COCOA IN GHANA:
THE COCOA FARMERS, THE COCOA MARKETING BOARD, AND THE ELASTICITY OF SUPPLY

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Cocoa is Ghana's greatest industry. The cocoa is grown and harvested by Ghanaians in the southern forest belt, usually on small farms of a couple acres in size. But the cocoa is marketed to the Western buyers, as in many less-developed countries, by a national marketing board. The paternalistic attitude taken by the marketing board towards the producers, whom in the past it has usually regarded as ignorant peasants, has aroused some controversy.

This paper consists of six sections: 1) a brief history of the growth of Ghana's cocoa industry, 2) an account of the origin and controversy of the Cocoa Marketing Board, 3) a discussion of the two opposing views of the cocoa farmer, 4) a survey of econometric studies which have been done of the price-responsiveness of the cocoa farmer, 5) a new regression analysis, using data up to 1973 and an Almon price lag, to attempt to estimate a cocoa supply function for Ghana, and 6) conclusions. The econometric results on the elasticity of supply with respect to the price paid to the producer should allow a conclusion as to which view of the cocoa farmer appears justified. They should also allow, when used with a previous estimate of the elasticity of demand, a comparison between what total export earnings actually were and what they would have been in a hypothetical long run equilibrium if there had been no Cocoa Marketing Board.

I. The Development of Cocoa in Ghana

Early attempts made in the nineteenth century to introduce cocoa trees from South America to the Gold Coast were of no commercial significance. But in 1879 a local farmer and blacksmith named Tete Quarshie smuggled in seedlings from Fernando Po and began a small cocoa farm. In 1890 the governor of the Gold Coast established the Aburi Botanical Gardens and encouraged the cultivation for export of both cocoa and coffee, though he thought the latter crop more promising. Cocoa farming spread rapidly due both to the ideal climate of the Gold Coast and the enterprising nature of Akwapim farmers in the Eastern region, who used capital earned in the palm oil and rubber trades to buy plots of forest land and plant the new crop. Production later spread to the Central, Ashanti, and Western regions, especially after construction of a railroad line to the port of Takoradi in the west by the colonial government in the 1920's. Cocoa exports grew from 80 lbs. in 1891, to 40,000 tons in 1911, to 240,000 tons in 1929. In the "Golden Age" of Gold Coast agriculture (1900-1930) cocoa production became the Colony's major industry, and the Gold Coast became the world's major cocoa producer. After 1930, the development of the industry levelled off, and did not increase again until the 1960's.

The world price of cocoa, which had been rising until 1929, fell sharply during the Depression. In 1937 the 12 large Western cocoa companies, who had previously been buying the cocoa beans competitively from Gold Coast middlemen, formed a

monopsonistic Agreement to set the buying price at a low level and allocate the purchased crop among themselves by quota. In protest, the cocoa farmers effectively withheld their crop from the market from October 1937 to April 1938. The British government came to the rescue of the buyers by declaring a truce. An investigation by the Nowell Commission in 1938 concluded that the conflict was the fault of neither the producers nor the buyers, but of the middlemen who sold the cocoa to the buyers on the coast for a higher price than they paid to the farmers in the producing areas. The Commission felt that the middleman links in the marketing chain were inefficient and exploitative.

II. The Cocoa Marketing Boards

When the second World War broke out the British government agreed to buy the entire Gold Coast cocoa crop directly, to keep the price paid to the producers from falling when part of the world market was cut off. This was the beginning of the statutory monopolies which were applied to most West African exports by a succession of British produce control boards. In 1944 and 1946 two Cocoa White Papers accepted the conclusion of the Nowell Commission that the pre-war marketing system had been unsatisfactory, and recommended that the marketing board system be continued after the war, with the explicit goal of stabilizing the price paid to the cocoa producers.

> By fixing a steady buying price in advance of the sale of each season's crop the Boards will cut the link between the price of cocoa in West Africa and the day-to-day price on the world market. Accordingly, in some seasons when world prices are high, the price paid to the producer will be less than the average realisation on overseas sales. The Boards will, on such occasions, show a 'surplus'. There will, however, be other seasons in which the average world price is below the price paid to producers. On these occasions the Boards will make a 'loss', which will be financed from the 'surpluses' occurred in years of high world prices. The intention is that 'profits' will be utilised primarily to maintain the maximum possible stability in the price paid to the producer.

The Gold Coast Cocoa Marketing Board was established in 1947, but from the beginning its record conflicted with the rationale upon which it had been founded. It consistently paid the producers less than it obtained for the cocoa on the world market, even after allowing for the expenses of operations and government export duties, and thus accumulated large surpluses. This trend may at first have been partly unintentional on the part of the Marketing Board, since its policy of "stabilizing producer prices" was of little use at a time when the world price of cocoa was rising very rapidly (from £18 per ton in 1944 to £395 per ton in 1954 in F.O.B. money prices). But the Board quickly developed a bureaucratic image of itself as a profit-making entity, rather than a mere marketing agent. The first time that the Board recorded a slight loss in reserves (1% of revenue in 1948-49) because it had raised the producer price almost to the world level, it immediately reduced the producer price again in order to maintain its surpluses.

The existence of the marketing boards in cocoa and other West African commodities was vigorously attacked in the early 1950's by P.T. Bauer, a free-trade economist.[2] Bauer argued that the British evaluation of the pre-war marketing system had been prejudiced against the middleman and had not appreciated the economic forces at work. He further argued that "stabilization" was a vague policy goal. First, it had not been specified whether stabilization was supposed to apply to producer prices, money incomes, or real incomes. The three possibilities were not consistent; for example, stabilizing prices in a year when the crop was small would mean preventing them from rising, and thus would destabilize producer incomes. Second, it had not been specified whether stabilization was supposed to mean constant prices or prices maintained steady along a trend. The Cocoa White Papers made it clear that producer prices were to be stabilized along the long-term trend of world prices, but the Marketing Board's accumulation of surpluses proved that prices had in fact lost contact with the trend. Bauer and F.W. Paish proposed an alternative scheme by which the government could stabilize producer prices along the trend.[3] In reply, Milton Friedman pointed out that the cocoa farmers could stabilize their incomes without government intervention, simply by saving in good years and borrowing in bad ones, though this would assume the existence of well-developed capital markets.[4]

The defense given for the existence of the Cocoa Marketing Board (CMB) gradually shifted from stabilization of producer prices to mobilization of savings for the development of the cocoa industry. The CMB at first had invested its surplus revenue in British bonds, but soon it began to spend some of the accumulated capital on storage, transport, and processing facilities, loans to cocoa farmers, education, research, and campaigns against the swollen shoot disease and capsid pests which had been taking a great toll among the cocoa trees. It was argued that these projects were for the long-term benefit of the industry, and would have been beyond the capabilities of the cocoa farmers if left to themselves.

