DM/83/39

INTERNATIONAL MONETARY FUND

Research Department

Agricultural Responses to Prices in Sub-Saharan African Countries

Prepared by Marian E. Bond*

Approved by Anthony Lanyi

May 23, 1983

Summary

In the 1970s many Sub-Saharan countries experienced a decline from the already slow rate of growth of agricultural production of the 1960s. Because the agricultural sector in these countries is by far the largest, its well-being remains crucial to their economies, especially in the face of the difficult task of adjusting to the oil price increases of the 1970s. Stagnating agricultural output has greatly hampered this adjustment process in Sub-Saharan Africa. Many economists maintain that inadequate market prices have been a principal reason for the poor performance of African agriculture in the 1970s; against this others argue that while a positive output response to producer prices is considered normal in the agricultural sectors of more developed countries, such a response may not occur in African countries.

This paper both reviews quantitative evidence on supply responses to producer prices from individual crop studies, and provides its own evidence on how aggregate agricultural production responds to changes in the rural/urban terms of trade, for a number of African countries. Supply responses are found to be positive for both individual and overall crop production. The evidence from individual crop studies suggests that long-run price elasticities tend to be larger than those for the short run, and that these elasticities are of a fairly sizeable magnitude. For some crop studies, the evidence also suggests that an increase in production can take place without an equivalent fall in the production of a substitute crop, and that the target income hypothesis is not supported by the data. For aggregate crops the evidence suggests that farmers do respond to rural/urban terms of trade.

To achieve a sound agricultural base in order to provide the necessary conditions for take-off into economic growth, governments need to

---

*The author would like to thank Youkyong Kwon for excellent research assistance.

consider a comprehensive package of policies, of which producer pricing policy is only one element. Such a package would need to include pricing policies with regard to consumer goods and inputs, as well as improvements in extension services, infrastructure, input availability, and credit facilities. A farmer may respond quite differently to a change in producer price when it is combined with cheaper consumer goods and improved infrastructure than to the price change alone.

I. Introduction

Although Sub-Saharan African countries differ greatly in their geographical and physical conditions, weather patterns and cultural heritage, the similarity of their economic structures is striking. In particular, in nearly all of these countries the agricultural sector remains dominant, and its well-being is crucial to the economy. It provides the means to feed the population, the surplus to support the industrial sector in its take off into economic growth, and the bulk of exports. Indeed very few countries have achieved sustained economic growth without first, or simultaneously, developing their agricultural sector. Nevertheless, over the 1970s the rate of growth of agricultural production in many of these Sub-Saharan African countries has declined from even the slow rates of the 1960s (Table 1).

This stagnation in agricultural production has come at a time when developing countries have been faced with the difficult task of carrying out structural adjustment following the oil price increases of the 1970s. This adjustment process is assisted by a growing agricultural sector that provides both ample food supplies and the bulk of exports, and thereby the low-price wage goods, savings, and the foreign exchange required by the industrial sector for expansion. On the other hand, the adjustment process is hampered by a declining agricultural sector unable to provide a surplus and often in need of subsidy from an already faltering industrial sector.

In view of the importance of the agricultural sector for growth and adjustment, governments need to determine what policies are best suited to stimulate agricultural production. In particular, a crucial question is the extent to which pricing policy can be used to encourage agricultural growth. Many economists maintain that inadequate market prices have been a principal reason for the poor performance of African agriculture in the 1970s. 1/ Opposing this view, it is often argued that although a positive

1/ This view is expounded in the World Bank report entitled Accelerated Development in Sub-Saharan Africa.

Table 1. Agricultural Production for Sub-Saharan African Countries

(Average growth rates, in per cent)

	1962-66	1967-71	1972-76	1977-81
Angola	3.96	2.15	-4.94	-1.02
Botswana	0.54	5.34	1.00	1.82
Burundi	4.30	1.45	2.12	2.02
Cameroon	6.33	5.17	2.45	1.89
Central African Republic	-0.59	3.40	2.89	1.87
Chad	1.07	-0.11	1.34	1.51
Congo	-5.21	2.39	1.36	0.20
Gabon	3.29	0.68	-1.30	3.94
Gambia	11.22	-0.53	1.39	0.84
Ghana	2.72	4.17	-0.92	0.51
Guinea	1.85	3.03	2.16	0.89
Ivory Coast	8.30	4.64	4.14	5.92
Kenya	2.21	2.78	4.19	2.86
Liberia	4.04	4.60	2.01	1.20
Madagascar	3.55	2.85	3.30	0.88
Malawi	7.24	7.03	1.98	4.74
Mali	2.48	2.25	2.37	2.77
Mauritania	2.51	-0.32	-1.36	4.57
Mauritius	3.11	2.31	5.94	-1.22
Mozambique	1.23	3.10	-1.63	-0.44
Niger	5.55	0.29	1.82	3.71
Nigeria	-0.27	2.81	2.24	3.28
Rwanda	5.74	7.51	3.91	3.28
Senegal	1.43	5.05	5.71	6.07
Sierra Leone	4.75	1.70	1.60	-1.02
Somalia	2.40	2.15	0.55	0.99
Tanzania	5.27	0.92	2.50	1.22
Togo	10.51	1.69	0.29	2.86
Uganda	2.28	2.69	0.05	0.27
Upper Volta	6.57	0.66	1.29	4.72
Zaire	2.52	2.57	2.09	0.73
Zambia	4.62	3.42	4.51	0.22

Source: FAO Production Yearbook, various issues.

output response to prices is considered normal in agricultural sectors of developed countries, such a response may not take place in African countries. Two major reasons are given to support this viewpoint. First, the subsistence sector is assumed to be very risk averse and to value leisure and other activities highly. Second, farmers in developing countries are assumed to have income targets. Consequently, if the producer price is increased, the production of a smaller amount of the commodity will provide the necessary income. This perverse reaction to a rise in producer prices leads to a backward sloping supply curve of output.

