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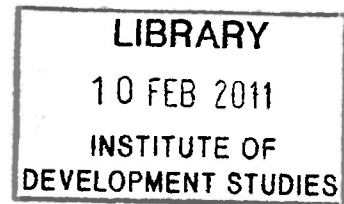
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REGIONAL SUPPLY ELASTICITIES IN UGANDA'S COTTON
INDUSTRY AND THE DISAPPEARING COTTON BALES

By

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ABSTRACT

The "Double Production" campaign in Uganda's cotton sector is a well known slogan in the Second Republic. Actual production however is declining instead. In this paper, we use time series acreage and price data disaggregated on a regional basis to estimate regional supply elasticities. We use the estimated regional differentials in supply responsiveness to explain why total output will decline especially in Buganda in the absence of a well designed pricing policy and in the light of a high demand for food crops in the current Ugandan environment of a disintegrating internal transportation system. We argue and prove empirically that the skyrocketing food prices in the urbanized central Uganda have effectively reversed the cash earning roles of cotton (a traditional cash crop) and those crops traditionally known as subsistence crops. This phenomenon has been reinforced by the well known producer price depressing effect of the Lint Marketing Board pricing policy as well as the breakdown of the commodity distribution system that has isolated the towns from the food producing rural areas in today's Uganda.

INTRODUCTION

The extent to which farmers react to changes in relative prices between crops or "groups" of crops has an important bearing on public policy towards agriculture. The pricing and marketing authorities, through the operation of such instruments as export tax rates on selected commodities or groups of commodities can alter significantly relative prices between competing crops or competing groups of crops and may thus directly influence the composition of output on the farm and between regions of a country.

In Uganda, cotton is currently the second major export and is by far the most widely grown cash crop in the country. The spatial distribution of cotton production, however has changed dramatically since the second world war. Before the war and in the immediate postwar years, two thirds of Uganda's crop was produced in Central Uganda (Buganda) and only one third was produced in Eastern and Northern Uganda. Since the 1950's, the focus of cotton growing has shifted northwards and eastwards. As a glance at tables 1 and 3 will show, acreage in the Eastern region almost doubled between 1950 and 1966 and in general, all regions experienced a great increase in acreage except Buganda where it has actually declined. Furthermore, in my recent interview with a Ministry of Agriculture economist, it was revealed to me that despite the government's efforts to attain a 500,000 bale production target through President Amin's "Double Production Campaign", the actual level of production this year is not expected to exceed 300,000 bales (c.f. 410,000 bales last year). This is in spite of the current upsurge in world market prices of cotton. His main explanation was that production in Buganda is continuing to decline. This phenomenon reflects changing economic interrelationships between various outputs on the multiproduct peasant farms and these interrelationships show responses by cotton farmers to the product price vector they have faced in each of the regions of the country in the light of the different production and marketing opportunities available. This paper attempts to analyse and estimate the response of these cotton farmers to the production and marketing possibilities on a regional basis against the background of the Lint Marketing Board pricing policy. We shall, in the end see whether the Government's Double Production campaign makes any economic sense in contemporary Uganda.

Prior to the research that underlies the content of this paper, the only significant attempt to estimate supply functions in Uganda's cotton industry known to this researcher is the work of Alesdair MacBean.¹ We shall presently spell out the essential ingredients of the MacBean study, raise our objections to the specification of the model (and hence to the results) and then proceed with our approach that yields remarkably different results.

MacBean utilised two basic specifications. Firstly, he regressed nationwide acreage data on producer prices. Secondly, he regressed the same dependent variable (nationwide acreage of cotton) on the relative price of cotton and coffee. In either case, no significant statistical correlation was found which led MacBean to conclude that any changes in cotton acreage and output must be considered purely random.

There are two serious shortcomings of this study. Firstly, cotton is one of the most widely grown crops, growing in every district of Uganda except Karamoja in the North, and Kigezi in the West. The range of production alternatives available to cotton farmers is different from region to region and in particular between Buganda region and the other three. The use of nationwide data therefore, is likely to hide some regional dissimilarities which may be important for economic responses. Secondly, by using the price of coffee to deflate the price of cotton, MacBean implied that the only significant production alternative of cotton farmers is coffee production. By specifying the model this way, MacBean seems to believe in an analytical distinction between "food crops" and "cash crops" in the decision by African farmers to allocate land inputs between different competing products. The implied argument in this specification is that since there are two cash crops, (coffee and cotton,) therefore only the price of coffee should be used to deflate cotton prices as an indication of the cash cropping alternatives of the farmers. This is false. Coffee is only an important cropping

1. MacBean, A. Export Instability and Economic Development. London: George Allen & Unwin Ltd. June 1966.

alternative in Buganda and not in the most important cotton producing area, East and Northern Uganda. Even in Buganda, food crops are important cash earners besides coffee and cotton. Thus MacBean's results about cotton supply in Uganda are questionable.

This paper attempts to overcome the limitations of the MacBean approach. We shall disaggregate the data and use regional cotton acreage and farmer price data to show that supply response is significant and that Africans do not grow certain commodities principally for their own food consumption and certain others exclusively for cash. Before probing the theoretical considerations in the specification of appropriate regional supply response models let us on the outset specify the production opportunities open to cotton farmers in the various regions of the country.

Summary of Production Alternatives Available to Cotton Farmers.

As noted earlier, the use of either nationwide aggregated production or acreage data as the dependent variable would conceal certain important regional dissimilarities in production alternatives. On a regional basis, these alternatives are much more defined and identifiable.

