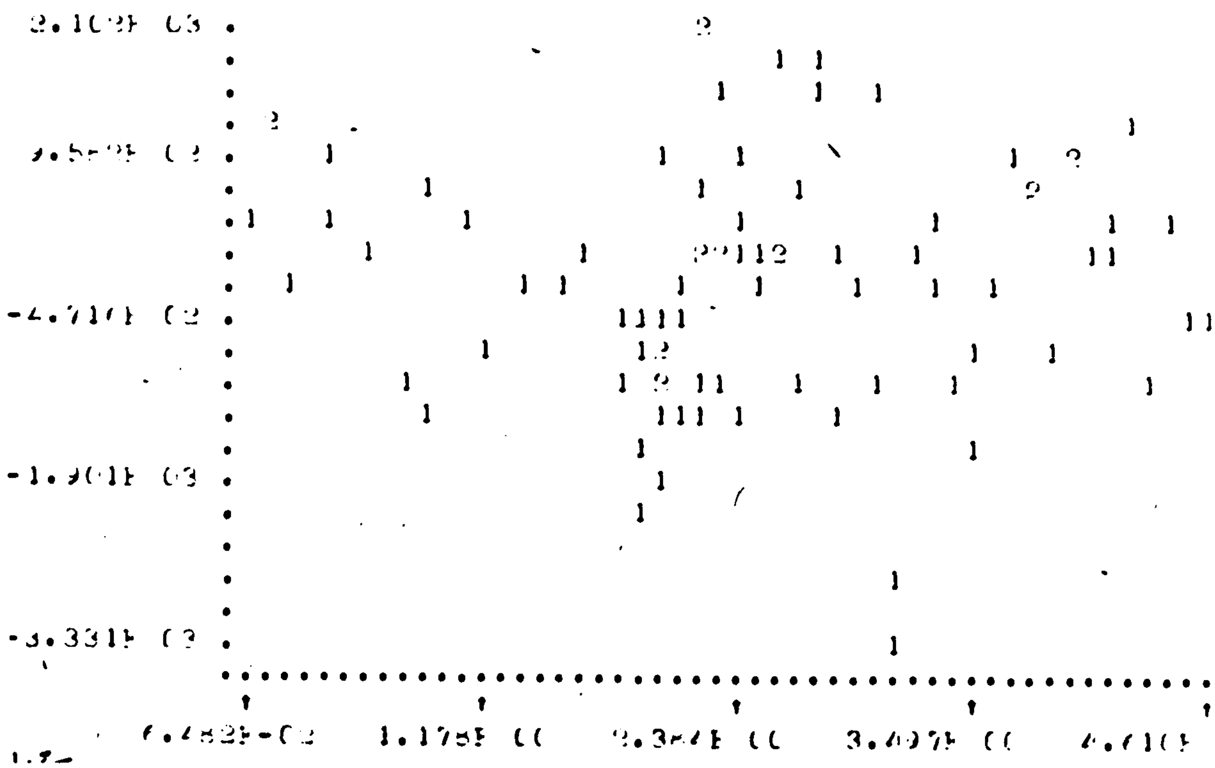

Figure 2. Residuals against income.