Sorting out the evidence relevant to these pricing issues is a complicated task. There is a whole array of prices in any economy and a change in any one can in principle lead to a change in agricultural production. However, producer responses will vary depending upon which price is changed. It is therefore important to distinguish between these responses. First, there is the distinction between the elasticity of response to the change in the relative price of the agricultural product and the elasticity of response to changes in the relative price of factor inputs. Second, the distinction must be made between the elasticity of response of an individual crop to a change in the relative producer price and the elasticity of aggregate agricultural production to the change in the general level of agricultural prices. The former is likely to be larger than the latter because farmers can often switch land and other resources between different crops more easily than they can add to or subtract from the sum total of resources committed to agriculture. Third, there is a difference between the response to price changes of marketed surplus (the residual amount arrived at after family consumption has been retained) and of the production of cash crop (those crops for which there exists little family consumption).

The main purpose of this paper is to both review the existing econometric evidence and to provide further empirical evidence on supply responses to farm prices in Sub-Saharan African countries in order to assess the quantitative significance of price in the agricultural sector. Section II presents evidence from studies that examine the change in production of individual crops as their producer prices and the producer prices of substitute or complementary crops change. Section III discusses the response of overall agricultural production to relative changes in an aggregate agricultural price index. The conclusions are summarized in Section IV.

II. Individual Crop Response to Price

The purpose of this section is to provide information on the key parameters estimated from empirical supply equations. Many problems are encountered in assessing econometrically the responsiveness of crop output to prices and other variables. First, the data are of poor quality

or simply not available. Second, a positive correlation between the producer price and marketed output indicates very little about the causal relationships underlying the choices of economic agents between leisure and production, food crops and cash crops, and wage work and work on own-farm. Third, empirical results depend on the choice of output and price variables. For example, either harvested tonnage or planted acreage could be used for the output variable. To the extent that acreage is used instead of quantity produced, there will be a tendency to underestimate the supply elasticity, as it takes no account of variations in the supply of inputs other than land per unit of harvested area. With regard to price variables, one problem facing the researcher is how to calculate the real producer price, and which input and alternative crop prices to include in the estimating equation.

In addition to relative prices, another very important variable that affects a farmer's cropping decision is his perception of risk. In particular, risks related to weather patterns and dependency on markets affect agricultural output. The risk of drought may lead a farmer to plant drought-resistant crops that could be marketed easily. The risk of being dependent on unreliable markets for supplies of inputs and food needs and uncertain receipts due to price fluctuations may discourage farmers from growing nontraditional or cash crops. Other nonprice constraints include poor transportation networks, inadequate research and extension facilities, unavailability of credit, shortages of fertilizer and other inputs, and the lack of consumer goods on which the farmer can spend his income. Measuring the impact of these factors is usually quite difficult.

Before deciding on the level of production of his crop the farmer has to choose between both consumption and production bundles. The three consumption activities that he can choose between are: goods that are produced and consumed within the family; goods that are purchased with cash; and leisure. In his production activities he has four alternatives: (i) producing food crops and other goods for own consumption; (ii) producing cash crops; (iii) offering his labor for a wage (or participating in other cash earning activities); and, (iv) taking more leisure. Changes in the prices of any of these consumption or production activities will affect the production of food crops or export crops. The way in which crop production is affected by a change in one of these prices depends upon the relative weights of the substitution and income effects in the consumption process, and upon whether or not subsistence goods are inferior in consumption. 1/

1/ For details of these effects, see the resource allocation model in Dean (1965).

It follows that the effect of producer prices on the production of cash crops cannot be considered in isolation from other variables; government policies also alter these other variables and thereby change economic incentives. For example, government policy that changes money wages in the industrial sector (or money rates of return from other cash earning activities) will produce a change in the production of cash crops. Government policies that overprice consumer goods sold for cash also have a strong effect on the production of cash crops. If prices of consumer goods are exorbitantly high in relation to cash received for crop production, producers may have little incentive to respond to changes in producer prices for cash crops.

On a crop-by-crop basis a great deal of empirical evidence has been accumulated. Positive supply responses have been observed for a wide variety of small holder cash crops in Sub-Saharan Africa such as cocoa, coffee, cotton, groundnuts, palm kernels, palm oil, rubber, sisal, and tobacco. The survey presented here is on a crop-by-crop, country-by-country basis.