A geographical study of the current cotton producing area, revealed that mixed beans, cassava, groundnuts, maize, sorghum millet, finger millet, plantains and sweet potatoes were the major cropping alternatives to cotton farmers in Eastern Uganda. In the Western region, this list includes field peas and tobacco in addition. In Northern Uganda, the list includes pigeon peas, tobacco, and simsim in addition, but does not include plantains. In Buganda, the most important cropping alternatives are mixed beans, soya beans, cassava, robusta coffee, groundnuts, maize, sorghum millet, finger millet, plantains and sweet potatoes. These must in one way or another be taken into account as significant food and cash earning alternatives to cotton production.

THE MODEL

Theoretical Aspects

It is useful to approach the problem with a simple model for a "typical" cotton farmer in Uganda. For a cultivator, the decision to commit land to cotton production at any time is

related to his expectations regarding the level of future real prices of cotton, the expected real opportunity cost of committing land to cotton production and the level of desired long run equilibrium acreage.² If the subscript denotes the period to which a variable refers, this hypothesis can be more formally expressed as equation :

$$(i) A_t = f(P_t^*, P_t'^*, A_t^*)$$

where A_t is acreage under cotton in year t , P_t^* is the expected real price of cotton at time t , $P_t'^*$ is the expected opportunity cost of committing land to cotton production. This opportunity cost does not only represent the real monetary earnings of other crops forgone but also the utility and security derived out of the production of food crops that could be grown on the land committed to cotton. A_t^* is the long run desired equilibrium acreage. We can reduce the generality of (i) by writing the model in the following way:

$$(ii) A_t = \alpha + \beta (P_t / P_t')^\alpha + \phi A_t^*$$

In this form, we are able to get rid of one dimension and at the same time we introduce the notion of relative prices. Further specification of the model is not an easy task. One crucial problem centers on the definition of "expected" prices and long run desired equilibrium acreage. Clearly, it is inappropriate to use set minimum producer price in the same year as an approximation for expected normal price. With the prevailing trends and variations in acreage, a regression of acreage on price is more likely to trace some hybrid function rather than an acreage response function.

One possible alternative is to assume that the relative prices and acreage of the previous period are used by the farmer as the best estimate of their expected "normal" level. In this case the general function would be

$$(iii) A_t = f(P_{t-1}, P_{t-1}', A_{t-1})$$

where (as in equation (i)) A_t is acreage of cotton at time t ; P_{t-1} and P_{t-1}' are the historical real prices of cotton and the

2. Because of the lack of an appropriate price index series, money prices are used in the estimations rather than real prices.

real opportunity cost of producing cotton at time $t-1$ respectively. A_{t-1} is the long run equilibrium acreage. This equation provides a useful approximation. Nevertheless, the assumption that expected price is determined solely by the previous year's price is unnecessarily restrictive.

Two alternative models of formation of expectations will be examined; the first by Miss Peter Ady³ and the second by Marc Nerlove.⁴

Ady's Formation of Expectations Model

Ady argues that in both Ghana and Nigeria, the introduction of statutory marketing in 1939 has led to a separation of world prices from producer prices and therefore this implies a change in the structure of price expectations.

Her contention is that throughout the period of statutory price control, it is more plausible to say that price expectations would be related not only to the level of controlled producer prices but also to levels obtaining for world prices. As a result, therefore, an appropriate price expectations model should take both series into account. Her model can be written as

$$\begin{aligned} \text{(iv) } P_t^* &= P_{t-1} + \alpha (\Pi_{t-1} - P_{t-1}) \\ &= (1-\alpha) P_{t-1} + \alpha \Pi_{t-1} \end{aligned}$$

where Π is world prices, P^* is expected price, and P is actual price.

This model sounds plausible for the specific case of analysing data that covers a period characterised by a "discontinuity" in the institutional structure of an industry like the Ghanaian cocoa industry prior to and after 1939 (the year when statutory marketing was established).

3. Ady, Peter, "Supply Functions in Tropical Agriculture", Oxford Economics and Statistics Bulletin, Vol. 30, 1968.

4. Nerlove, Marc, The Dynamics of Supply: Estimation of Farmers' Response to Price (Baltimore: The Johns Hopkins University Press, 1958).

In the case of the Ugandan cotton industry, the period covered by our data 1945-1967 is characterised by a homogeneous export marketing set up. Furthermore, this model is relevant only if producers expect domestic price movements to be positively correlated to world price movements. This might occur when the government first begins to interfere in the setting of price but not after producers have gotten accustomed to the lack of relationship between world and domestic prices as has very much been the case with Uganda cotton.⁵ Besides, given the nature of the mechanism by which actual producer prices may be determined (as opposed to the minimum prices set by the board) farmers can receive a price different from the minimum price stipulated by the board.⁶ Ady's model, therefore is not used in our subsequent analysis. The Nerlovian adaptive expectations model is used instead.

The Nerlovian Adaptive Expectations Model

The Nerlovian adaptive expectations model is a distributed lag model. Let $(P/P')^*_t$ be cotton farmers' expectation at time t of long run "normal" relative price, and let $(P/P')_t$ be actual relative price at time t . $(P/P')^*_t$ will be last period's expected "normal" relative price plus some factor which is proportional to the difference between actual and expected "normal" relative price. Mathematically, this can be written as:

$$(v) \quad \left[\frac{P}{P'} \right]^*_t = \left[\frac{P}{P'} \right]^*_{t-1} + \beta \left[\left(\frac{P}{P'} \right)_{t-1} - \left(\frac{P}{P'} \right)^*_{t-1} \right]; \quad 0 < \beta \leq 1$$

where β is a constant called the coefficient of expectations. This is to say that each period, farmers revise their notion of "normal" relative price in proportion to the difference between the then current relative price and their previous idea of "normal" relative price. Equation (v) is a first order difference equation in $(P/P')^*_t$. It can

5, 6. See Alibaruho, George. "The Impact of Marketing Board Policy on the Level and Variability of Cotton Producer Prices in Uganda; 1945-1969" I.D.S. Discussion paper No. 199, Nairobi, March 1974.

$$(vi) \quad (P/P')_t^* = Z (1-\beta)^t + \sum_{\lambda=0}^t \beta(1-\beta)^{t-\lambda} \{P/P'\}_\lambda - 1$$

Where Z is a constant the value of which depends upon the initial conditions, equation (vi) is an expression of people's notion of the normal relative price as a weighted average of past relative prices. The weights are functions of β and they decline as one goes back in time.