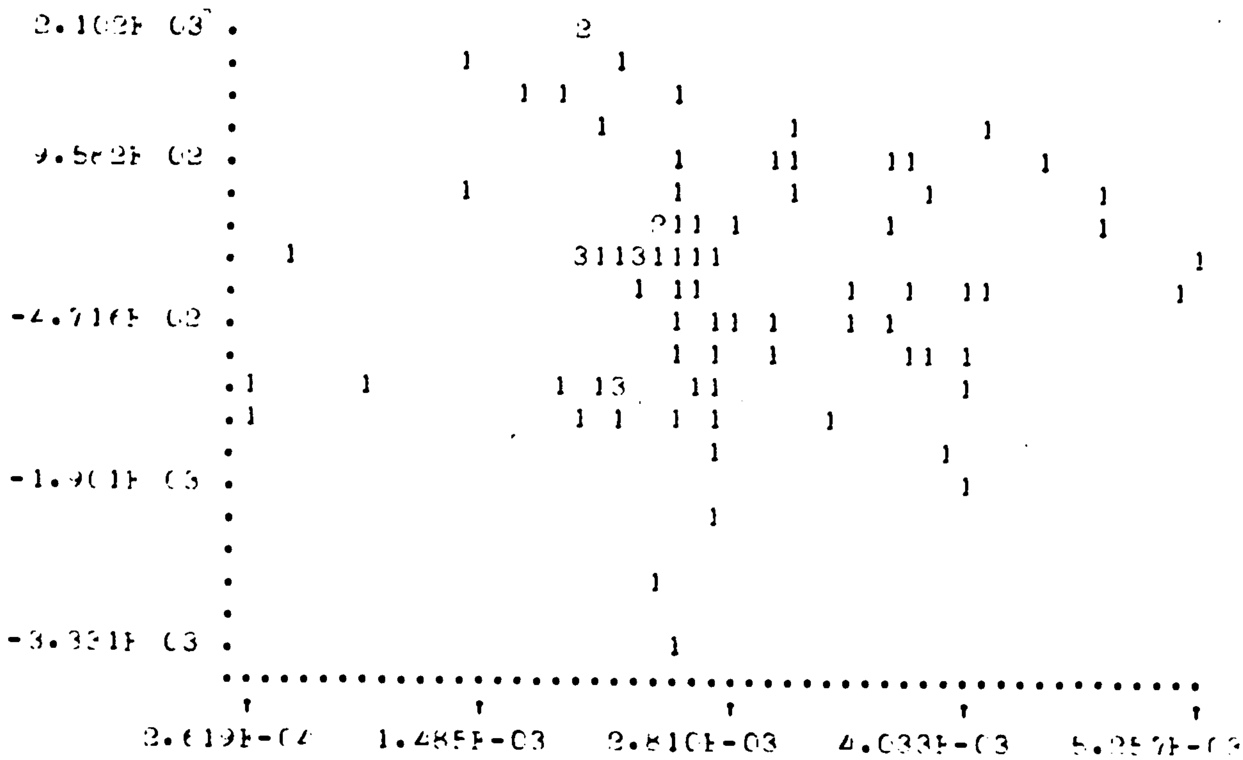

Figure 3. Residuals against price of cocoa beans.

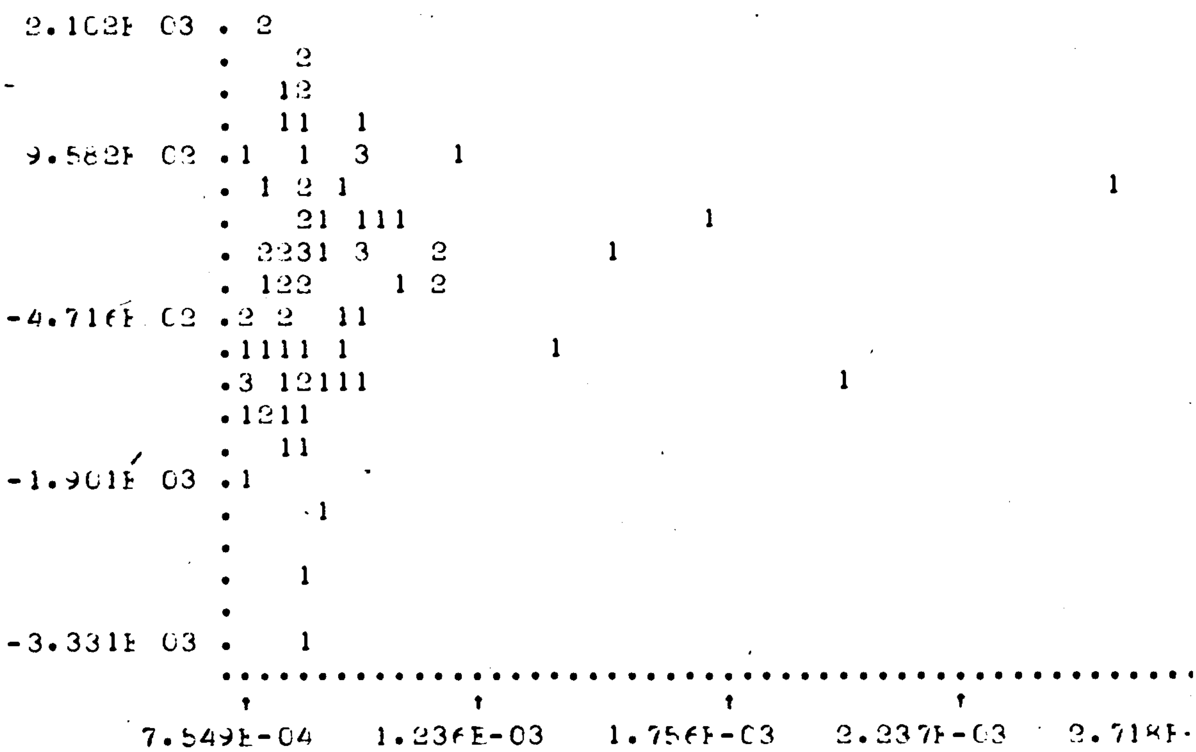

Figure 4. Residuals against price of sugar.

In order to determine whether or not the relationship of the error terms to PS is heteroskedastic, we will conduct a statistical test of the equality of variances for the variable PS. We will carry out the test by ordering PS in ascending order and fitting a regression equation to each half of the observed values of PS. We will then conduct the test to determine if the error variances for the two regression equations are significantly different.

Test for Homoskedasticity.

Model 1.3 $Q_i = \beta_0 - \beta_1 PS1 + \varepsilon_{1i}$ $i = 1, 2, \ldots 42$

Model 1.4 $Q_i = \beta_0 - \beta_2 PS2 + \varepsilon_{2i}$ $i = 1, 2, \ldots 42$

HYPOTHESES

$H_o: \sigma_1^2 = \sigma_2^2$

versus $H_a: \sigma_1^2 \neq \sigma_2^2$

Where σ_1^2 is the variance of the error terms of model 1.3 and σ_2^2 is the variance of the error terms of model 1.4.

TEST STATISTIC

$F^* = \frac{MSE1}{MSE2}$ distributed $F(n_1-1, n_2-1)$ when H_o is true

Where MSE1 is an unbiased estimator of σ_1^2,

MSE2 is an unbiased estimator of σ_2^2.