Most of the estimates of price responsiveness presented here are obtained from functional forms based on the model presented below, which includes both acreage functions and yield functions. 1/

Acreage Equations

$$A_t^D = a_o + a_1 P_t^e + a_2 Z_t + u_t \qquad (1)$$

$$P_t^e = P_{t-1}^e + \beta(P_{t-1} - P_{t-1}^e) \qquad (2)$$

$$A_t = A_{t-1} + \gamma (A_t^D - A_{t-1}) \qquad (3)$$

Yield equations

$$Y_t^* = \sum_{i=k}^{\infty} \delta_i A_{t-i} \qquad (4)$$

$$Y_t = b_o + b_1 Y_t^* + b_2 P_t + b_3 Z_t + u_t \qquad (5)$$

where

A_t = actual acreage under cultivation at time t

A_t^D = acreage desired to be under cultivation at time t

1/ See Askari and Cummings (1977) for a more detailed description of the acreage equations.

P_t = actual real producer price at time t (the nominal producer price deflated by the consumer price index)

P_t^e = expected real producer price at time t

Y_t^* = potential yield at time t

Y_t = actual yield at time t

Z_t = other exogenous factors including the prices of substitutes and complementary crops affecting supply at time t.

δ_i = potential yield per acre in year t of crop planted in year i

β, γ are the expectations and adjustment coefficients.

k is the age at which the plant (tree) begins to bear.

This basic model has been employed in a variety of ways in empirical work. Its modification depends upon the crop under investigation, alternative crops that compete for land and labor, the inclusion of other factors of particular importance for the country or crop being investigated, and the time horizon that must be considered for each crop.

Conceptually, the short run can be defined as the period in which productive capacity cannot be changed, but output can be varied by using the fixed capacity with different amounts of variable factors. In the context of particular crops, however, this definition becomes blurred. For annual crops, defined as those whose sowing-to-sowing cycle is one year or less (e.g., cotton), output in the short run can be altered by varying either the acreage under cultivation, or the intensity of farming, or both. In this case $A_t^D = A_t$, $P_t^e = P_t$, and $Y_t^* = \delta A_t$ (equation 4): that is, only acreage under cultivation in the current year is important. For perennial crops, however, the stock of trees corresponds to a fixed factor, so that in the short run output can be changed only by varying the intensity of farming, and in the long run capacity can be changed by varying the acreage under planting. For an annual crop there is likely to be a high correlation between the elasticity of acreage and the elasticity of output with respect to price. For a perennial crop, on the other hand, there is likely to be very little relationship between the elasticity of acreage and the elasticity of output, because it may take many years for a tree to mature and reach peak output.

Short-run price elasticities of acreage and yields can be derived from the separate equations specified above: namely from equation (3) (after substituting (1) and (2) into (3)) and from equation (5) (after substituting (4) into (5)). To obtain the long-run elasticities, the model must be solved simultaneously. In some empirical work the long-run elasticities have been obtained by using the acreage and yield equations simultaneously. In others the acreage and yield equations are used to obtain the coefficients separately and these coefficients are merely added.

The summary of the own-price elasticities of supply for individual crops for Sub-Saharan Africa is presented in Table 2, for cocoa, coffee, cotton, groundnuts, palm kernels, palm oil, rubber, sisal, and tobacco. The focus is on the elasticity of response of individual crops to changes in relative producer prices. Where equations were estimated in level form, the resulting coefficients have been converted to elasticities for purposes of comparison. Information on individual supply responses does not necessarily provide information on the elasticity of aggregate agricultural production. Nevertheless, to the extent that many of the studies presented here do give information on the cross-price substitution effects, own-price responses provide some information on how total agricultural output might respond to an overall increase in agricultural producer prices. The supply elasticities are discussed below on a crop-by-crop basis.

A great variety of studies have been conducted on the response to price incentives of West African cocoa growers. Once cocoa reaches maturity it does not compete with food crops (maize and cassava) for labor inputs, because these food crops can be planted and harvested throughout the year in alternate rows with cocoa plants. Before planting, however, cocoa competes with other perennial crops, such as coffee. The estimates of the short-run (first year) supply elasticities vary greatly. In the only study where the estimate of the short-run elasticity is statistically significant, the magnitude of the estimated elasticity is about 0.7. With respect to the long-run supply response, practically all studies conclude that, allowing for the length of time for a tree to reach maturity, there is a large output response to real producer prices. The average of the estimates of the long-run elasticity is about 0.9; the long-run output responses for the Ivory Coast, Cameroon, and Ghana are larger in size than those for Nigeria.

In both Bateman's (1965) and Behrman's (1968) supply equations, quantity produced is used as the dependent variable because of the lack of available data on acreage. Equations similar to (1) and (3) are solved for A_t (acreage), 1/ and then substituted into the quantity-produced

1/ Bateman uses actual acreage and Behrman desired acreage. This may explain the higher long-run estimates obtained by Bateman.