Having discussed the problem of how changes in current relative prices affect producers' expectations of the level of future relative prices, we can build on this knowledge and see how adjustments to a changed level of relative prices occur over time. In the real world, people's notion of the long-run "normal" level of prices is constantly changing; so is actual acreage. In order to describe changes in acreage in response to changes in relative price, we must decompose the problem into the effect of the change in relative price on the expected level of future relative prices; the effect of a change in the expected level of future prices on the long run equilibrium acreage upon current acreage.

A relationship between actual acreage (A) and long run equilibrium acreage (A*) and time would afford a solution to the third of the comparative dynamics problems posed above. One plausible relationship between A and A* is that in each period, actual acreage is adjusted in proportion to the difference between acreage desired in long run equilibrium and actual acreage in that period. If the subscript t stands for the period to which a variable refers, then the relation is:

$$(vii) \quad A_t - A_{t-1} = \gamma (A_t^* - A_{t-1}); \quad 0 < \gamma \leq 1$$

We suppose γ to be a constant and its magnitude depends on the elasticities of supply to the cotton farmers of new land and the ease with which land committed to other crops can be turned over to cotton production over different periods in time; i.e. the factors which cause the difference between short run and long run elasticity of acreage response determine γ . γ is the coefficient of adjustment.

Equation (vii) is a first-order difference equation in actual acreage A_t . It can be solved for A_t as a function of A* for previous periods. If we express acreage at time t as a deviation from acreage at time zero, the arbitrary constant of the solution to (vii) is equal to zero and the solution becomes

$$(viii) A_t = \sum_{\lambda=0}^t (1-\gamma)^{t-\lambda} A^*\lambda.$$

that is current acreage depends on the levels of long run equilibrium acreage desired in the past.

When we combine the distinction between long run equilibrium acreage and observed acreage (short run equilibrium acreage) with the distinction between expected "normal" relative price and observed relative price, it is implied that (i) long run equilibrium acreage is a function of expected "normal" relative price, (ii) expected normal relative price is a function of last period's observed relative price and last period's expected "normal" relative price and (iii) observed acreage is a function of long run equilibrium acreage and last period's observed acreage. But neither long run equilibrium acreage nor expected "normal" relative price can be observed. We must, therefore, find a relationship connecting observed values of acreage during different time periods with observed values of relative price during different time periods. Otherwise γ and β will enter the expression for A_t in terms of past prices symmetrically thereby giving rise to an identification problem. Then, it would not be possible to describe separately, effects^{of}/changes in factors which cause (i) changes in β (the coefficient of expectations) or (ii) changes in γ (the coefficient of adjustment). This is the same as saying that we cannot separate the difference between long run and short run elasticities of acreage from the difference between current (or last period's) actual price and expected level of future prices. Yet it is very important to separate the two inasmuch as the relationship of current acreage to past relative prices will change in quite different ways depending on which type of lag predominates, relative price and current relative price or the one between desired long run equilibrium acreage and current acreage.

To get around this, as Marc Nerlove demonstrated, we must assume a relationship between the expected level of future relative prices and the desired long run level of acreage.⁷ Suppose this relationship was of the form

$$(ix) A_t^* = \delta (P/P')_t^*$$

δ would certainly be positive for an individual farm. It may or may not be positive for the industry. Equation (ix) can be solved for

7. Nerlove, Marc, *op. cit.*

$(P/P')^*$. Substituting the solution expression lagged one period into equation (v), we have

$$(x) \quad (P/P')^*_t = \beta(P/P')_{t-1} + (1-\beta) \frac{A_{t-1}}{\delta}$$

Substituting (ix) into (viii) we have

$$(xi) \quad A_t^* = \delta\beta(P/P')_{t-1} + (1-\beta) A_{t-1}$$

Substituting (x) into (vi), we have

$$(xii) \quad A_t = \delta\beta\gamma(P/P')_{t-1} + [(1-\beta) + (1-\gamma)] A_{t-1} - (1-\beta)(1-\gamma) A_{t-2}$$

β and γ enter equation (xii) symmetrically but if either the elasticity of expectations or adjustment is unity, A_{t-2} drops out. If we knew that the coefficient of A_{t-2} were zero, this formulation would allow us to distinguish between (a) neither β nor γ are unity; and (b) either β or γ or both are unity. This means we can tell (i) whether there is a lag in the adjustment of expected "normal" relative price to current relative price and (ii) a lag in the adjustment of current acreage to long run desired equilibrium acreage or (iii) whether (i) or (ii) occur but not both (i) and (ii). To achieve full differentiation, we find some kind of "instrumental" variable, say E_t , that belongs in the relationship between A_t^* and P_t^* . If this variable can be found, let the relationship be

$$(xiii) \quad A_t^* = \delta P_t^* + \phi E_t$$

Then (xiv)
$$A_t = \delta\beta\gamma P_{t-1} + [(1-\beta) + (1-\gamma)] A_{t-1} - (1-\beta)(1-\gamma) A_{t-2} + \phi\gamma E_t - \phi(1-\beta)\gamma E_{t-1}$$

β and γ enter (xiv) asymmetrically and therefore, we can in principle distinguish between the two types of lags provided E_t does not satisfy a relationship such as $E_t^* = E_{t-1}^* + \gamma(E_{t-1} - E_{t-1}^*)$ the same relationship by which expected "normal" price and long-run equilibrium acreage are defined.