TEST

Reject H_o if

$$F^* \geq F_{1-\alpha/2}(n_1-1,\ n_2-1) = F_{.975}(41,\ 41) = 2.02 \text{ for } \alpha = .05$$

$$\leq F_{\alpha/2}(n_1-1,\ n_2-1) = F_{.025}(41,\ 41) = .495 \text{ for } \alpha = .05$$

TEST RESULTS

TABLE 3

AVTABLE OF MODEL 1.3

Source of Variation	D.F.	Sum of Squares	Mean Square
Regression	1	14117011.8	14117011.8
Residual	40	46749311.2	1168732.8
TOTAL	41	60866323.0	

TABLE 4

AVTABLE OF MODEL 1.4

Source of Variation	D.F.	Sum of Squares	Mean Square
Regression	1	8285453.77	8285453.77
Residual	40	74554540.3	1863863.51
TOTAL	41	82839994.0	

Table 3 refers to the values of PS that are less than the median of PS. Table 4 refers to the values of PS that are greater than the median of PS.

From Table 3 and Table 4 we get

$$F^* = \frac{MSE1}{MSE2} = \frac{11687327.8}{1863863.51} = .627$$

F* does not fall in the critical region so we do not reject H_o and conclude that model 1.1 meets the assumption of homoskedasticity.

Nonmulticollinearity. The absence of multicollinearity in the values of the independent variables that are observed means that the variables are not correlated with each other. Since it is not common to find a sample with a total absence of multicollinearity, what we are really concerned about is drawing inferences from a model in which the independent variables are highly correlated with each other.

It is justified to be concerned about a high degree of multicollinearity in the sample because in this case although the least squares estimators are still best linear unbiased estimators, they have variances that are large. They therefore provide estimates of the regression parameters that are not accurate.

One criterion that is used to measure the level of multicollinearity, which we will use here, is based on the value of R^2 (coefficient of multiple determination) and is suggested by Jan Kmenta.[3]

By definition

$$R^2 = 1 - \frac{SSE}{SSTO}$$

Where SSE is the measure of the variation associated with the dependent variable

[3]Jan Kmenta, Elements of Econometrics (New York: Macmillan Publishing Co., Inc., 1971), p. 390.

when independent variables are in the model. SSTO is the variation associated with the dependent variable when the independent variables are not in the model.

The test is carried out by regressing each of the independent variables on the rest of the independent variables and a value of R^2 is calculated for each of the regression equations. A high degree of multicollinearity is said to exist in the sample if any of the R^2's have a value that is near 1.

Table 5 shows that the highest of the R^2's, which is .54 cannot be said to be close to 1; therefore, by the criterion above, the sample does not possess a high degree of multicollinearity.

TABLE 5

TEST FOR MULTICOLLINEARITY

Regression Equation	R - SQ
I = f(FQ, SQ, TQ, PCB, PS)	.54
PCB = f(FQ, SQ, TQ, I, PS)	.46
PS = f(FQ, SQ, TQ, I, PCB)	.32
FQ = f(SQ, TQ, I, PCB, PS)	.35
SQ = f(FQ, TQ, I, PCB, PS)	.34
TQ = f(FQ, SQ, I, PCB, PS)	.33

Nonautocorrelation. When the assumption that $Cov(\varepsilon_i, \varepsilon_j) = 0$, $i \neq j$ is satisfied, the error terms are said to be uncorrelated. ε_i and ε_j are normally distributed, so if they are uncorrelated, it implies that they are independent. When the assumption is false, the error terms are said to be autocorrelated, or serially correlated.

When the error terms are correlated the least squares estimators are still unbiased but they do not have minimum variance. When confidence intervals or acceptance regions of statistical tests are calculated and when the error terms are correlated, they (i.e. confidence intervals and acceptance regions) will be smaller or larger than the correct ones depending on whether the expected value of $S^2(\hat{\beta})$ is larger or smaller than the variance of β.

<u>Test for autocorrelation</u>. Our test for the presence of autocorrelation in model 1.1 will be based on the first order autoregression model 1.5:

$$e_t = \rho e_{t-1} + \lambda_t \qquad (1.5)$$

The assumptions of model 1.5 are:

λ_t is distributed $N(0, \sigma_\lambda^2)$, $t = 1,\ldots,n$

$$E[\lambda_t] = 0$$

$$E[\lambda_s \lambda_t] = \begin{cases} 0 & \text{if } t \neq s \\ \sigma_\lambda^2 & \text{if } t = s \end{cases}$$

<u>HYPOTHESES</u>

H_o: $\rho = 0$

versus H_a: $\rho \neq 0$

We are interested in testing whether or not $\rho = 0$ in model 1.5 because if $\rho = 0$ then $e_t = \lambda_t$. From the assumption of model 1.5 it can be shown that $Cov(\lambda_t, \lambda_s) = 0, t \neq s$ which implies that $Cov(\varepsilon_t, \varepsilon_s) = 0, t \neq s$ if $e_t = \lambda_t$.

TEST STATISTIC

$$t^* = \frac{\hat{\rho}}{s(\hat{\rho})}$$ distributed $t(n-1)$ when H_o is true.

Where

$\hat{\rho}$ is the estimated regression coefficient of e_{t-1} in model 1.5

$s(\hat{\rho})$ is the estimate of $\sigma(\hat{\rho})$.

TEST

Reject H_o if

$t^* \geq t_{1-\alpha/2}(n-1) = t_{.975}(83) =$ ~~1.79~~ 1.99 for $\alpha = .05$

$\leq -t_{1-\alpha/2}(n-1) = -t_{.975}(83) = -1.99$ for $\alpha = .05$

TEST RESULTS

$t^* = 1.20$ and we do not reject H_o and conclude that $\rho = 0$, model 1.1 therefore does not violate the assumption of independence of the error terms.