Table 2. Cash Crop Supply Elasticities

(By crop and region)

Crop/ Region	Period	Author	Year	Short-run Elasticity (First year) 1/	Long-run Elasticity 1/
Cocoa					
Ghana	1947-64	Behrman	(1968)	--	0.71*
Ghana (old areas)	1949-62	Bateman	(1965)	0.39	0.77
Ghana (medium areas)	1949-62	Bateman	(1965)	0.42 to 0.51	1.28
Ghana (new areas)	1949-62	Bateman	(1965)	0.61 to 0.87	1.06
Nigeria	1947-64	Behrman	(1968)	--	0.71*
Nigeria	1947-64	Behrman	(1968)	--	0.45*
Ivory Coast	1947-64	Behrman	(1968)	--	0.80*
Cameroon	1947-64	Behrman	(1968)	0.68*	1.81*
Coffee					
Kenya	1946-64	Maitha	(1970)	0.64*	1.33*
Kenya (estates)	1946-64	Maitha	(1970)	0.66*	1.38*
Kenya (smallholders)	1946-64	Maitha	(1970)	0.64*	1.48*
Kenya	1946-64	Ford	(1971)	--	1.07*
Kenya (estates)	1946-64	Ford	(1971)	--	1.18*
Kenya (smallholders)	1946-64	Ford	(1971)	--	1.55*
Africa	1943-60	Bacha	(1968)	0.14 to 0.24	0.37 to 0.60
Africa	1947-73	de Vries	(1975)	0.12*	0.44*
Cotton					
Nigeria 2/	1948-67	Oni	(1969)	(0.23 to 0.38)	(0.28)
Nigeria	1950-64	Diejomaoh	(1972)	0.67*	0.67*
Sudan	1951-65	Medani	(1970)	0.39*	0.50*
Uganda	1922-38	Frederick	(1969)	0.25*	0.25*
Uganda Buganda	1922-38	Frederick	(1969)	0.67* to 0.73*	0.67* to 0.73*
Uganda Buganda 2/	1945-66	Alibaruho	(1974)	(0.50)	(0.63)
Uganda (Eastern region) 2/	1945-66	Alibaruho	(1974)	(0.23)	(0.44)
Uganda (Western region) 2/	1945-66	Alibaruho	(1974)	(0.26)	(0.62)
Uganda (Northern region) 2/	1945-66	Alibaruho	(1974)	(0.02)	(0.07)
Groundnuts					
Nigeria	1948-67	Olayide	(1972)	0.24 to 0.79	0.24 to 0.79
Palm Kernals					
Nigeria	1949-64	Oni	(1969)	0.22 to 0.28	0.22 to 0.28
Nigeria (Eastern)	1949-64	Oni	(1969)	0.28 to 0.39	0.28 to 0.39
Nigeria	1950-64	Diejomaoh	(1972)	0.25*	0.25*
Palm Oil					
Nigeria	1950-64	Diejomaoh	(1972)	0.81*	0.81*
Nigeria	1949-63	Helleiner	(1966)	0.41*	0.41*
Nigeria	1949-64	Oni	(1969)	0.29 to 0.35	0.29 to 0.35
Nigeria (Eastern)	1949-64	Oni	(1969)	0.41* to 0.70*	0.41*to 0.70*
Rubber					
Liberia	1950-72	Ghoshal	(1974)	0.14	0.22
Nigeria	1952-72	Olayemi and Olayide	(1975)	0.04	1.75*
Sisal					
Tanzania	1945-67	Gwyer	(1971)	0.06*	0.48* to 0.76*
Tobacco					
Malawi	1926-60	Dean	(1966)	0.48*	0.48*
Nigeria 2/	1945-64	Adesimi	(1970)	(0.60*)	(0.82*)

1/ Asterisk indicates that the estimate is significantly different from zero at the 0.05 level of significance.

2/ In these equations, acreage rather than quantity produced was used as the dependent

equation similar to equations (4) and (5). The long-run elasticity is the response after newly planted trees have come into full bearing and all other adjustments have occurred.

The estimates of the cross-price elasticities between cocoa and coffee (at the planting stage) are large, negative, and significantly different from zero at the 5 per cent significance level in both studies; the size of the parameter estimates are almost twice as large as the estimates of own-price effects. Bateman concludes that cocoa production responds to both cocoa and coffee prices, and to the length of time a region has been planted in cocoa. The Bateman and Behrman studies, however, both omit some of the important variables that farmers may consider when making their production choice, such as the money wage outside the agricultural sector, and the availability of cash goods.

Supply models for coffee have been estimated by Bacha (1968), de Vries (1975), Ford (1971), and Maitha (1970), for both Kenya, and all of Africa. These studies show that even after allowing for the substitution (cross-price) effects of changes in the relative price between coffee and cotton (which is regarded as the major alternative crop for coffee) coffee production responds strongly to a rise in its producer price. For the period from 1943 to 1973 estimates of the short-run elasticity of production average to about 0.5, while the long-run elasticities average to about 1.1. The studies on Kenya by Ford and Maitha contain equations for both acreage and yield per acre. The short-run supply elasticity is obtained from the yield per acre equation, since in the short run coffee acreage is fixed. The long-run supply elasticities are derived by summing the long-run price elasticities for acreage and for yield per acre. The long-run elasticities estimated for industry and estate coffee by Maitha are considerably larger than those estimated by Ford. One important reason for this result is that Ford estimated the coefficients from the acreage and yield equations separately and then simultaneously determined the long-run elasticities. This simultaneous determination was not attempted by Maitha. Both these studies demonstrate that in the long run most of the supply responsiveness for coffee comes from the change in yield per acre rather than from the change in acreage, demonstrating that even if the producer price has little effect on the acreage under coffee production, it has a strong effect on yield.