STATISTICAL ANALYSIS

Preliminary statistical analysis based on alternative specifications of the models showed that variations in cotton acreage

in Buganda could not be adequately explained with the same models that can reasonably explain the variations in the other three regions. Besides, on a priori grounds, we know that Uganda's most important export crop (coffee) grows in Buganda (and not anywhere else in the cotton producing area). Therefore, in the succeeding statistical analyses, Buganda region is treated differently from the other three.

East, West and Northern Regions

Let AE_t , AW_t , AN_t , be the acreage at time t of cotton in Eastern, Western and Northern Uganda respectively. Let PC_t be the observed producer price of cotton and PC_t^* the expected price of cotton at time t . We shall postulate as before that:

$$(xv) \quad (i) \quad AE_t = c_1 + d_1 PC_t^* + u_{t1}$$

$$(ii) \quad AW_t = c_2 + d_2 PC_t^* + u_{t2}$$

$$(iii) \quad AN_t = c_3 + d_3 PC_t^* + u_{t3}$$

The u_{ti} are stochastic error terms.

One of the features of our analysis is a recognition that there are certain significant structural and environmental differences between regions. These differences may give rise to regional variations in farmers' sophistication and expectations about price. Consequently, we shall assign a different expectation coefficient to each region; β_1 , β_2 , and β_3 for Eastern, Western and Northern regions respectively.

Then, as before,

$$(xvi) \quad (i) \quad PC_t^* - PC_{t-1}^* = \beta_1 (PC_{t-1} - PC_{t-1}^*)$$

$$(ii) \quad PC_t^* - PC_{t-1}^* = \beta_2 (PC_{t-1} - PC_{t-1}^*)$$

$$(iii) \quad PC_t^* - PC_{t-1}^* = \beta_3 (PC_{t-1} - PC_{t-1}^*)$$

As was demonstrated previously by a process of substitution, it is possible to transform a relationship between long run equilibrium acreage and expected "normal" price into a relationship between actual acreage, lagged observed price and lagged observed acreage. Applying the same operation on equations (xv) and (xvi) we have:

$$\begin{aligned}
 \text{(xvii) (i)} \quad AE_t &= c_1 \beta_1 + \delta \beta_1 PC_{t-1} + (1 - \beta_1)AE_{t-1} \\
 &\quad + U_{t1} - (1 - \beta_1) U_{t1-1} \\
 \text{(ii)} \quad AW_t &= c_2 \beta_2 + \delta \beta_2 PC_{t-1} + (1 - \beta_2)AW_{t-1} \\
 &\quad + U_{t2} - (1 - \beta_2) U_{t2-1} \\
 \text{(iii)} \quad AN_t &= c_3 \beta_3 + \delta \beta_3 PC_{t-1} + (1 - \beta_3)AN_{t-1} \\
 &\quad + U_{t3} - (1 - \beta_3) U_{t3-1}
 \end{aligned}$$

Equations (xvii) (i), (ii), and (iii) indicate regressions for East, West and Northern Uganda of the form

$$\begin{aligned}
 \text{(xviii) (i)} \quad AE_t &= c'_1 + d'_1 PC_{t-1} + e_1 AE_{t-1} + v_{t1} \\
 \text{(ii)} \quad AW_t &= c'_2 + d'_2 PC_{t-1} + e_2 AW_{t-1} + v_{t2} \\
 \text{(iii)} \quad AN_t &= c'_3 + d'_3 PC_{t-1} + e_3 AN_{t-1} + v_{t3}
 \end{aligned}$$

In this model, the residual v_t will be serially correlated and correlated with lagged acreage if the residuals u_{ti} are not serially correlated. The residuals v_{ti} must be independent if statistically consistent and unbiased estimates of the parameters in equations (xvii) are to be obtained. It is noted also that only if the u_{ti} satisfy an autoregressive structure of the form:

$$\text{(xix) } u_t = (1 - \beta_i) u_{ti-1} + \varepsilon_{ti}$$

will the v_{ti} be serially uncorrelated; otherwise, v_{ti} will be negatively serially correlated but since $0 < \beta_i \leq 1$, (xix) implies that u_{ti} are positively serially correlated and the correlation is $1 - \beta_i$. Logically, there is no basis for deciding between the assumption that the correlation between u_{ti} and u_{ti-1} is zero and the assumption that it is $(1 - \beta_i)$. Hence only the Durbin-Watson statistic of the regression can make us decide one way or the other. Therefore ordinary least squares estimates of c'_i , d'_i and e_i in (xviii) provide a method of estimating c_i , δ_i , in (xvii) and β_i in (xvi). (i=1,2,3) Equation (xviii) is the basis of the statistical analyses in Eastern, Western, and Northern Uganda. In the final regressions, log linear relationships are adopted.