The cocoa farmers did not all share this view. The residents of the interior cocoa-producing regions had traditionally resented the alliance of coastal tribes and the British administration which ruled the colony. This resentment, combined with the financial grievances of the cocoa farmers, was behind an unsuccessful Ashanti secessionist movement in 1954.

During the transition of the Gold Coast into the independent state of Ghana, completed in 1957, the emphasis further shifted from using the CMB revenues for the development of the cocoa industry to using them for the development of the national economy. President Kwame Nkrumah relied heavily on revenue from the CMB surpluses and the cocoa duties to finance his schemes for national development, culminating in the Seven-Year Plan of 1963-64. Nkrumah's radical approach to

development had the support of many western economists. Development was thought to require diversification, industrialization, and import substitution, and these in turn to require forced saving in the agricultural sector to support them. If the goal of stabilization was any longer discussed, the concern was with stabilization of the entire economy (for example, by crop diversification) or stabilization of government revenues, rather than stabilization of cocoa producers' incomes.

The opponents of the CMB admitted that its rate of saving was greater than that of the cocoa farmers, but argued that the system had no advantage over a direct tariff, and that both means of financing national development were in fact inequitable with respect to the cocoa farmers, many of whom were quite poor. The proponents of the CMB system argued that it was politically more acceptable to the population than a tariff, and that the cocoa industry was the only source of revenue available to finance Ghanaian development. They also argued that the system was not inequitable, but an example of progressive taxation.

> The cocoa farmers themselves...are the first to admit that even so they are much better off than any of the other major occupational groups in the Gold Coast. They are also fully aware of the fact - and so is everybody else in this country - that their high present-day income is, on the whole, not due to greater initiative, or to harder work than the rest of the population... As a matter of 'justice' between groups, they are therefore, on the whole, ready to accept the idea of a redistribution of some of their group's 'monopolistic' earnings among the other nine-tenths of the population. [5]

The most telling criticism of the marketing board system, after the question of its possible inequity, is that the low price paid to the cocoa farmers would discourage production. Stagnation in the industry in the 1950's appeared to support this view, although the ravages of swollen shoot, especially in the older Eastern region, were probably a more important cause of the failure of production to expand. The proponents of the CMB argued that the price elasticity of supply was very low:

> [T]he evidence in existence certainly does not seem to endorse [the argument that low producer prices restrict output]... [T]his increase in the new regions is the result of plantings at a time when cocoa payments to farmers were some eight to ten times lower than today [1954].[6]

The opponents of the CMB replied that the long run elasticity was relatively high, that low prices would discourage new planting, future output would fall, and Ghana would lose its one source of prosperity in the world economy.

That Nkrumah's socialist blueprint for development was a failure is evident from Ghana's low growth rate (in comparison, for example, with the high growth rate of the neighboring Ivory Coast) and from the critical state that the national finances had reached by the time he was deposed in 1966, though many would argue that these were the price of economic and psychological independence from the West. The inadequacy of government revenues was also partly due to a pronounced decline in world cocoa prices in the late 1950's and early 1960's.

In any case, the policies of Nkrumah's successors have been less controversial. The money prices paid to the cocoa farmers have been raised every year since 1966 but one. This policy has the political reason of satisfying the residents of the cocoa-growing regions as well as the economic reason of encouraging investment in Ghana's most important industry. But the producer prices are still well below the world price level, and nobody any longer expects the CMB to be abolished.

Over the last ten years, support has grown for the formation of a cartel of the cocoa-producing countries such as the 1972 Proposed International Cocoa Agreement. Such a cartel to be effective would require the cooperation of the consuming countries, and in any case presupposes that the cocoa is marketed by government boards such as the CMB, rather than competitively. Indeed, it is likely that the restriction of output caused by the mere existence of the marketing boards raises the world price enough to raise total income (since the elasticity of supply, even if greater than zero, is certainly less than unity), though this has never been given as an official justification for their existence.

OPEC does not require cooperation of consuming countries

III. Are the Cocoa Farmers Capitalists?

The debate on the Cocoa Marketing Board can be viewed as a debate on whether the cocoa farmers are ignorant peasants who need to be forced to save and shown how to develop their industry, or whether they could do better on their own. Alternatively, it can be viewed as a debate on whether the farmers will continue to produce the same amount regardless of the price they receive and thus can be used as a source of national revenue, or whether they are price responsive. The first question concerns their marginal propensity to save and invest, the second their elasticity of supply. Both questions are part of the general debate on whether peasants are rational profit-maximizing capitalists.

The traditional view of the cocoa farmer is that he is an ignorant peasant. From the inception of the industry, the Colonial Department of Agriculture attacked the cocoa farmers as concerned only with "the attainment of the maximum amount of money with a minimum expenditure of energy, however uneconomical the system"[7] and expressed a "dread of disaster overtaking the industry through the careless or negligent practices employed by natives."[8] The Colonial governors opposed economic restrictions on the farmers only to avoid political discontent. The small government research establishment regarded itself as partly responsible for the growth of the industry. The West African Cocoa Research Institute's suggested remedy to the swollen shoot epidemic of the 1950's was to cut out infected

trees to prevent the virus from spreading. Widespread opposition among the cocoa farmers to the cutting out practice was taken as evidence of their stubborn backwardness. An F.A.O. report on cocoa in 1955 took the common view of the producers as "helpless, ignorant primitive peasants."

> That cacao production is an exclusively African enterprise in two chief producing areas [Ghana and Nigeria] is a fact of the most profound significance. This means, broadly, that unless aided by a competent and effective extension service, production is bound to be deficient in flexibility to adapt itself to new circumstances, which demand new techniques and scientific knowledge and practice. Production is not a rational system of resource management, but a kind of continuous strip-mining. The 'farmer' does little work on the trees and has as yet no conception of the connection between the outlay of effort and the crop he harvests. [9]

The cocoa farmers themselves objected to the view held of them by the Colonial Department of Agriculture.

> My conviction is that the cocoa farmer, speaking with all due respects to all responsible people who hold a contrary opinion, is not guilty of being so lazy and so careless doing things that he does not care whether he earns his livelihood or not. I desire to take this opportunity of recording most emphatically our deepest resentment at the idea which seems to prevail in certain quarters that the native farmer is, and can be, content with any price that is offered him for his commodity. [10]

The intellectual defense of the cocoa farmer as an "economic man" originated in two sources, in addition to attacks on the CMB by writers like Bauer. The first consisted of anthropological and historical work on the cocoa farmers of Southern Ghana which was done by Polly Hill and other economists. The second consisted of statistical attempts to demonstrate that the price elasticity of supply was relatively high.