Studies of cotton production and acreage in Nigeria, Sudan, and Uganda show significant short-run and long-run supply responses as shown in Table 2. Cotton, an annual crop, competes with other crops, in particular, coffee and groundnuts, so that in the short run, yield as well as acreage can vary. Diejomaoh (1972), Frederick (1969), and Medani (1970) estimated output equations for cotton and found that after taking account of the cross-price substitution effects with coffee and groundnuts, there is a marked own-price effect. The average of the estimates of the short-run own-price yield elasticity is about 0.5. As might be expected with an annual crop, the long-run elasticity is not very much larger than the

short-run elasticity. 1/ The average of the estimates of the long-run price elasticity is also about 0.5. These results are generally supported by the estimates of acreage response obtained by Alibaruho (1974) and Oni (1969). However, Alibaruho finds the own price elasticity to be much larger in the long run than in the short run. The evidence from the cross-price elasticities also suggests that an increase in the producer price of cotton relative to coffee would induce a rise in cotton output that would be significantly larger than the fall in coffee output.

Sisal is a perennial crop that has been grown in Tanzania since the beginning of the century. Gwyer (1971) finds that sisal planters in Tanzania are influenced by prices in the year of planting and in the two previous years. Gwyer estimates separate equations for acreage and yield. The short-run supply elasticity, derived from the yield (output per hectare of mature acreage) equation is small (0.06), but significant. The long-run elasticity, the sum of the acreage and yield elasticities, is large (0.62). 2/ Gwyer also finds that in the short run producers react to any current price stimuli by varying the frequency of the harvesting, rather than by heavy harvesting and overcutting--a reaction that would lead to future decline in yields. Since there is no shortage of land suitable for sisal cultivation, most of the long-run response comes from producers changing their planting decisions.

Most studies of the supply responses of palm products (oil and kernels) show significantly positive own-price effects. Although palm oil and palm kernels are tree crops, the trees tend to grow in the wild and producers' responses are essentially related to harvesting decisions rather than planting decisions. Consequently, in econometric work, palm product yields can be modeled as for an annual crop. For this reason, the long-run elasticity does not differ from the short-run yield elasticity. Most of the studies for palm products have been carried out on data between the late 1940s and mid-1960s for Nigeria. The average of the elasticity estimates is about 0.2 for palm kernels and 0.5 for palm oil. Olayide (1969) has noted that Nigerian palm producers respond very strongly to world prices, and has suggested that Nigeria's export marketing policies be revised so that producer prices closely reflect world prices.

Rubber is a perennial crop, which only begins to produce after five years. Most of the statistical evidence from Africa--mainly from Liberia

---

1/ None of the studies for cotton estimates cotton yield and acreage simultaneously. However, to the extent that the relationship between acreage and yield per acre is likely to be strong for an annual crop, the estimates presented here are likely to be reasonable approximations to those determined simultaneously.

2/ These long-run elasticities are not determined simultaneously and are therefore likely to be overestimates of the true elasticity.

and Nigeria--suggests that the short-run response of rubber production to price is inelastic. Estimates of short-run yield elasticities for rubber range from 0.04 to 0.14. Olayemi and Olayide (1974) use a polynomial lag model to show that while output response to a price change may be inelastic for the first few years the price response rises to a peak at around the fifth year when new plantings come into production. In subsequent years the price effect declines. A total price elasticity of 1.75 was calculated over a period of eight years indicating that, when all production adjustments are made, the long-run price response is large. The effects of the price change are two-fold: the price increase induces the farmer not only to undertake new plantings but also to take more intensive care of mature trees. At first only the effect of more intensive care shows up; but after five to six years new plantings come into production and add their own effect to output.

Studies on tobacco, an annual crop, find a marked response to the real producer price of tobacco. A study by Adesimi (1970) focuses on the acreage response in Nigeria's western provinces, where tobacco competes for land and labor inputs with yams, cassava, and maize. The study shows that the tobacco acreage is positively related to the price of tobacco and negatively related to the price of yams, and also that if the prices of both products increase tobacco acreage will still increase. A study by Dean (1966) on tobacco production in Malawi focuses directly on the output equation and obtains a somewhat smaller supply response.

Another study of African tobacco production by Dean (1965) for Malawi bears indirectly on the issues considered here. Dean's main interest was to determine whether the tobacco grower's labor supply curve (and hence that for tobacco itself) is backward bending. The rise in tobacco production that is associated with a rise in the tobacco price is interpreted by Dean as indicating that increased amounts of labor are allocated to tobacco production when there is an increase in the return to labor in this activity, and that this result is consistent with the hypothesis that the supply curve of labor for tobacco production is upward sloping. The negative coefficient on the wage variable indicates that a rise in wages obtainable abroad decreases the amount of labor allocated to tobacco. This constitutes evidence against the presence of a backward-bending supply curve.