The Data

Table 1

ACREAGE AND PRICE DATA

t	AE	AW	AN	PC	DU ¹
1945	554000	28000	137000	17	0
1946	634000	24000	185000	18	0
1947	524000	28000	187000	20	0
1948	768000	44000	267000	22	0
1949	696000	42000	364000	30	0
1950	656000	58000	312000	33	0
1951	779000	56000	262000	45	0
1952	805000	53000	273000	50	0
1953	867000	57000	284000	50	0
1954	904000	66000	337000	51	0
1955	883000	62000	267000	61	0
1956	892000	53000	277000	55	0
1957	875000	78000	316000	56	0
1958	1229000	90000	410000	58	0
1959	857000	92000	291000	47	0
1960	825000	86000	355000	48	0
1961	1084000	86000	443000	55	0
1962	1062000	71000	393000	57	0
1963	1189000	80000	484000	57	1
1964	1278000	95000	473000	51	1
1965	1375000	93000	529000	56	1
1966	1328000	100000	517000	60	1

Source: Ministry of Agriculture, Entebbe, Revised Crop Acreages,
The Government Printer 1960.

Ministry of Agriculture Annual Reports, The Government
Printer (various issues).

1. DU is a dummy variable that takes on the value 0 up to
1962 and the value 1 from 1963 to signify the transfer of the counties
Buyaga and Bugangaizi from Buganda to Western Region.

TABLE 2
REGRESSION COEFFICIENTS FOR REGIONAL ACREAGE FUNCTIONS
FOR UGANDA COTTON
(EAST, WEST AND NORTH), 1945-1966¹

Region	Constant	Cotton Price Lagged 1 yr.	Cotton Acreage Lagged 1 yr.	DU	R ²	D.W ²
Eastern	6.233821	.228825	.484599		.6800	2.3395
	(2.626538)	(.137695)	(.221085)			
	2.373398*	1.661829*	2.191912*			
Western	3.697908	.262348	.578082	.120266	.8570	1.9064
	(1.500182)	(.174573)	(.184179)	(.098752)		
	2.464973*	1.502796*	3.138705*	1.217863*		
Northern	3.610782	.0196277	.713637		.6818	2.2371
	(1.868665)	(.140116)	(.175776)			
	1.932279*	.140083*	4.059919*			

1. The figures in parentheses are the standard errors of the estimates.

2. D.W = Durbin Watson Statistic.

* T - Statistic

Buganda Region

In the case of Buganda, the single equation model developed by Theil, was used to incorporate a price of coffee variable.⁸ This model involves the assumption that the coefficients of expectation related to producer prices of cotton and coffee differ from one another. This is a reasonable assumption, especially given the very different gestation periods for the two crops. This implies that the variable, time, determines their expected "normal" price differently.

⁸ Theil, H., Forecasts and Economic Policy (unpublished manuscript, April 1956).

We can now write the model as

$$(xx) \quad AB_t = c_4 + d_4 PC_t^* + d_5 PCOF_t^* + u_t$$

Where AB_t is acreage of cotton in Buganda at time t , PC_t^* is the expected normal producer price of cotton at time t , $PCOF_t^*$ is the expected "normal" producer price of coffee at time t , u_t is a stochastic error term. Suppose β_4 and β_5 are the respective price expectation coefficients. Each of these expected "normal" prices can be written as weighted averages of past prices so that

$$(xxi) \quad AB_t = a_0 + a_1 \beta_4 \sum_{\lambda=0}^t (1-\beta_4)^{\lambda-1} PC_{t-\lambda} \\ + a_2 \beta_5 \sum_{\lambda=0}^t (1-\beta_5)^{\lambda-1} PCOF_{t-\lambda} + U_t$$

Performing the Koyck transformation on (xxi) by first shifting one period backwards, then multiplying both sides by $(1-\beta_4)$ and subtracting the result from (xxi) we have

$$(xxii) \quad AB_t - (1-\beta_4) AB_{t-1} = a_0 \beta_4 + a_1 \beta_4 PC_{t-1} \\ + a_2 \beta_5 PCOF_{t-1} + a_2 \beta_5 [(1-\beta_5) - (1-\beta_4)] \\ [PCOF_{t-2} + (1-\beta_5) PCOF_{t-3} + (1-\beta_5)^2 PCOF_{t-4} \\ + \dots] + u_t - (1-\beta_4) u_{t-1}$$

Shifting (xxii) one period back, multiplying by $(1-\beta_5)$, and subtracting the results yields

$$(xxiii) \quad AB_t = a_0 \beta_4 \beta_5 + a_1 \beta_4 PC_{t-1} + a_2 \beta_5 PCOF_{t-1} \\ - a_1 \beta_4 (1-\beta_5) PC_{t-2} - a_2 \beta_5 (1-\beta_4) PCOF_{t-2} \\ + [1-\beta_4 + 1-\beta_5] AB_{t-1} \\ - (1-\beta_4) (1-\beta_5) AB_{t-2} + u_t - [1-\beta_4 + 1-\beta_5] \\ u_{t-1} + (1-\beta_4) (1-\beta_5) u_{t-2}$$

Equation (xxiii) suggests a regression of the form

$$(xxiv) \quad AB_t = c_4 + d'_4 PC_{t-1} + d'_5 PCOF_{t-1} + d'_6 PC_{t-2} \\ + d'_7 PCOF_{t-2} + d'_8 AB_{t-1} + d'_9 AB_{t-2} + w_t$$