Polly Hill, with the aid of land ownership data collected in the swollen shoot campaign, investigated the circumstances under which the cocoa industry had first developed in Southern Ghana at the beginning of the century. She found that the original farms were established on forest land purchased by farmers who migrated westward from the Akwapim Ridge, and that it was their intiative which was responsible for the phenomenal growth of the industry. She explicitly described the cocoa farmers as "capitalists" and attacked the "ignorant peasant" view.

> Many present-day writers take for granted that the so-called 'small peasants' who produce the food and export crops are invariably, in certain broad and important senses, 'inefficient'... In my opinion the migrant cocoa-farmers of Southern Ghana, with whom I am here concerned, were real economic innovators: people who bent their energies and intelligence to the business of cocoa-farming with supreme success.[11]

Steven Hymer has followed Hill's approach. In regard to the "superior know-how" of the Colonial administration, Hymer and R.H. Green have argued that, while the cocoa farmers acted with economic rationality, used proven techniques of production, and planned for the future, the Department of Agriculture denigrated and discouraged their efforts, supported measures for quality control and crop diversification when they were not economically practical, and were unable to suggest effective remedies for the swollen shoot and capsid menaces. "In terms both of economic rationality and calculation...the Gold Coast cocoa farmers...had significantly better records than the Gold Coast Department of Agriculture" in the period before World

War II.[12]

Hill gives ten reasons for considering the farmers whom she has studied capitalists: 1) they participated as buyers in a land market, 2) they regard cocoa as a business, 3) they pursue it on a large scale, 4) they have a commercial attitude towards land, as shown by their formation of companies to buy plots which the members then split into strips proportionate to their cash contributions, 5) they are not hampered, as claimed, by demands of their extended families (abusuas), 6) they save, first to buy the land, then by keeping it fallow for future use, 7) family leaders branch out and supervise the farming of multiple holdings, 8) they take a long view, reinvest profits in land, and plant on the land in response to high prices, 9) they continue to regard themselves as migrants, with their business in the forests and their home roots in the Akwapim Ridge, and 10) they did not rely on the Colonial administration to invest in transportation projects, but contracted and financed on their own three bridges across the river Densu.

The cocoa farmers do not meet the rigorous economic definition of rational competitive profit-maximizers. They do participate actively in a commodity market, and at an earlier period participated in a land market. But the frequent transfer of land ownership ended long ago. None of the markets, including especially the less-developed labor and capital markets, has ever been universal in scope or perfectly competitive in structure. Furthermore, it is undeniable that

Western technology, research, capital, and economies of scale can be of benefit to the cocoa industry, as has been demonstrated by spraying campaigns against capsid pests and viral infections in the 1950's and 1960's.

Nevertheless, insofar as the cocoa farmers produce an export crop which originally required an innovative response to economic opportunity to establish, and which still requires a high rate of saving and investment to plant, they do appear to be active in a monetized economy and to plan for the future, in comparison with most farmers throughout the less-developed world. (And without such comparisons, the debate on whether peasants are rational profit-maximizers or capitalists can become semantic and tautological.) But we should examine the econometric evidence on their elasticity of supply before we accept wholeheartedly Hill's conclusion "that the Ghanaian migrant cocoa-farmer has shown himself to be remarkably responsive to economic incentives, remarkably dedicated (within the framework of cocoa-farming) to the pursuit of economic end."[13]

IV. Econometric Estimates of Elasticity

The short-run price-responsiveness of the supply of cocoa is generally admitted to be very low. Though current prices may have some effect on harvesting and processing efforts, some observors have argued that price has always been above short run marginal cost. Prices are thought to

have their major effect on new planting of trees (usually on land which has been purchased long before), either by influencing expectations of future prices, or by supplying capital for current investment.

Early attempts to demonstrate the long run price-responsiveness of the supply of cocoa were limited to informal observations that the trend in production appeared to be roughly correlated with the prices paid to the producers with a lag for the time it takes the cocoa trees to mature. The problem with all statistical investigations of the long run elasticity of supply is that no data on new cocoa plantings exist in Ghana, so one must rely on output data. Trees planted in response to an increase in prices would begin to bear cocoa pods 7 to 10 years later, reach their peak after 16 to 20 years, and keep producing anywhere from 25 to 40 years. Thus producer prices, even when lagged, can be correlated to output only approximately.

Bauer and B.S. Yamey circumvented the problem of the lags in demonstrating the price-responsiveness of the farmers.[14] They showed that Nigerian cocoa farmers had made the extra effort (chiefly fermenting the beans sufficiently) to produce cocoa in the higher grades in sharp response to large price differentials offered by the Nigerian marketing board for different grades.

The first econometric supply study was done by Peter Ady, who ran a regression of output, using as the only independent variable deflated prices lagged nine years.[15] She used a double log formulation to obtain an elasticity of .36 and an R^2 of

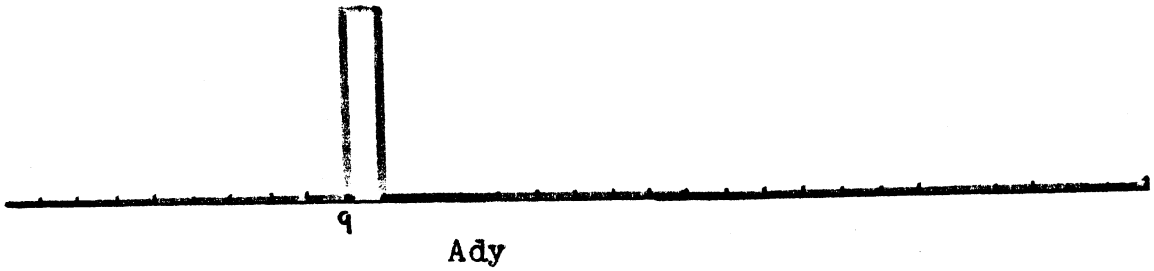
.69. When she used first differences to correct for auto-correlation, she obtained an elasticity of .43 and an R^2 of .47. There are some problems with the specification of her model (particularly her effort to find a short run supply relationship), and the data were drawn only from the years 1930 to 1940.

Robert Stern's more thorough study, covering a variety of different cocoa-producing countries and time periods, conceptually separates the supply-response process into the long run planting step and the short run harvesting step. In the first step, the yearly acreage planted is assumed to be a function of recent real prices. This model is tested successfully for pre-war Nigeria, where data on acreage planted are available, using five-year moving averages. In the second step, the yearly change in acreage harvested is assumed to be a function of the current price. This model is tested successfully for Ghana in the 1930's. Stern then assumes that the planted seedlings join the permanent stock of bearing trees eight years later, and thus combines the two models into his basic equation: $\Delta Y_t = b_0 + b_1 P_{t-8} + b_2 \Delta P_t$. His results are poor for all countries and time periods. His highest R^2, for Ghana in the crop years from 1919-20 to 1963-64, is .17. Stern's attempt to find a positive price elasticity cannot be termed successful.