3.2 The Regression Relationship

In this section we are concerned with whether or not the regression relationship that model 1.0 specifies is correct. That is, whether or not the independent variables have a relationship to the dependent variable that is statistically significant. We will carry out three tests to determine if the variables together are related to the demand for cocoa beans.

Test 1. Existence of regression relationship between Q_i and all of the independent variables.

HYPOTHESES

H_o: $\beta_1 = \beta_2 = \beta_3 = \beta_4 = \beta_5 = \beta_6 = 0$

versus H_a: NOT H_o

TEST STATISTIC

$F^* = \frac{MSR}{MSE}$ which has the $F(\rho-1, n-P)$ distribution when H_o is not true.

Where

n = sample size

P = number of parameters in model 1.1

MSE = error mean square

MSR = regression mean square

TEST

Reject H_o if

$F^* \geq F_{1-\alpha}(P-1, n-P) = F_{.95}(6, 77) = 2.23$ for $\alpha = .05$

TEST RESULTS

TABLE 6

AVTABLE OF MODEL 1.1

Source of Variation	DF	Sum of Squares	Mean Square
Regression	6	64912613.50	10818768.90
Residual	77	80644203.80	1047327.32
TOTAL	83	145556817.0	

From Table 6,

$$F^* = \frac{MSR}{MSE} = \frac{10818769.0}{1047327.3} = 10.33$$

F^* is greater than 2.23 so we reject H_o and conclude that a significant statistical relationship exists between the quantity of cocoa beans demanded and the set of independent variables in model 1.1.

Test 2. Test for the existence of a regression relationship between the quantity of cocoa beans demanded and the time of the year.

1.0 Full Model: $Q_t = \beta_o + \beta_1 I - \beta_2 PCB - \beta_3 PS + \beta_4 FQ + \beta_5 SQ + \beta_6 TQ + \varepsilon_t$

1.6 Reduced Model: $Q_t = \beta_o + \beta_i I - \beta_2 PCB - \beta_3 PS + \varepsilon_t$

HYPOTHESES

H_o: $\beta_4 = \beta_5 + \beta_6 = 0$

versus H_a: NOT H_o

TEST STATISTIC

$$F^* = \frac{SSE(R) - SSE(F)}{P - Q} \div MSE(F)$$ which has the $f(q, n-p)$ distribution when H_o is true.

Where

Q = number of regression coefficients in the reduced model

P = number of regression coefficients in the full model

R refers to the reduced model

F refers to the full model.

<u>TEST</u>

Reject H_o if

$$F^* \leq F_{1-\alpha}(q,\ n-P) = F_{.95}(4,\ 77) = 2.507 \text{ for } \alpha = .05$$

<u>TEST RESULTS</u>

TABLE 7

AVTABLE FOR REDUCED MODEL 1.6

Source of Variation	D.F.	Sum of Squares	Mean Square
Regression	3	30759650.6	10253216.9
Residual	80	114797167.0	1434964.58
TOTAL	83	145556817.0	

From Tables 6 and 7,

$$F^* = \frac{SSE(R) - SSE(F)}{P - Q} \div MSE(F)$$

$$= \frac{114797167 - 80644204}{3} \div 1047327.3 = 10.87$$

Since F* is greater than 2.507 we concluded that seasonal effects do explain a significant amount of the variation associated with the quantity of cocoa beans demanded.

Test 3. Existence of regression relationship between the set of independent variables I, PCB, PS and the quantity of cocoa beans demanded.

1.0 Full Model: $Q_t = \beta_0 + \beta_1 I - \beta_2 PCB - \beta_3 PS + \beta_4 FQ + \beta_5 SQ + \beta_6 TQ + \varepsilon_t$

1.7 Reduced Model: $Q_t = \beta_o + \beta_4 FQ + \beta_5 SQ + \beta_6 TQ + \varepsilon_t$

HYPOTHESES

H_o: $\beta_1 = \beta_2 = \beta_3 = 0$

versus H_a: NOT H_o

TEST STATISTIC

$$F^* = \frac{SSE(R) - SSE(F)}{P - Q} \div MSE(F)$$

TEST

Reject H_o if

$F^* \leq F_{1-\alpha}(Q, n-P) = F_{.95}(4, 77) = 2.507$ for $\alpha = .05$

TEST RESULTS

TABLE 8

AVTABLE FOR MODEL 1.7

Source of Variation	D.F.	Sum of Squares	Mean Square
Regression	3	41688839.9	13896280.0
Residual	80	103867977.0	1298349.72
TOTAL	83	145556817.0	

From Tables 6 and 8,

$$F^* = \frac{SSE(R) - SSE(F)}{P - Q} \div MSE(F)$$

$$= \frac{103867977 - 80644204}{3} \div 1047327.3 = 7.39$$

Since F* is greater than 2.507 we reject H_o and conclude that together, the variables I, PCB, and PS have a significant statistical relationship to the quantity of cocoa beans demanded.

The results of this chapter have shown that model 1.1 satisfies the assumptions of a linear regression model and that it specifies a demand relationship for cocoa beans that is correct. In the next chapter we will analyze the demand equation in order to determine the characteristics of the demand for cocoa beans.