Where w_t is a residual term. β_4 and β_5 enter (xxiii) asymmetrically; so we could estimate them from estimates of the d'_i in (xxiv); ($i=4, 5, \dots, 9$). An estimate of β_4 may be obtained from the ratio of the coefficients of $PCOF_{t-2}$ to the coefficient of PC_{t-1} . An estimate of β_5 may be obtained from the ratio of the coefficients of PC_{t-2} to the coefficient of $PCOF_{t-1}$. On the other hand, estimates of β_4 and β_5 may be obtained by solving a quadratic in the coefficients of AB_{t-1} and AB_{t-2} in the following way. Let \hat{d}'_i denote least squares estimates of d'_i . Since

$$(xxv) \quad \hat{d}'_8 = 1 - \beta_4 + 1 - \beta_5$$

$$\text{and } (xxvi) \quad \hat{d}'_9 = - (1 - \beta_4) (1 - \beta_5)$$

$$= - \sqrt{1 - \beta_4 - \beta_5 + \beta_4 \beta_5}$$

$$\text{We have (xxvii) } 1 - \hat{\beta}_4 \text{ or } 1 - \hat{\beta}_5 = \frac{\hat{d}'_8 \pm \sqrt{\hat{d}'_8 + 4\hat{d}'_9}}{2}$$

where \hat{d}'_8 and \hat{d}'_9 are the least square estimates of d'_8 and d'_9 respectively; $\hat{\beta}_4$ and $\hat{\beta}_5$ are the computed coefficients of expectations of cotton and coffee prices respectively. If $\hat{\beta}_4$ is given by the root taken with the plus sign, then $\hat{\beta}_5$ will be given by the root taken with the minus sign and vice versa.

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COTTON ACREAGE IN BUGANDA, PRICE OF COTTON
AND PRICE OF COFFEE

t	AB	PC	PCOF	DU ¹
1945	428000	17	15	0
1946	409000	18	15	0
1947	298000	20	17	0
1948	477000	22	19	0
1949	526000	30	21	0
1950	508000	33	25	0
1951	416000	45	40	0
1952	342000	50	50	0
1953	398000	50	70	0
1954	432000	51	100	0
1955	374000	61	75	0
1956	346000	55	75	0
1957	348000	56	80	0
1958	384000	58	80	0
1959	325000	47	68	0
1960	250000	48	56	0
1961	278000	55	50	0
1962	459000	57	55	0
1963	278000	57	48	1
1964	281000	51	57	1
1965	293000	56	43	1
1966	223000	60	40	1

Source : See table 1

1. See table 1

TABLE 4

REGRESSION COEFFICIENTS FOR REGIONAL ACREAGE FUNCTIONS FOR UGANDA COTTON (BUGANDA)
1945 - 1966¹

Constant	Cotton Price Lagged 1 year	Cotton Price Lagged 2 yrs	Coffee Price Lagged 1 yr.	Coffee Price Lagged 2 yrs.	Acreage of Cotton Lagged 1 year	Acreage of Cotton Lagged 2 yrs.	DU	R ²	D-W ²
15.938632	.504492	.173093	-.305966	-.403634	.0982843	-.332345	-.358361	.6350	1.7862
(4.087206)	(.411706)	(.328088)	(.566786)	(.252469)	(.250529)	(.231616)	(.164256)		
3.899641*	1.225370*	.527582*	-.539826*	-1.598748*	.392307*	-1.434897*	-2.181718*		

1, 2 See footnote 1 and 2 on Table 2

* T - statistic

Tests for Serial Correlation

In our previous discussion, the question of serial correlation could not be resolved on theoretical grounds. We are now in a position to resolve it by applying the Durbin-Watson test.

Let the null hypothesis be that the disturbances are not correlated and the alternative hypothesis be that they are positively autocorrelated. The null hypothesis is rejected in favor of the alternative hypothesis when the Durbin-Watson statistic of the regression takes a sufficiently small value.

East and Northern Regions

For each of these regions, the sample size for the regressions consists of 21 observations, the twenty-second having been lost through a process of lagging variables. There were 3 coefficients to be estimated, including the constant. At the 95% level of confidence, we shall reject the null hypothesis in favor of the alternative hypothesis if $D-W < 1.13$. We shall accept the null hypothesis and reject the alternative hypothesis if $D-W > 1.54$. The test is inconclusive if

$$1.13 < D-W < 1.54.$$

In the case of the regressions for Eastern and Northern regions, the Durbin-Watson statistics of 2.3395 and 2.2371 make us accept the null hypothesis and reject the alternative hypothesis.

Western Uganda

In the case of Western Uganda, there are 4 sample statistics to be estimated and with 21 observations, we shall reject the same null hypothesis in favor of the alternative hypothesis if $D-W < 1.03$. We shall accept the null hypothesis and reject the alternative hypothesis if $D-W > 1.67$. The test will be inconclusive if $1.03 < D-W < 1.67$. In the regression for Western region the Durbin-Watson statistic of 1.9064 makes us accept the null hypothesis.

Buganda

In the case of Buganda, there are eight sample statistics to be estimated. With 20 observations, the lower and upper bounds of the 5% points of the Durbin-Watson statistic are .54 and 2.34 respectively.

The Durbin-Watson statistic for Buganda's regression of 1.7862 makes the test inconclusive.

Hypothesis Testing About Sample Statistics

We can now test the null hypothesis that the regression coefficients are not significantly greater than zero against the alternative hypothesis that they are significantly greater than zero. In the case of Eastern and Northern Uganda there are 21 observations and 3 statistics to estimate. This gives us 18 degrees of freedom.

At the .05 level of significance, therefore, we shall reject the null hypothesis in favor of the alternative hypothesis if the T-statistic of the estimate is less than 1.734. We shall accept the null hypothesis and reject the alternative hypothesis if the T-statistics are greater than 1.734.

In each of the two regions, the constant term is significant. The lagged price coefficient is not. The lagged acreage coefficients are very significant. We therefore accept the null hypothesis for the lagged price coefficients but reject it in favor of the alternative hypothesis for the constant term and the lagged acreage coefficients. At the 0.10 level of significance, however, the lagged price coefficient in Eastern region is significant. At this level of significance, we would reject the null hypothesis for all coefficients of the Eastern region estimate.