The principal findings from the studies from Sub-Saharan African countries can be summarized as follows. First, with few exceptions, the own-price elasticities are positive and significant from an economic and statistical standpoint even in the short run. The size of the short-run elasticities are not very large, however. Second, in general, the long-run own-price elasticities tend to be larger than those for the short run

and of fairly sizeable magnitudes. Since many of the equations also contain cross-price effects, these own-price responses provide some support 1/ for the view that overall agricultural output does increase with an overall increase in agricultural producer prices. Third, the findings tend to suggest that spare capacity suitable for crop cultivation often exists and that increasing producer prices can lead to increased productivity per acreage. Finally, the findings also contradict the view that peasant farmers have only income goals and that they therefore react perversely to changes in producer prices.

III. Overall Output Responses

The previous section dealt with the findings on the response of individual crops to price changes, but a more important question is that of how aggregate agricultural production responds to price changes. Aggregate agricultural production can change in response to (i) a change in the relative prices of export versus food crops and (ii) a change in the rural/urban terms of trade. Changing the price of export crops relative to food crops will have important implications for the balance of payments, as well as for overall agricultural production. For most African countries, food as well as export crops are traded goods, so that a change in the terms of trade in favor of export crops could either improve or deteriorate the current account depending on the size of the import and export sectors and the output response to price changes for each crop. How aggregate production responds to change in the rural/urban terms of trade depends on a number of factors, such as the movement of labor and materials from the urban to the rural sector, the question of the trade-off between leisure and production, and how much new investment in agriculture is undertaken.

Reliable and conclusive evidence of aggregate supply responses in Africa is difficult to find. Very few tests have been made of how aggregate supply--production or marketed surplus of either individual farmers or the agricultural sector as a whole--responds to the general agricultural price level or to the urban rural terms of trade. It would seem reasonable to believe that the elasticity of aggregate production is lower than that of individual crops; the latter involves the redeployment of resources within the agricultural sector whereas the former includes transferring resources to the agricultural sector from other sectors, or

---

1/ The cross-price terms will only capture all the switching behavior of farmers if the equation is correctly specified. Since most of the studies presented here omit important variables that farmers consider when making their production choice, a considerable part of the own-price elasticity could also be due to switching effects.

utilizing unemployed or underemployed resources existing within the sector. Though it is widely accepted that leisure has gradually taken a smaller proportion of the time of the agricultural sector as the cash economy has made inroads into African rural society, (Helleiner [1975]), this assumption has not been verified empirically.

One method sometimes used to assess overall supply responses is to study the impact of devaluation on a country's overall exports, since in most of these countries exports come predominantly from the agricultural sector. There are, however, serious problems associated with studies, and for the following reasons they are not considered in this paper in connection with the price response of aggregate agricultural supply:

1. Increases in production of agricultural exports may be offset by a reduction in the production of food crops, so that this does not necessarily imply an overall increase in output following devaluation.

2. Devaluation may not necessarily have an effect on agricultural producer prices if the authorities regulate prices and output changes following devaluation. Furthermore, export changes following devaluation may be caused by other factors, such as the existence of large stocks prior to devaluation, or diversion of export crops that are being sold illegally across borders. In these cases, the measured impact of a devaluation may appear to be much larger than the actual impact.

3. The price of primary products varies considerably from year to year and cannot be held constant while the effect of a devaluation is assessed.

4. The medium-term and longer-run effects of a devaluation depend largely on the supporting policies taken by the authorities.

A recent study on Sub-Saharan African countries by Shankar Acharya, (1981) considers both export and food crop production together. Acharya concludes that failure to maintain incentives in these countries' agricultural sectors was the major reason for their poor performance in agricultural production: Africa's food production per capita declined by 7 per cent between 1967 and 1978 in contrast to increases of 7 to 8 per cent in Asia and Latin America. Nevertheless, Acharya also shows that there were sharp differences in outcomes between market-oriented economies--namely, Ivory Coast, Malawi, and, to a lesser extent, Kenya--which sustained the most favorable environments for private peasant agriculture and the étatist economies--Ghana, Sudan, and Tanzania--which introduced a high level of state ownership and tried to force the pace of industrialization by skewing the structure of incentives against agriculture. The evidence in Table 3 shows that Ivory Coast, Kenya, and Malawi achieved massive increases in export volumes despite the fall in their terms of trade, and were able to more than quadruple the purchasing power of their exports over the period 1954-56 to 1975-77. In contrast, the purchasing power of exports remained nearly constant for Ghana, while Sudan and Tanzania recorded very modest gains. Export volumes of the

Table 3. Export Volume and Terms of Trade

(1970 = 100)

	1954-56	1964-66	1975-77
Ivory Coast			
Export volume	22	83	152
Terms of trade	139	82	102
Purchasing power	31	68	155
Kenya			
Export volume	17	81	103
Terms of trade	154	103	106
Purchasing power	26	83	112
Malawi			
Export volume	29	77	118
Terms of trade	111	97	113
Purchasing power	32	74	133
Ghana			
Export volume	52	96	92
Terms of trade	148	66	92
Purchasing power	77	64	84
Sudan			
Export volume	42	80	76
Terms of trade	119	90	115
Purchasing ower	50	71	86
Tanzania			
Export volume	39	95	69
Terms of tade	123	100	113
Purchasing power	47	95	78

Source: United Nations Conference on Trade and Development, Handbook of International Trade and Development Statistics, 1979.