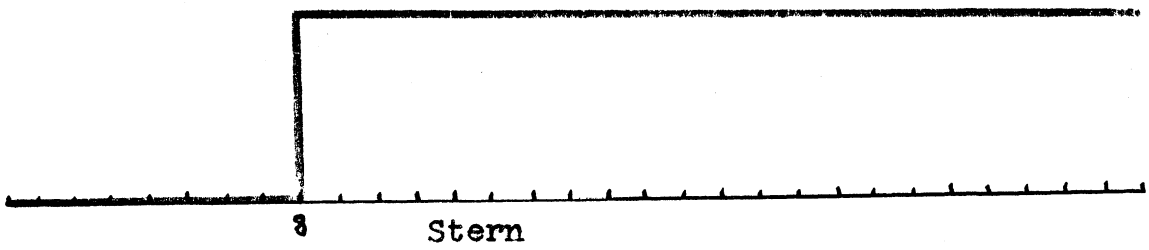
Probably the most careful econometric study of the supply of cocoa in Ghana is the thesis of Merrill Bateman. Bateman estimates separate supply functions for each of the five cocoa-growing regions of Ghana (Volta, Eastern, Central, Western, and Ashanti, with Ashanti subdivided further), on the grounds of different soil conditions and agronomic histories in each region. His model, like Stern's (but unlike Ady's), uses changes in output for the dependent variable; he assumes that prices influence planting and that planting determines the change in the stock of bearing trees which in turn influences the change in output. He concludes from experimenting with the data that the yield of cocoa trees attains a first plateau after 8 years and its peak after 12 years; thus prices lagged 8 years and 12 years are two of his independent variables.

This model would be literally correct only if the stock of cocoa trees is not subject to depreciation, i.e. if the yield does not decline after 12 years but remains at its peak level. This simplification may be more realistic than the opposite extreme, implicit in Ady's model, which is to assume that the cocoa trees bear fruit during some year such as the ninth and during no others, so that output is a function only of price lagged 9 years. But the true pattern of yield consists of a gradual increase in yield to the peak, followed by a gradual decline until the tree stops producing altogether. (Figure 1 shows the yield patterns implicit in various models, and those suggested by agricultural experts to represent reality.)

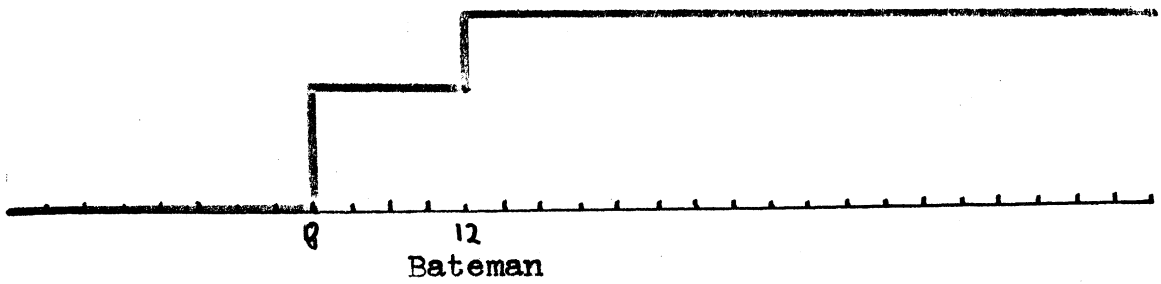
Figure I: Lag Structures



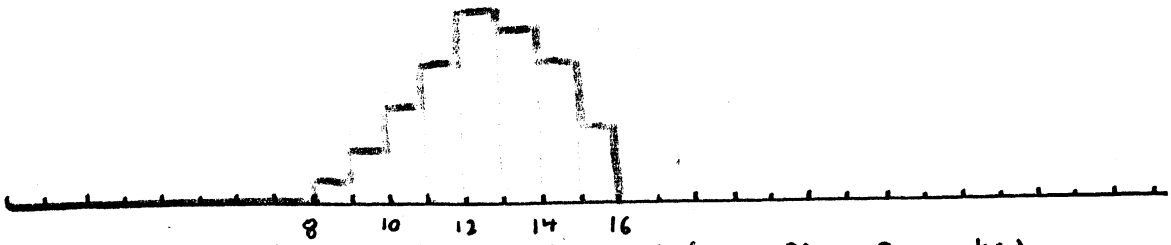
Ady



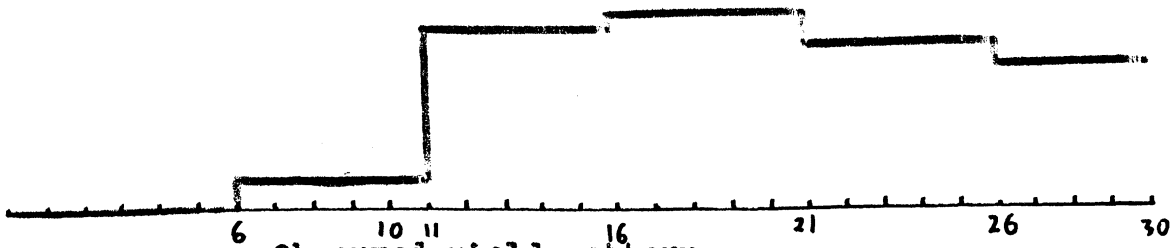
Stern



Bateman



This study, Section V (see fig. 3, p.41)



Observed yield pattern,
Bateman, Table XIV, p.81

The effects of swollen shoot and capsids tend to truncate the yield pattern. The fact that plantings have increased over time will similarly tend to skew the pattern forward; trees planted relatively recently will be more important than those planted 20 to 40 years ago. The best model for a supply equation would probably be a polynomial distributed lag covering all the most important years, rather than just one or two. There is no need to use first differences in output, which in any case do not give a true classical supply equation (expressing quantity as a function of price).

Bateman's other variables besides deflated cocoa prices lagged 8 and 12 years include deflated coffee prices lagged 8 and 12 years, since coffee is believed to be an important alternative crop. He also uses local rainfall (expressed in first differences, since the dependent variable is expressed in first differences). Rainfall during the growing season (March to September) is necessary for a good crop, but too much humidity stimulates the black pod virus, which can destroy the crop. Experimenting to get the best fit, Bateman concludes that rain in the spring helps the crop, while rain in the late summer hurts it through black pod. The exact months used vary from region to region. He also tried prices lagged one year to test for short run price elasticity. (All variables are lagged an extra year because the crop is identified by the year it is sold on the world market, even though most of the harvesting is completed in the previous fall.) But this variable, and others such as output lagged one year, were dropped from the model when they did not appear significant.