CHAPTER 4

VARIATIONS IN THE DEMAND FOR COCOA BEANS

In microeconomic theory, demand is defined as the quantity of a commodity that consumers are willing and able to buy at a specified price. The sum of consumer demand is market demand. The demand for a product in one period may differ from the demand in another period for two reasons.

First, there may be a change in the level of demand. The level of demand is determined by the willingness and ability of consumers to buy a certain amount of the product. When either of these changes, demand changes and there is said to be a shift of the demand curve. The variables in model 1.0 that cause the demand curve to shift are income and quarterly effects.

The second reason why demand in one period may not be the same as demand in another period is that there may be a change in the quantity demanded. In this case, the curve has not shifted to a new level of demand but there is a change in the quantity of the product that is demanded by consumers at a specified level. Changes in the quantity of the product that consumers demand are the results of changes in the price of the product. When there is a change in the quantity demanded, there is said to be a movement along the demand curve. In model 1.0 the variables that cause movements along the demand curve are PCB and PS because they directly affect the prices of finished cocoa products. PCB may be looked upon as the major determinant of movement along the demand curve while PS may be looked upon as the minor determinant since cocoa beans are the major ingredient in finished cocoa products; although this could become the other way around if sugar became scarce and most likely more expensive. In the next two sections we will take a closer look at the characteristics of the demand for cocoa beans by examining the variables that shift the demand curve and the variables that change the quantity of cocoa beans demanded.

4.1 Changes in the Quantity of Cocoa Beans Demanded

Price of sugar. Figure 5 shows that the price of wholesale sugar in the United States from 1956 to 1976 was stable over most of the period. Because of the lack of a great amount of variation in the price of sugar, we would not expect it to have greatly influenced the demand for cocoa beans, which Figure 6 shows varied a great deal. Figure 5 and Figure 6 show no distinct pattern between the variations of PS and CB (quantity of cocoa beans imported into the United States from Ghana).

Although there is a lack of a distinct pattern between the graphs of the variables, the negative regression coefficient of PS in model 1.1 does verify the hypothesis that the demand for cocoa beans is inversely related to the price

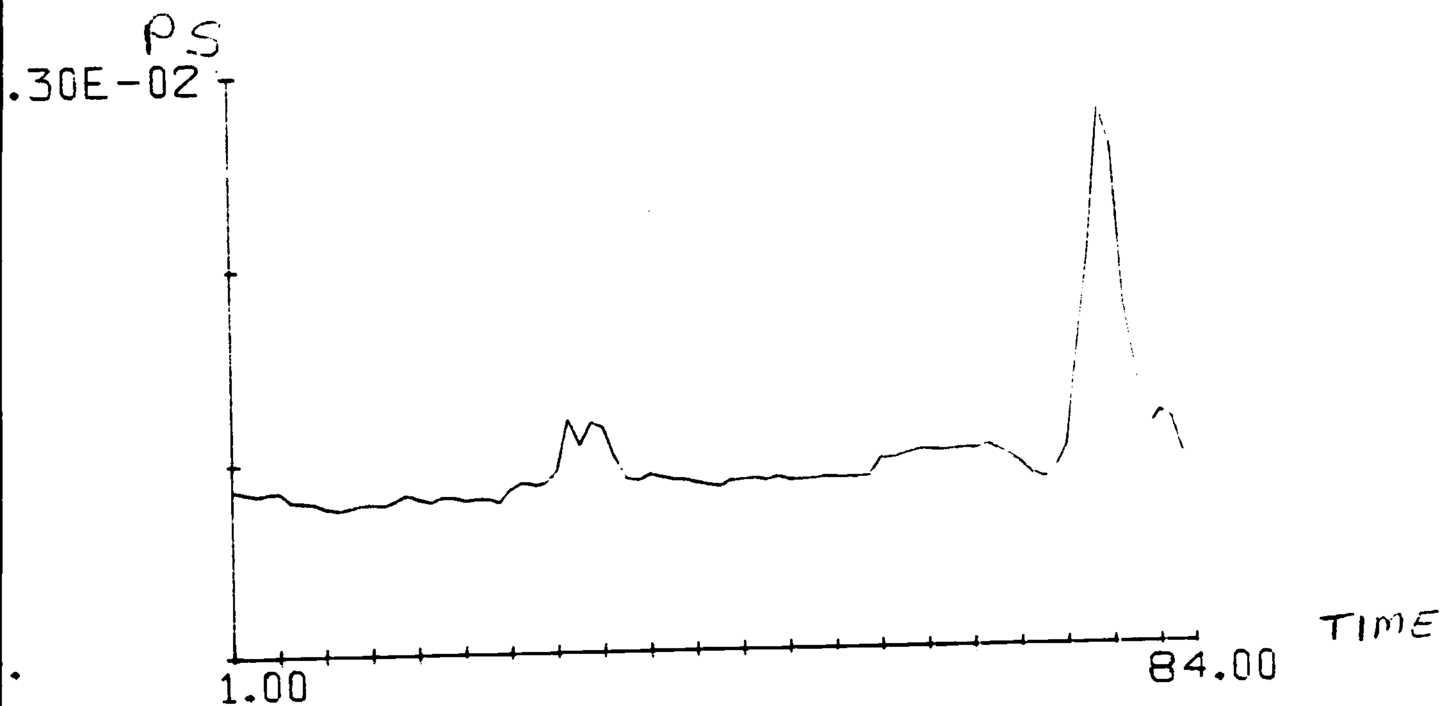

Figure 5. Price of sugar.