Ivory Coast, Kenya, and Malawi increased seven-fold, six-fold, and four-fold, respectively between 1954-56 and 1975-77 whereas they increased by 75 per cent for Ghana and Tanzania, and by 70 per cent for the Sudan over the same period. Thus Acharya concludes that the market-oriented countries clearly generated volume increases outweighing the adverse price trends whereas the étatist countries did not and therefore had to rely more and more on foreign aid.

In an attempt to provide stronger evidence of the response of aggregate output to relative changes in rural/urban prices in Sub-Saharan African countries, a very simple empirical equation has been estimated for nine predominantly agricultural African countries--Ghana, Kenya, Ivory Coast, Liberia, Madagascar, Senegal, Tanzania, Uganda, and Upper Volta. It should be noted at the outset that any empirical testing of the responsiveness of aggregate output to relative price changes involves numerous difficulties. First, the aggregate function is obtained by adding across the supply functions for individual crops. Individual crops respond very differently to price changes, as can be seen from Table 2, and the estimator from group data is always less efficient than the estimator from ungrouped data. Adding across supply functions also has important implications for the lag structure. Second, increasing the real producer price index will lead to a reduction in the proportion of agricultural output growth in the subsistence sector--this effect is not captured in this study. Third, for some countries, the time series are short, and for most countries the quality of the data is poor.

The equation derived here is based on the methodology of Nerlove (1958). Actual per capita total agricultural output, Q_t, is related to its long-run equilibrium level, $\bar{Q}_t$, by the behavioral assumption that actual quantity would adjust in proportion to the deviation from the equilibrium level; in the following equations β denotes the elasticity of this adjustment.

$$\ln Q_t - \ln Q_{t-1} = \beta (\ln \bar{Q}_t - \ln Q_{t-1}) \qquad (6)$$

$\bar{Q}_t$ is the long-run equilibrium quantity produced at price PR_t, where PR_t is the aggregate real producer price, i.e., the urban/rural relative price index expressed as a weighted average of producer price indices deflated by the consumer price index. The equation for equilibrium output takes the form:

$$\ln \bar{Q}_t = a_o + a_1 \ln PR_t \qquad (7)$$

By substituting equation (7) into equation (6), equation (8) is obtained:

$$\ln Q_t = bo + b_1 \ln PR_t + b_2 \ln Q_{t-1} + b_3 t + b_4 Z_t \qquad (8)$$

where $b_2 = 1 - \beta$ is the elasticity of adjustment coefficient, $b_1 = a_1\beta$ is the short-run price elasticity, and $a_1 = b_1/\beta$ is the long-run price elasticity. A time trend, t, was added to take into account long-run structural changes and a dummy variable, Z_t, was added to capture the influences of unusual weather patterns. 1/

In constructing equation (8), it is necessary to note data limitations. Data on per capita agricultural output obtained from FAO are based on a crude methodology and are hence subject to large measurement errors. On the other hand, good data for producer prices are available only for some of the countries and some of the crops.

Table 4 contains the regression results of equation (8) for the nine African countries mentioned earlier. The estimation procedure used is that of ordinary least squares multiple regression and the number in parenthesis is the t statistic for each of the respective coefficients. For each country the time period for which the investigation was carried out is given along with the results.

The overall fit of the equation is reasonably good except for Liberia. Omitted variables and data measurement errors are likely to be the important causes of the poor fit. With the exception of Senegal and Upper Volta, the estimate of the constant term is significant at the 95 per cent level for all countries. The constant could be interpreted as subsistence output, or the level of output that would be produced regardless of the producer price. This coefficient is higher for Tanzania than for any of the other countries.

For all countries, the estimated relative price coefficient is positive. The estimates show that the relative price is an important determinant of overall agricultural output, particularly for Ghana and Kenya. The size of the coefficient for Ghana shows that a rise in the real overall aggregate producer price of 10 per cent will result in a 2 per cent increase in overall agricultural output after one year. The average of the estimated price elasticities for the nine countries is 0.12; this is lower than the estimates obtained for individual crops (Table 2).

1/ Data sources are as follows. Annual series on total per capita agricultural production were obtained from FAO Production Yearbook (various issues). Annual series on nominal producer price indices for individual crops, the weights of individual crops in overall agricultural production, and the consumer price index were obtained from various Fund staff papers. Determination of whether the dummy variable was 1 or 0 was based on information gathered by the Fund staff and contained in various reports.