Bateman tries different variables and functional forms for each region, and comes up with several heterogeneous supply functions, all but one of which are highly significant. The cocoa price coefficients are significant in most of the equations with elasticities from .12 to .47 for the 9-year lag, and elasticities from .25 to .40 for the 12-year lag. If the elasticities are weighted by regional output and aggregated (price effects should be aggregable even if one accepts Bateman's argument that the whole regional supply equations are not), one obtains a national supply elasticity of .28 for the 8-year lag and .32 for the 12-year lag. Bateman's separate supply functions are unwieldly for practical use, though his final conclusion "concerns the folly of trying to estimate an aggregate cocoa supply function for the entire forest zone of Ghana."[16]

The practical use to which Bateman's thesis puts his supply equations involves some misleading economic reasoning. In order to compute what cocoa prices and incomes would have been during the post-war period in the absence of the CMB, he assumes that the producers would have been paid the F.O.B. price which actually prevailed, minus the necessary customs duty and expenses of operations paid by the CMB. Then,

> An adjusted production series for the period 1954-62 was obtained by inserting the new producer price series into the estimated supply functions. The results suggested that production would have exceeded 800,000 tons in 1962 in contrast to actual output of slightly more than 400,000. On the other hand, estimates of cocoa price demand elasticities for the major cocoa consumers indicated that

> the price of cocoa would have fallen drastically if the additional production had been consumed. The final calculations indicated that Ghanaian proceeds from cocoa would have fallen to zero by the late 1950's.[17]

Bateman concludes on this basis that, "One would have to admit that it was somwhat fortuitous that the Cocoa Marketing Board, regardless of the reason, kept producer prices as low as they did during the 1950's."[18]

The result is misleading in that it is based on an oversimplified cobweb model. Rather than finding a long run equilibrium by solving the simultaneous demand and supply equations, Bateman in effect plugs the given abnormally high producer price into the supply equation, and then plugs the resultant abnormally high output into the demand equation to obtain a zero price. This reasoning would require the following assumptions: 1) the CMB is suddenly removed in 1946 and the producer price is raised all at once to the currently prevailing world price, despite the fact that it is well above long run equilibrium, 2) the cocoa farmers act blindly on that abnormally high price, with no regard either to the lower producer prices of the past or prices predicted for the future, 3) they are able to double their output in a short period of time, without exhausting the supply of available factors of production or bidding up their prices, 4) even during the time that the thousands of acres of new trees are growing, the world cocoa market does not discount the future value of cocoa on the basis of crop predictions, and the farmers continue to plant new trees right up to the time that the tidal wave breaks, and

5) when the trees mature, the farmers continue to harvest and process the cocoa beans, even though their price has actually fallen to zero.

Bateman's analysis could be used to argue that if the CMB were to be removed, the producer price should not be raised to the market price in one jump. But the conclusion that the price would fall to zero assumes that the estimated elasticities apply over unrealistically large ranges and that price could fall below short run marginal cost. In any case, the analysis should not be used to argue that the existence of the CMB was "fortuitous". One should only reach an evaluation of the income effects of the Board after finding the long run equilibrium which would have prevailed in the absence of the CMB. The price under this equilibrium would necessarily be lower than the previous world price but higher that the previous producer price. Producer income could only go up. One could argue that if total income, given by output times price, is lower in the absence of the CMB (with the higher output but lower world price), then the existence of the CMB is beneficial to Ghana as a whole, even if detrimental to the cocoa farmers. This would in fact be the case given the demand and supply elasticity estimates that Bateman uses, since both are less than unity, but it is not the argument that he gives.

In the ten years that have elapsed since the studies of Stern and Bateman, surprisingly, few new econometric studies of the supply of cocoa have appeared.

S.A. Oni recently did one such study for cocoa in Western Nigeria, taking advantage of data for acreage farmed and quantity of chemical spraying, which is not available in Ghana. His dependent variable is output (rather than changes in output) and his independent variables are current price (to test for short run price-responsiveness), acreage (the data was obtained from swollen shoot surveys), rainfall (April to October of the crop year), humidity (in the same period), an index of chemical spraying, a trend term (as a proxy for technical progress in combatting diseases) and lagged output (as a proxy for the stock of wealth available to cocoa farmers for new investment). All variables are highly significant and of the expected signs, even when he aggregates the data for the entire region. He obtains a short run price elasticity of .08, a long run elasticity of .49, and an R^2 of .98. The success of Oni's results is largely due to his data on acreage.

V. A New Econometric Model of Supply

My econometric analysis includes data on cocoa production in Ghana up to 1973. I decided, as Bateman did, to begin with 1946, thus avoiding the effects of World War II. Data on some of the variables are not available before the War if one allows for the necessary lags. Simple regressions of output on price, using output figures back to 1921 and price figures back to 1909, give less satisfactory results then the postwar regressions, but are discussed below.

For reasons mentioned above, I used output as the dependent variable. (Regressions using changes in output as the dependent variable were tried, but were less successful.) Autocorrelation of the errors was not a serious problem. Most of the Durbin-Watson statistics were close to 2.00. This is consistent with the high variability that characterizes the production of cocoa from year to year.

Simultaneity from the existence of a demand equation was not a problem for three reasons. 1) The producer price is the relevant variable for the supply equation, while world demand determines only the F.O.B. price received by the CMB, and the two prices are independent. The price which the CMB decides to pay to the producers may be influenced by the price it received on the world market in the preceding year, but these prices are correlated only weakly with the current world price. (The serial correlation of world prices in my data was only .71.)

2) In any case, the prices operate on supply with a planting lag of at least eight years, by which time the price has changed completely. Even the short run effects of price on harvesting and processing efforts operate with a one-year lag since there is some delay between the time the cocoa is brought to regional buying stations and the time that the CMB sells it on the world market (often in the following calendar year). 3) As additional insurance, Ghana is only one of many cocoa producers. Ghana cannot assume that the world price is given, since its production is such a large proportion of the world's (currently 1/3). But if the world elasticity of demand is about .4,[19] then the elasticity facing Ghana is about 1.2, which means that demand effects are at least not primary. (The CMB may engage in some speculation to try to get the best possible price on the international market, but for the most part it does not exploit monopoly power in selling its crop.)

As in previous studies, the prices used were the prices paid to the producers in pounds sterling per long ton, deflated by an index of import prices (1950-52=100). The distributed lag structure used for prices was the Almon polynomial lag. Preliminary tests, using lags over the entire range from the preceding period to 25 periods back, confirmed the expected pattern (Figure 1, page 18): a significant positive effect in t-1 and also t-2 (reflecting the short run elasticity), no significant effects from t-3 to t-7 or t-8 (the coefficients actually came out negative in this range), and then significant positive effects which begin around t-8 (when the cocoa trees

first bear fruit), reach their peak at t-12 or t-13 (when they mature) and decline until they become insignificantly different from zero around t-16. Henceforth only prices in t-1 and the range from t-8 to t-16 were used. The degrees of freedom in the Almon polynomial were kept to three, to avoid excessive "curve-fitting" (except for the preliminary 25 year polynomial, which had five degrees and no zero restrictions).