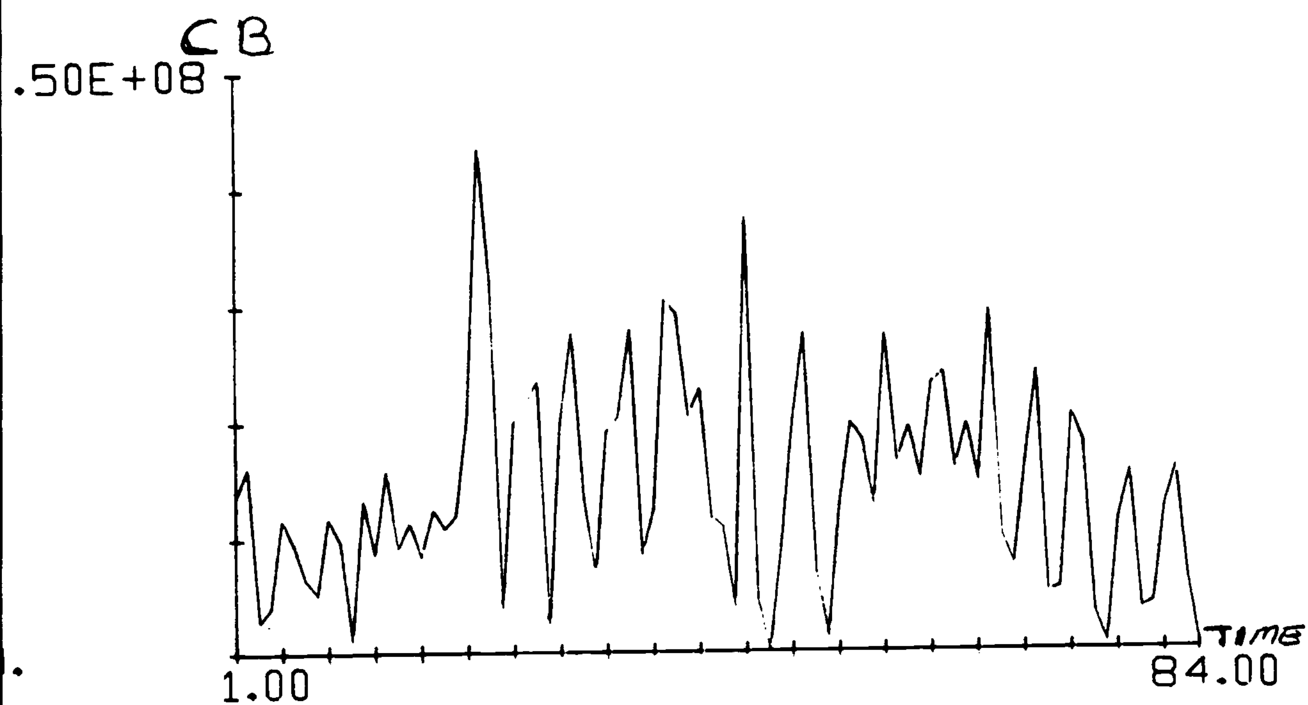

Figure 6. Quantity of cocoa beans imported.

of sugar. Whenever there was an increase (decrease) of one cent in the price of sugar, there was a decrease (increase) of $(354200)^2$ lbs. in the demand for cocoa beans.

Price of cocoa beans. It was hypothesized in Chapter 2 that the relationship betweeen PCB and the quantity of cocoa beans demanded is an inverse one. The hypothesis is supported by the negative regression coefficient of PCB. The regression coefficient of PCB is -522000^2 which means that a quarterly increase (decrease) of one cent in the price of cocoa beans brought about a decrease (increase) of 522000^2 lbs. in the quantity of cocoa beans demanded. The hypothesis is also supported if Figure 6 is compared with Figure 7. A comparison of these Figures shows an inverse relationship between the two variables over most of the period under study.

Figure 7 also shows that the price of cocoa beans fluctuated widely. It is therefore important to determine how sensitive changes in the quantity of cocoa beans that is demanded is to changes in the price of cocoa beans. The concept of price elasticity of demand allows us to measure the level of sensitivity of quantity changes to price changes. Price elasticity of demand is defined to be the percent to which the quantity that is demanded changes when there is a one percent change in the price of the product. Price elasticity of demand is measured by

$$\left|\overline{\eta}_{Q \cdot PCB \cdot Z}\right| = \left|\frac{\partial Q}{\partial PCB} \frac{\overline{PCB}}{\overline{Q}}\right|$$