Table 4. Elasticity Coefficients for Aggregate Agricultural Supply Responses for Nine Sub-Saharan African Countries

	b_o	b_1	b_2	b_3	b_4	D-W	R^2	SEE	Time Period
Ghana	1.74	0.20	0.42	-0.01		2.11	0.824	0.06	1963 to 1981
	(2.27)	(3.16)	(2.55)	(1.70)					
Kenya	2.52	0.10	0.36	-0.003	0.04	2.24	0.676	0.02	1966 to 1980
	(2.93)	(3.06)	(1.91)	(1.86)	(2.61)				
Ivory Coast	4.06	0.13		-0.01	0.04	2.56	0.636	0.03	1969 to 1978
	(5.42)	(0.77)		(1.43)	(2.56)				
Liberia	3.97	0.10	0.08	-0.01		2.07	0.182	0.04	1966 to 1980
	(2.28)	(0.88)	(0.25)	(1.48)					
Madagascar 1/	2.70	0.10	0.31	0.0001	0.07	1.95	0.774	0.02	1968 to 1981
	(2.91)	(0.63)	(1.48)	(0.03)	(4.27)				
Senegal 2/	3.68	0.17		0.0002	0.16	2.30	0.781	0.12	1970 to 1979
	(1.45)	(0.36		(0.009)	(3.83)				
Tanzania	4.66	0.03		-0.02		2.28	0.961	0.01	1972 to 1981
	(21.27)	(0.69)		(8.98)					
Uganda	3.06	0.05	0.30	-0.02		2.13	0.864	0.04	1968 to 1978
	(2.12)	(0.54)	(0.88)	(1.97)					
Upper Volta	3.25	0.22	0.08	-0.01		1.83	0.470	0.047	1964 to 1980
	(1.89)	(1.16)	(0.32)	(1.92)					

1/ Corrected for first order autocorrelation $\rho = 0.36(1.66)$.
2/ Corrected for first order autocorrelation $\rho = -0.72(2.59)$.

Agricultural output exhibits a negative time trend for most of the countries. The estimated coefficients for the time trend are negative for Ghana, Kenya, Ivory Coast, Liberia, Tanzania, Uganda, and Upper Volta, and is particularly strong in the equation for Tanzania, reflecting the unfavorable climate to agricultural investment that has been created, the deterioration of the infrastructure and support services available to the rural farmer, and the growing lack of availability of cash goods to the rural sector.

The dummy variable for weather conditions is the most significant factor in the equations for the Ivory Coast, Madagascar, and Senegal. It would appear that for these countries the weather was a more important determinant of total agricultural output than any other variable.

The elasticity of adjustment, b_2, and the long-run price elasticity, a_1, are given in Table 5. Ghana, Kenya, Liberia, Madagascar, Uganda, and Upper Volta all have long-run price elasticities that are greater than the short-run price elasticities, but for the majority of these countries the confidence interval is well below the 95 per cent significance level. Despite the considerable differences for individual countries, the average long-run price elasticity for six countries is only very slightly larger than the average short-run price elasticity for the nine countries.

The findings that come from these empirical results and from the Acharya study do provide considerable evidence for positive aggregate supply responses to changes in rural/urban terms of trade. On the basis of intercountry comparisons, Acharya demonstrates that the structure of incentives influences agricultural performance. The estimates reported here support this view. However, structural changes have, for nearly all the countries, hindered agricultural production, and for a few countries, weather patterns have dominated all other variables. Long-run price elasticities have proved to be difficult to measure, but for some countries there is a clear indication that these differ in size from short-run price elasticities.

IV. Conclusion

In many Sub-Saharan African economies, governments need considerable information in order to review their agricultural pricing and support policies. This paper presents evidence from studies of both individual crops and overall crop production for a number of African countries. It is found that for both individual crops and aggregate production supply responses are positive. In general, for individual crops, the longer-run price elasticities tend to be larger than those for the short run, and are of a fairly sizable magnitude. For aggregate crop production there appears to be some evidence that farmers do respond to rural/urban terms of trade. Turning the terms of trade in favor of the agricultural sector does lead to increased agricultural production. As far as substitution effects are concerned, the evidence from individual crop studies suggests that for some crops an increase in production can take place without an equivalent fall in production of substitute crops.

Table 5. Short-Run and Long-Run Price Elasticities for Aggregate Agricultural Supply For Nine Sub-Saharan African Countries

Country	Short-run Price Elasticity b_1	Elasticity of Adjustment b_2	Long-run Price Elasticity a_1
Ghana	.20	.58	.34
Kenya	.10	.64	.16
Ivory Coast	.13	--	--
Liberia	.10	.92	.11
Madagascar	.10	.69	.14
Senegal	.54	--	--
Tanzania	.15	--	--
Uganda	.05	.70	.07
Upper Volta	.22	.92	.24
Average for Nine Countries	.17	.74	.18

The target-income hypothesis, which implies a backward bending supply curve of labor, is not supported by the evidence presented in this paper. The studies also show that neither labor nor land presents major constraints upon agricultural expansion. Individual crop studies tend to suggest that spare capacity suitable for crop cultivation often does exist, and that when producer prices increase productivity per acreage is also likely to rise.

A realistic pricing policy is only one element in a comprehensive package of government action that would be required to ensure a sound agricultural base. Such a package would need to include pricing policies with regard to consumer goods and inputs as well as improvements in extension services, infrastructure, input availability, and credit facilities. A package of changes may elicit a very different repsonse from farmers than a price change alone. For example, an increase in the producer price together with cheaper consumer goods and an improvement in extension services will offer more of an output incentive to the farmer than a mere increase in the producer price. Therefore, governments need to be informed of the likely effects of changes in these other variables, along with those of changes in pricing policies, in order to assess more accurately the possible outcomes of a variety of policy packages.