Coffee prices were used as one independent variable. It is postulated that high coffee prices divert resources from the planting of cocoa. New York spot prices were used, as per Bateman's suggestion that the prevalence of smuggling of coffee through the neighboring Ivory Coast and Togo made the world price more relevant than the Ghana F.O.B. price. The coffee prices, expressed in U.S. cents per pound, were deflated by the same import price index. Lags in the range from t-8 to t-16, like those used for cocoa, were used for the coffee prices.

Rainfall was an important independent variable. Agricultural experts agree that the seasonal distribution of rainfall, for example how much occurs in the March-September growing season, is crucial, but it is not clear precisely what the effects are. I first followed Bateman's theory that rainfall in the March-May period has a positive effect and rainfall in the July-August period has a negative effect (by stimulating black pod), but the results showed negative coefficients for both variables. I therefore used instead a single variable for the entire March-September season: average monthly rainfall measured in inches at Kumasi. I also followed the suggestion

of experts that rainfall in a certain middle range is optimal, by transforming the rainfall figures into absolute deviations from their mean of 5.098 inches. As expected, deviations in either direction had a negative effect in all regressions (the coefficient estimates were between -15.74 and -17.94) and this form was more significant than the others (the t-statistics were between -2.34 and -2.92). Results are shown in Table 1.

Another independent variable tried was output lagged one period, under a variety of possible hypotheses. If the model used by Stern and Bateman, whereby prices influence the change in output, is correct, then one would expect the coefficient of lagged output in my equations to be 1.0. But the coefficient was about half of that (e.g. .52 in equation 2), when significant. In the full polynomial price lag model, lagged output lost its significance (indicating that its previous effect was probably as a proxy for other variables), and so was dropped from the final regressions.

Finally, a trend term was included to measure technological progress against disease, or any other factor that may have operated over time. The coefficient came out positive (3.48 in equation 1) when significant, indicating a secular yearly increase in production. But the trend term lost its significance in the full model, as lagged output did, and so was dropped from the final regressions.

The short run price variable came out significant in some regressions, such as equation 2. The coefficient of .62 gives an elasticity of .21 when evaluated at the means. However the

Table I: Regressions of Cocoa Output

(1946-1973)

Equation	Constant	$Year_t$	$Output_{t-1}$	$Rain_{t-1}$	P_{t-1}	P_{t-12}	C_{t-12}	R^2	F
(1)	-66.26	3.48	.37	-15.97	-	.88	-	.840	30.2
	(-.88)	(1.96)	(2.42)	(-2.37)		(3.16)			
(2)	-5.89	-	.52	-17.94	.62	1.24	-	.842	30.5
	(-.13)		(4.27)	(-2.66)	(2.03)	(4.23)			
(3)	89.44	-	.66	-16.22	-	1.16	-1.52	.831	28.4
	(2.89)		(4.75)	(-2.34)		(3.94)	(-1.58)		

with Almon lags						Cocoa coefficients (peak)	Cocoa coefficients (sum)	Coffee coefficients (peak)	Coffee coefficients (sum)		
(4)	326.34	-3.16	-.04	-16.97	.18	.72	3.82	-1.13	-3.13	.905	22.7
	(1.37)	(-.61)	(-.24)	(-2.78)	(.37)	(2.79)		(-3.11)			
(5)	173.46	-	-	-15.74	-	.57	2.87	-1.04	-1.92	.903	40.8
	(8.44)			(-2.92)		(5.49)		(-4.28)			
(6)	5.11	-	-	-0.34	-	.18	.98	-0.20	-.98	.865	28.1
in logs	(39.88)			(-1.92)		(6.26)		(-6.04)			

(1925-1973)

	Constant	Holdup dummy	WWII dummy	peak	sum		
(7)	212.48	57.52	24.66	.23	1.47	.751	33.1
	(19.01)	(1.66)	(1.19)	(5.30)			
(8)	.44	-.44	-.44	.39	1.13	.931	148.2
in logs	(2.02)	(-.73)	(-1.19)	(12.15)			

(t-statistics in parentheses)

variable was not significant in the full model.

Simple 8 and 12 year lags were tried for cocoa and coffee prices as in Bateman's model. All signs came out as expected, but the 8 year lags were not significant. Alone, the 12 year lag for cocoa worked quite well (equations 1, 2 and 3). Equation 3 is typical; the coefficient of 1.16 gives an elasticity of .34 when evaluated at the means. The 12 year lag for coffee (equation 3) narrowly missed being significant at the 95% level. Its coefficient of -1.52 gives a cross elasticity of -.21 at the means. The R^2's for these models with 12 year lags are all around .84.

The Almon lags for cocoa and coffee prices give better fits (equations 4 and 5); R^2's around .90. The cocoa polynomial reached its peak at t-14 with a coefficient of .57, giving an elasticity of .16. (This number should be interpreted as the elasticity for period t-14, holding constant for the other periods.) The sum of the lag coefficients was 2.87, giving an elasticity for the entire range from t-8 to t-16 of .82. The coffee polynomial reached its peak at t-15 with a coefficient of -1.04, giving a 14-year cross elasticity of .14. The sum of the lag coefficients was -1.92, giving an elasticity for the entire range of .26.

An alternative to the linear model used thus far, is the multiplicative or double-log formulation. The multiplicative model is particularly appropriate if the only independent variables are prices and rainfall, since one could argue that the former determine acreage in bearing and the latter

determines yield per acre. Using this formulation gives similar results as the linear model (equation 6). The cocoa polynomial reaches a peak elasticity of .18 in period t-14 and has an overall elasticity of .98. The coffee polynomial reaches a peak elasticity of -.20 in t-14 and has an overall elasticity of -.98. The fact that the price coefficients are inverses suggests that perhaps the ratio of the two prices should be used as a single variable. This formulation is reasonable on a priori grounds; the ratio represents relative price expectations in the farmers' decision whether to plant cocoa. The best supply equation may be of the form:

$$Q = 5.11\ (RAIN)^{-.034}\ (COC/COF)^{.98},$$

where COC/COF represents the ratio of cocoa prices to coffee prices (they need no longer be deflated) over the period 8-16 years earlier, and RAIN still represents deviations from the mean rainfall.

To estimate an elasticity over the period since 1925, it was necessary to drop the coffee and rainfall variables, and to add dummy variables for the war of 1939-45 and the cocoa holdup of 1937-38. In the results (equations 7 and 8), the dummy variables had little significance, but cocoa prices retained enough explanatory value to give a good fit. In the linear model, the polynomial reached its peak elasticity of .04 at t-12 and had an overall elasticity of .25. The R^2 was .75. In the double-log model, the polynomial reached its peak elasticity of .39 at t-10 and had an overall elasticity of 1.13. The R^2 was .93. It appears that the multiplicative model fits the data better than the linear model.