In the case of Western region at the .05 level of significance, with 17 degrees of freedom, we shall accept the null hypothesis and reject the alternative hypothesis if the T-statistic is less than 1.740. We shall reject it in favor of the alternative hypothesis if the T-statistic is greater than 1.740. Looking at the results in table 2 therefore, we accept the alternative hypothesis about the dummy variable (DU) and price coefficients. However, we reject it in favor of the alternative hypothesis about the constant term, and lagged acreage. At the .10 level of significance, however, we would reject the null hypothesis in favor of the alternative hypothesis about all coefficients except the dummy variable.

In the case of Buganda with only 12 degrees of freedom, we accept the null hypothesis and reject the alternative if the T-statistic is less than 1.782 (at .05 level of significance). We would reject it in favor of the alternative hypothesis if the

T-statistic is greater than 1.782. The corresponding T-value at the .10 level of significance is 1.356.

Looking at the results in table 4, only the constant term and the dummy variable (DU) are significant at the 0.05 level. But at the .10 level, the price of coffee lagged 2 years and acreage of cotton lagged 2 years are significant. We therefore reject the null hypothesis in favor of the alternative or vice versa at different levels of significance according to whether or not the coefficients are significant in the sense specified above.

The signs of the coefficients show that cotton acreage responds positively to changes in cotton producer prices. In addition, in the Buganda regression, cotton acreage responds negatively to changes in coffee producer prices. All these relationships bear out the prediction of theory. The standard errors of the regressions are not very high and R-squared is fairly high, the fit being best in Western region. The greater relative importance of the dummy variable in Buganda vis a vis Western region suggests that its significance in Buganda is not just due to the physical re-demarcation of the regional boundaries but also to the political upheaval in Buganda in the immediate post independence years. In each case, it exhibits the correct sign -- negative for Buganda, which lost the counties, and positive for Western region which gained the counties.

The Coefficients of Expectation, the Short Run and Long Run Elasticities

Short run elasticity of acreage with respect to cotton and coffee prices is straightforward. It is simply the coefficient of the price variable lagged one period. To know the long run own price or cross elasticity, we must determine d_1, d_2, d_3 in equation (xv); d_4 and d_5 in equation (xx). To do this, we must first compute $\beta_1, \beta_2, \beta_3, \beta_5$ respectively. As can be seen from equations (xv) and (xvii), for Eastern, Western and Northern regions,

$$(xxviii) \beta_i = \frac{\Lambda}{(1 - d'_i)}; i = 1, 2, 3.$$

Where d'_i are least square estimates of the d'_i in equation (xvii).

From equation (xxviii) and the regression results in table 2, we get the following values for β_i :

- Eastern Region (β_1) = 0.5154
- Western Region (β_2) = 0.4219
- Northern Region (β_3) = 0.2864

Buganda

Using the ratios of the price coefficients as specified in the previous discussion,

$$(xxix) \quad (i) \quad \beta_4 = d'_7/d'_4 = (-) \quad 0.8000$$

$$(ii) \quad \beta_5 = d'_6/d'_5 = (-) \quad 0.5656$$

From equations (xv) (xx) and the regression results in tables 2 and 4, we get the estimates of d_1 , d_2 , d_3 ; d_4 and d_5 (which are also estimates of long run elasticity) shown in column 2 of Table 5.

TABLE 5
SHORT RUN AND LONG RUN ELASTICITIES
OF ACREAGE

	Short Run Elasticity	Long Run Elasticity
Eastern Region	$d'_1 = 0.2288$	$d_1 = 0.4439$
Western Region	$d'_2 = 0.2623$	$d_2 = 0.6217$
Northern Region	$d'_3 = 0.0193$	$d_3 = 0.0684$
<u>Buganda</u>		
Own Price Elasticity	$d'_4 = 0.5045$	$d_4 = 0.6306$
Cross Elasticity	$d'_5 = -0.3060$	$d_5 = -0.5410$

It can be observed from the estimates of the own-price elasticity that in the short run there appears to be little price response. But in the long run, the response is very significant. This response is also different in different regions of the country, a factor that may be important for regional pricing policy. Northern Uganda shows the least sensitivity to price changes. In Buganda, the short run own-price elasticity is more important than in any other region. This fact seems to support my a priori contention that Buganda is the more economically developed region with more production opportunities than other regions. The short run cross elasticity is negative (as it should be) but less than the own price elasticity. This is also what it should be. Probably because of the longer gestation period of coffee (vis a vis cotton) adjustment of expectations about price is slower ($\beta_5 < \beta_4$ in equation (xxi)). The cross elasticity

increases in the long run from -0.3060 to -0.5410. Thus in the long run, the price of coffee has been important in Buganda in the marginal resource transfer away from cotton.

The Food Crop Factor as an Opportunity Cost in the Marginal Allocation of Land to Cotton Production

A question of special interest in the empirical analysis was the importance of food crop production in the process of allocating land to cotton production. One view associated with the backward sloping supply curve, though very much obsolete in the profession now, would predict that the higher the producer price of cotton, the lower would be the acreage under cotton and the higher would be the acreage of food crops.⁹ My contention is that this hypothesis rests on an analytical distinction between crops grown "principally" for food and crops grown "principally" for cash to meet the supposedly "fixed" cash requirement of African farmers.

To test these hypotheses, ideally we should have a price proxy for food crops grown in each region. But besides groundnuts and simsim, there is no comprehensive record of the price of plantains, cassava, etc. So, we cannot introduce directly the price of these food crops in the model as an opportunity cost of producing cotton. But there is a way around this data limitation.