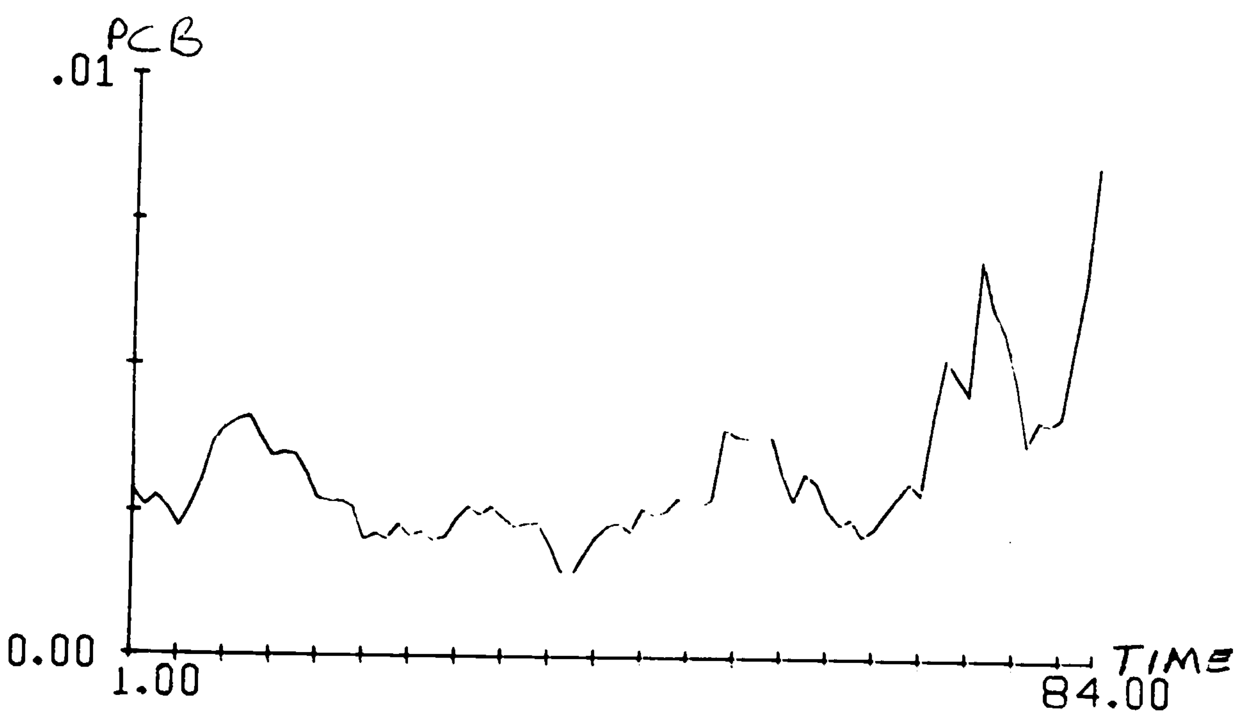

Figure 7. Price of cocoa beans.

Where

$\bar{\eta}$ = the average coefficient of elasticity

$\bar{Q}$ = the value of model 1.1 when the independent variables are replaced by their average values for the years 1956 to 1976

$\overline{PCB}$ = the average value of PCB for the years 1956 to 1976

Z = all other variables in the demand equation except Q and PCB

The subscript $Q \cdot PCB \cdot Z$ means that we are computing the partial price elasticity of demand. We want the partial price elasticity of demand because model 1.1 is a function of several variables and in order to examine the elasticity with respect to PCB we have to hold constant the effects of the other variables. Since elasticity varies continously along a linear demand curve, our results will have more meaning if we compute the average price elasticity.

For price elasticity of demand, $|\eta|$ is an indication of the degree to which the demand for a product is elastic or inelastic.

$|\eta| > 1$ means that demand is price elastic. That is, a one percent change in price results in more than a one percent change in quantity demanded.

$\eta < 1$ means that demand is price inelastic. A one percent change in price results in less than a one percent change in quantity demanded.

$\eta = 1$ means that demand has unit price elasticity. A one percent change in price results in a one percent change in quantity demanded.

For our data,

$$|\eta_{Q \cdot PCB \cdot Z}| = \left|\frac{\partial Q}{\partial PCB} \frac{\overline{PCB}}{\overline{Q}}\right| = .47,$$

therefore the demand for cocoa beans is price inelastic.

In the next section we will look at the variables that cause the demand curve to shift to a new level of demand.

4.2 Changes in the Level of Demand

Income. Income shifts the demand curve upwards or downwards because it affects both the ability and willingness of consumers to buy a product. The regression coefficient of I in model 1.1 is 240.88 which means that a quarterly increase (decrease) of one billion dollars in the level of personal income shifts the demand curve upwards (downwards) by $(240.88)^2$ lbs.

Figure 8 shows that personal income in the United States increased steadily from 1956 to 1976. This contrasts sharply with the fluctuations in the quantity of cocoa beans imported, which is shown in Figure 7. It would be useful to