VI. Conclusions

We can reach the following conclusions about the price elasticity of supply of cocoa in Ghana. The short run elasticity, with respect to P_{t-1}, may be about .21, although the effect is not certain. The peak long run elasticity with respect to P_{t-14} alone (holding constant for the other periods) is about .16. The straight long run elasticity with respect to P_{t-12} (and the adjoining periods, to the extent that they are correlated with P_{t-12}) is about .34. The long run elasticity with respect to the prices in the periods between t-8 and t-16 considered together is about .82.

The third figure (.34) can be compared to Ady's figures of .36 and .43, Bateman's figures which average .32, and Oni's Nigerian figure of .49. Even if one does not accept the precise accuracy of the elasticity estimates, the hypothesis that the cocoa producers respond to prices is clearly validated.

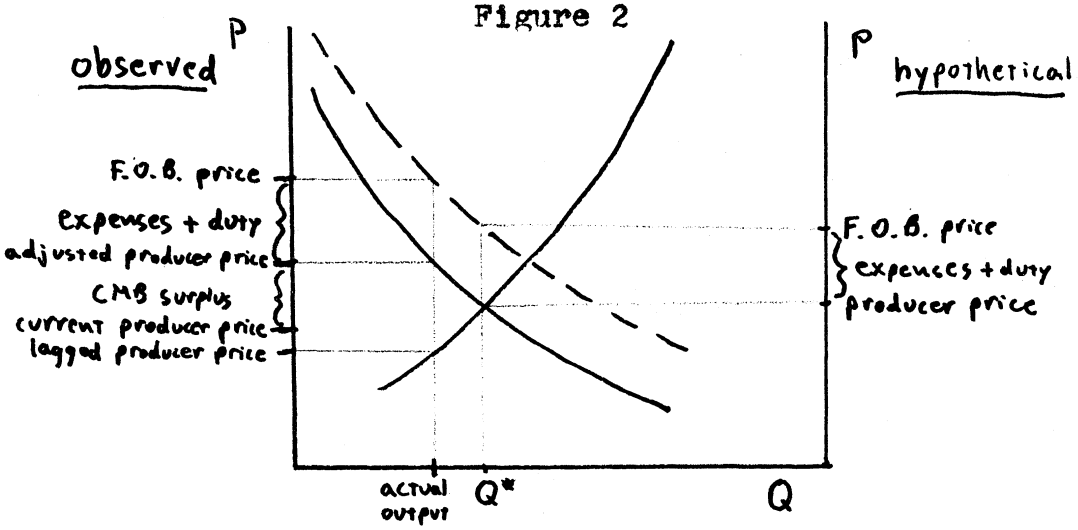
This conclusion has two implications for the analysis of the producers and their relationship with the Cocoa Marketing Board. The first is that the cocoa farmers, even if they are not profit-maximizing capitalists, are sensitive to economic incentives and inclined to invest in the future. The second is that the CMB's policy of paying the producers a price lower than the market level restricts output.

A rough calculation of what the market equilibrium would have been in the absence of the CMB can be made. The aim is similar to that in Bateman's exercise, except that a long run

equilibrium is sought, rather than a cobweb path. Average figures for the 1946-1973 period were used. The demand elasticity estimate used was F. Helmut!s figure of -.407 (which is in the middle of the range of various estimates of world elasticity which have been made), divided by Ghana's share of world cocoa production to arrive at an estimate of the demand elasticity facing Ghana. This number, -1.221, was assumed to be the arc elasticity of demand, while .82 was assumed to be the arc elasticity of supply in a long-run equilibrium.

I subtracted the CMB's expenses and customs duty per unit of cocoa exports from the price actually obtained by the CMB on the world market, to obtain an "adjusted producer price," i.e. the actual producer price plus the CMB surplus (see Figure 2). The demand relation assumed is that the percentage change from the actual average output (322,210 tons) to equilibrium output (Q^*), divided by the percentage change from the "adjusted producer price" (161.4 ₺/ton), is equal to the demand elasticity -1.221. The supply relation assumed is that the percentage change from actual output (322,210 tons) to equilibrium output (Q^*), divided by the percentage change from actual average producer price lagged 8-16 years (95.0 ₺/ton) to the equilibrium price (P^*), is equal to the supply elasticity .82. The values of P^* and Q^* which satisfy the two simultaneous equations are $P^* = 125.7$ ₺/ton and $Q^* = 405,900$ tons. Table 2 shows the appropriate prices and revenues that

Figure 2



Computations (using 1946-1973 averages)

lagged producer price	95.0 £/ton	
Accra F.O.B. price	241.4 £/ton	
CMB expenses + duty	80.0 £/ton	
adjusted producer price	161.4 £/ton	
actual output	322.2 000tons	
demand relation	$\frac{(Q^*-322.2)/322.2}{(P^*-161.4)/161.4}$	= -1.22
supply relation	$\frac{(Q^*-322.2)/322.2}{(P^*-95.0)/95.0}$	= .82
equilibrium solution	P* = 125.7 £/ton	
	Q* = 405.9 000tons	

Table 2

	Observed Averages		Hypothetical Equilibrium	
	Price (£/ton)	Revenue (000£)	Price (£/ton)	Revenue (000£)
Producers	109.4	35,247	125.7	51,022
CMB expenses and duty	80.0	25,776	80.0	32,472
CMB surplus	52.0	16,755	0.0	.000
Total F.O.B.	241.4	77,781	205.7	83,494

actually prevailed together with those that would have existed in the absence of the CMB. It can be seen that not only producer income, but even total national revenue is higher without the CMB. This is because the number used for the demand elasticity facing Ghana is greater than unity and the number used for supply elasticity is sufficiently close to unity. If all cocoa producers increased their output as much as Ghana is hypothesized to have done, then the much lower world demand elasticity would be the relevant figure; the Accra price would fall by more than what was computed above, and total national revenue would decline substantially. This also would have been the result if I had used any of the estimates for long run supply elasticity based on a single price lag (such as .34), rather than the Almon elasticity based on prices over an eight year range.

We can easily check that the increase in revenue (7,921,000 £) is enough to cover the increased marketing costs and duties (6,696,000 £). However it is almost certainly not enough to cover the increased costs of producing the cocoa, so that net income may be lower. On the other hand, one might not wish to subtract the customs duty, since it is part of the same government cocoa policy as the CMB. Also, the producer income includes certain "voluntary" contributions to the Plan for national development that the cocoa farmers were induced to make during the Nkrumah years.

The result calculated above was close (because both elasticity estimates were close to unity), and different calculations, especially with lower elasticity estimates, might give a different answer. But the conclusion from this exercise is that, on the basis of purely static considerations, the Cocoa Marketing Board system restricted output to the extent that it reduced national revenue in the period since 1946. This does not necessarily mean that, from a dynamic point of view, the system was harmful to Ghanaian economic development. It is possible that the uses to which the government put the surplus revenue collected by the CMB will pay off for Ghana in the future, or perhaps would have done so under different political leadership. The important points regarding the cocoa farmers are that this development effort was partly financed by taxing them, and that their restriction of output demonstrates that the cocoa farmers are responsive to economic incentives.

DATA

(1) Year	(2) Output in 000 long tons	(3) Producer price in £/ton	(4) Index of import prices	(5) Producer price deflated (3)/(4)	(6) Coffee price in ¢/lb.	(7) Coffee price deflated (6)/(4)	(8) Monthly rainfall in inches	(9) F.O.B. price in £/ton
1909	20	40.5	15.1	268.2				37.4
1910	23	39.5	15.9	248.4				38.3
1911	40	41.5	16.3	254.6				40.6
1912	40	43.5	16.8	258.9				42.6
1913	47	44.5	16.7	266.5				49.2
1914	56	46.5	16.8	258.9				41.5
1915	66	33.5	18.8	178.2				47.2
1916	82	59.5	24.2	245.9				53.3
1917	86	60.5	30.0	201.7				34.6
1918	70	39.5	39.0	101.3				27.1
1919	148	31.5	50.6	62.3				47.0
1920	145	75.5	75.0	100.7				80.6
1921	116	20.5	64.1	32.0				35.8
1922	162	23.0	42.5	54.1				36.7
1923	195	25.5	41.7	61.2				33.2
1924	201	23.0	44.5	51.7				32.5
1925	211	33.0	43.9	75.2				37.7
1926	207	29.0	41.5	69.9				39.8
1927	238	43.0	39.0	110.3				55.9
1928	207	48.5	39.1	124.0				49.9
1929	242	35.0	35.4	98.9				40.8
1930	232	32.0	30.6	104.6	13.0	42.4		36.6
1931	223	15.5	23.4	66.2	8.6	36.8		22.5
1932	212	17.0	22.6	75.2	10.6	46.9		23.6
1933	256	16.5	20.8	79.3	9.1	43.8		21.1
1934	220	10.5	19.5	53.8	11.1	56.9		17.6
1935	276	14.0	21.0	66.7	8.9	30.5		19.4
1936	285	15.5	21.3	72.8	9.5	44.6		24.6
1937	300	38.0	24.8	153.2	11.1	44.8		42.3
1938	240	12.5	22.6	55.3	7.8	34.5		17.2
1939	298	13.0	21.4	60.7	7.5	35.0		18.2
1940	242	15.9	27.7	57.3	7.2	25.9	4.66	20.1
1941	237	13.1	31.5	41.5	11.4	36.2	6.44	18.3
1942	251	14.9	38.5	38.8	13.4	34.8	5.38	19.2
1943	207	13.1	44.0	29.7	13.4	30.5	5.98	18.6
1944	195	13.1	45.5	28.7	13.4	29.5	5.29	19.2
1945	229	22.4	51.0	43.9	13.6	26.7	5.03	30.8

DATA cont.

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
1946	209	27.1	59.0	45.9	18.7	31.7	4.57	40.2
1947	192	51.3	80.9	63.4	26.4	32.6	7.89	92.3
1948	208	74.7	86.0	86.8	26.8	31.2	5.26	196.8
1949	278	121.3	80.8	150.1	31.8	39.4	7.37	129.1
1950	248	84.0	86.8	96.7	50.9	58.6	4.94	204.0
1951	262	130.7	104.0	125.6	54.3	52.2	6.51	262.8
1952	211	149.0	109.2	136.5	54.1	49.5	6.92	247.8
1953	247	130.5	98.9	132.0	58.5	59.2	5.54	237.3
1954	211	134.4	93.7	143.4	78.3	83.6	5.70	395.0
1955	220	143.1	91.8	155.9	57.0	62.0	6.02	318.4
1956	237	149.3	94.6	157.8	58.3	61.6	5.10	217.8
1957	264	140.6	95.6	147.1	57.3	59.9	6.91	195.5
1958	207	134.4	94.6	142.1	48.9	51.7	5.14	315.7
1959	255	119.5	93.7	127.5	37.6	40.1	5.91	274.9
1960	317	112.0	93.7	119.5	36.9	39.4	6.11	219.4
1961	433	112.0	95.3	117.5	36.3	38.1	5.19	170.9
1962	410	112.0	95.3	117.5	34.4	36.1	7.19	159.1
1963	422	110.1	92.8	118.7	34.6	37.3	7.65	204.9
1964	436	100.8	92.2	109.3	47.9	52.0	5.87	187.7
1965	557	92.4	96.6	95.6	45.1	46.7	5.76	138.4
1966	410	77.0	87.2	88.3	41.4	47.5	8.87	193.2
1967	376	86.4	92.7	93.2	38.4	41.4	4.63	238.0
1968	415	102.9	90.2	114.0	37.6	41.7	10.81	319.5
1969	334	115.6	107.0	108.1	40.8	38.1	4.98	415.5
1970	409	121.9	129.2	94.3	55.7	43.1	6.70	305.5
1971	386	121.9	130.0	93.8	46.1	35.5	4.63	232.4
1972	457	105.6	130.0	81.2	54.4	41.8	6.13	270.5
1973	411	137.5						585.3

(2) from Gill & Duffus Cocoa Statistics Table 1, p.5-9

(3) 1909-1939 from Bateman p.209-211, 1940-1973 Gill & Duffus, Table 15, p.39

(4) index 1950-52 = 100; 1909-1919 from Viton, Table 6, p.93; 1920-1958 from Ghana Central Bureau of Statistics; 1959-1973 from IMF International Trade Statistics

(6) N.Y. spot price for Santos No. 4, from Commodity Yearbook

(8) March-September average, measured at Kumasi, from U.S. Weather Bureau Monthly Climatic Data for the World

(9) 1909-1961 from Anyane Ghana Agriculture pp.204-207; 1962-1973 from Gill & Duffus, Table 15, p.39 (not strictly comparable with earlier figures)

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2. References (6) to (10)
3. Bauer and Paish (8)
4. Friedman (14)
5. Niculescu (30), p. 731
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7. quoted by Green and Hymer (20)
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10. Nana Ofori Atta, Legislative Council Debates 1925-6 in Kay (26), p. 251
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12. Green and Hymer (20)
13. Hill (23), p. 3
14. Bauer and Yamey (9)
15. Ady (3)
16. Bateman (5), p. 173
17. ibid., p. 203
18. ibid., p. 188
19. Weymar (38), p. 101

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Abbrev.: E.B.G.=Economic Bulletin of Ghana (F.S.=First Series, S.S.=Second Series); E.J.=Economic Journal

Table 3: 25-Year Almon Lag Plots