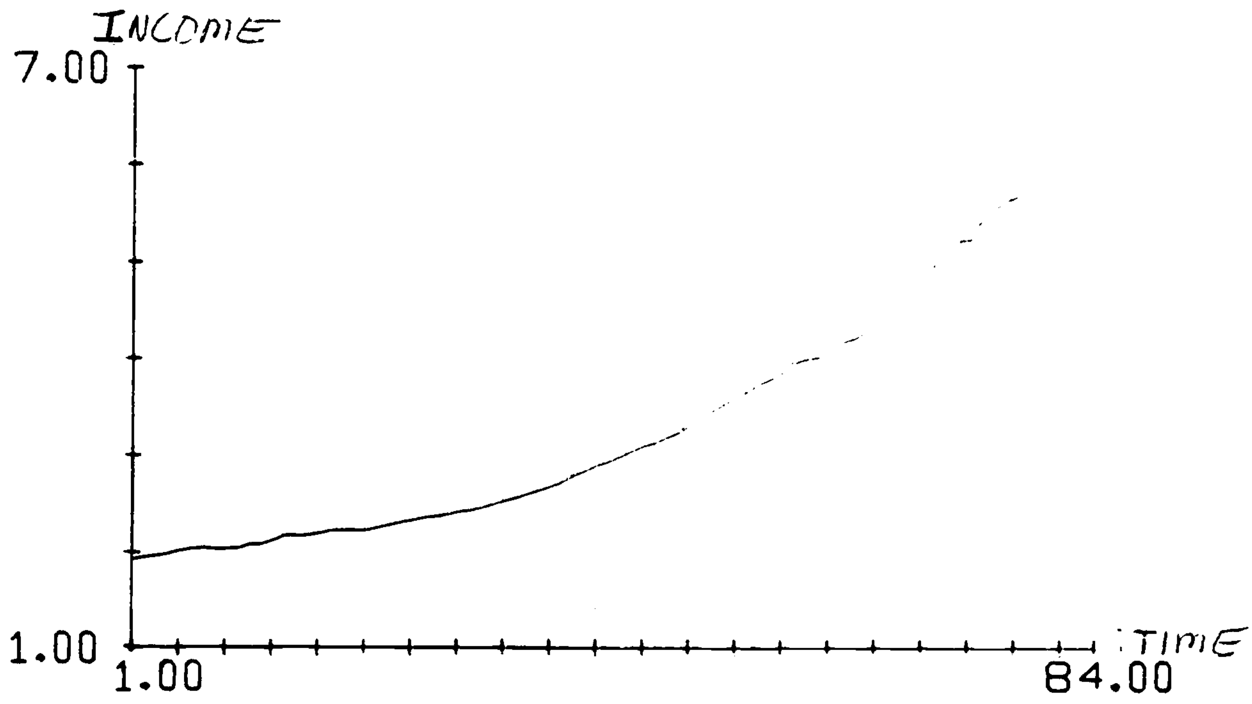

Figure 8. United States personal income.

find out how strong the influence of the level of income on the quantity of cocoa beans that is demanded is.

A concept similar to price elasticity of demand, called income elasticity of demand, will be used to measure the sensitivity of quantity changes to income changes. Income elasticity of demand is defined to be the percent to which the quantity that is demanded changes when there is a one percent change in the level of income:

$$\bar{\eta}_{Q\cdot I\cdot Z} = \frac{\partial Q}{\partial I}\frac{\bar{I}}{\bar{Q}}$$

For normal goods, $\eta_{Q\cdot I\cdot Z} > 0$ so we do not need to take its absolute value.

If

$\eta > 0$, a one percent change in income results in a change in the quantity that is demanded that is greater than one percent

$\eta = 1$, then demand has unit income elasticity. A one percent change in income results in a one percent change in the quantity of the good that is demanded

$\eta < 1$, a one percent change in income results in a change in the quantity demanded that is less than one percent.

For our data,

$$\bar{\eta}_{Q\cdot I\cdot Z} = .23$$

therefore the demand for cocoa beans is income inelastic.

Quarterly effects. In model 1.0 quarterly effects are represented by the variables FQ, SQ, and TQ. The regression coefficients of FQ, SQ, and TQ which are 1325.7, 1617.1, and 507.65 respectively mean that the rate (number of lbs.) at which the demand for cocoa beans is shifted upwards by FQ, SQ, and TQ is $(1325.7)^2$, $(1617.1)^2$, and $(507.65)^2$ respectively.

In the next chapter we will provide a summary of the conclusions of the analysis.

CHAPTER 5

SUMMARY AND CONCLUSIONS

The equation for the United States demand for Ghanian cocoa beans was hypothesized to be

$$Q_i = \beta_0 + \beta_1 I - \beta_2 PCB - \beta_3 PS + \beta_4 FQ + \beta_5 SQ + \beta_6 TQ + \varepsilon_i$$

It was shown that this equation meets the assumptions of a linear regression model and that it specifies a relationship between the quantity of cocoa beans demanded and the independent variables that is statistically significant.

The results obtained from the analysis are:

1. The time of the year does influence the demand for cocoa beans.
2. The demand is income inelastic; that is, a one percent increase (decrease) in income results in less than a one percent increase (decrease) in the quantity of cocoa beans that is demanded.
3. The demand is price inelastic. This means that a one percent increase (decrease) in price results in less than a one percent decrease (increase) in the quantity that is demanded. Therefore if the price of cocoa beans is reduced, there will be a reduction in gross revenue.

In view of the above results we will make the following recommendations to policy makers in Ghana. Policy makers should:

1. Find the (quantity, price) combination at which the price elasticity of demand for cocoa beans is one, and produce at that quantity or sell at that price, in order to maximize total revenue. This would have to be done in cooperation with other producers.[4] Or, alternatively,
2. Continue to work with other producer countries and consumer countries to stabilize the price of cocoa.[5]
3. Try to expand their market in countries that have a high income elasticity of demand.
4. Promote the use of cocoa in countries where the income elasticity is low through advertising, etc.
5. Become more active in the production of secondary and finished cocoa products.
6. Try to diversify their economy to become less one-product dependent.

[4] We should note that in 1964-1965 producers of cocoa tried to restrict output but prices declined due in part to a decline in cocoa consumption. See Commodity Yearbook, 1966 (New York: Commodity Research Bureau, Inc.).

[5] Presently producer countries and consumer countries are attempting to negotiate a ceiling price and a floor price for cocoa. See Commodity Yearbook, 1980 (New York: Commodity Research Bureau, Inc.).

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