We can define a new dependent variable that would show the allocation of land between cotton and food crops. This variable is the acreage of cotton divided by food crop acreage at the same time period. The explanatory variables would remain the same as in the previous models. By observing what happens to the quality of the fit and the significance of the sample statistics, we can make a number of qualitative and quantitative conclusions regarding the validity of the "food crop" -- "cash crop" and "backward rising supply curve" theories about African farmers. We can see how well and how negatively the price factor systematically allocates land between cotton production and food crop production.

9. See for example, Khatkhate, D.R. "Some Notes on the Real Effects of Foreign Surplus Disposal in Underdeveloped Economies" The Quarterly Journal of Economics, Vol. LXXVI May 1962.

5:11b Statistical Results

The relationship between variables is log linear as before. The acreage of food crops is the sum of the acreage for each region of the food crops discussed previously as the cropping alternatives of the cotton farmer in the four regions. In the case of Western region, however, because cotton grows only in Toro and Bunyoro districts, only the food acreage in those two districts was used to deflate cotton acreage. The definition of variables is as follows:

- AFE = acreage of food crops in Eastern Uganda
- AFW = acreage of food crops in Western Region
- AFN = acreage of food crops in Northern Uganda
- DU = a dummy variable given a zero or one value to represent the effect of the transfer of the cotton producing counties of Buyaga and Bugangaizi from Buganda to Bunyoro

- AFB = Acreage of food crops in Buganda.

The results show very interesting regional differences. The food crop factor is negligible at any reasonable level of statistical significance in Eastern region and Northern region. At the 95% level of confidence, only the constant term is significant in East and Northern Uganda. In Western Uganda, the lagged acreage coefficient is still significant but less significant than in the model whose results were shown in table 2. In the three regions, R-squared diminishes; from 0.6800 in the Eastern region to 0.0119; 0.8570 in Western region to 0.6609; and in the Northern region from 0.6812 to 0.1229. In the case of Buganda, however, the opposite happens. The price coefficient is significantly different from zero at the 0.10 level of significance while the lagged acreage coefficient is significantly different from zero even at 0.025 level of significance. The short run price elasticity of land allocation is 0.385926 while the long run elasticity is 0.615 and the price expectations coefficient is 0.6269. Compared with the original model, R-squared increases from 0.6350 to 0.6996. As a matter of fact, this model gives a much better fit to Buganda's data than the previous model.

These results show the importance of the food crop factor in Buganda vis a vis the other regions -- the lower the price of cotton, the higher will be the acreage allocated to food crops. This makes

TABLE 6
FOOD CROP ACREAGE IN UGANDA'S FOUR REGIONS
1945-1966

Year (t)	AFE	AFW	AFN	AFB	DU
1945	1676000	204000	779000	855000	0
1946	1587000	247000	837000	1066000	0
1947	1487000	240000	885000	955000	0
1948	1597000	233000	944000	1016000	0
1949	1636000	244000	1081000	1090000	0
1950	1666000	248000	1137000	981000	0
1951	1717000	258000	1139000	999000	0
1952	1593000	268000	1186000	1063000	0
1953	1932000	281000	1260000	1498000	0
1954	2207000	269000	1256000	1381000	0
1955	2048000	256000	1198000	1288000	0
1956	2061000	245000	1114000	1188000	0
1957	1957000	246000	1147000	1055000	0
1958	2171000	288000	1142000	1027000	0
1959	2379000	311000	1275000	1171000	0
1960	2040000	238000	1225000	1184000	0
1961	2294000	272000	1545000	1167000	0
1962	2353000	248000	1442000	1125000	0
1963	2306000	341000	1581000	1172000	1
1964	2688000	438000	1893000	1412000	1
1965	3041000	360000	1727000	1510000	1
1966	3106000	410000	1932000	1486000	1

Source: See Table 1.

TABLE 7
REGRESSION COEFFICIENTS FOR REGIONAL RELATIVE ACREAGE FUNCTIONS
FOR UGANDA COTTON AND FOOD CROPS, 1945-1966¹

Region	Constant	Price of Cotton Lagged 1 yr.	Acreage of Cotton Divided by Acreage of Food Crops and All Lagged 1 yr.	DU	R ²	D-W ²
Eastern	3.654282	-.0291785	.0701527			
	(.795924)	(.0756673)	(.209342)		.0119	2.1246
Western	4.591245*	-.385616*	.335111*			
	.364696	.128095	.702951	.022257	.6609	2.0301
	(.719631)	(.200072)	(.174446)	(.160815)		
North	.506782*	.640247*	4.029622*	.138402*		
	3.65681	-.194502	.152881		.1229	2.2229
	(1.063144)	(.163591)	(.192702)			
Buganda	3.439649*	-1.188949*	.793356*			
	.221025	.385926	.373092	.456806	.6996	1.6783
	(1.084949)	(.237877)	(.179274)	(.125288)		
	.203719*	1.622376*	2.081130*	-3.646043*		

^{1,2} See Footnotes 1,2 on Table 2.

* T - Statistic.

a lot of sense, though not in the sense of the backward rising supply curve theory. Besides being a much more economically developed region than the other three regions, it is also one of the most densely populated, with very little new land potentially cultivatable. Because of better transport facilities and a higher level of urbanization in Buganda, food crops are more sellable than in the rest of the country. These "food" crops are therefore "cash" crops. They should, therefore, be important in the marginal resource allocation to cotton production in the standard economic theory fashion. The results confirm that the higher the price of cotton the greater the acreage that will be devoted to cotton vis a vis food crops and vice versa, even in the short run. Thus the cash earning roles of "food crops" and so-called "cash crops" is interchangeable. Looking at AFB column in Table 6, it is clear that food production in Buganda has increased steadily over the time covered by the sample data. Yet Buganda is one of the most densely populated regions with very little virgin land potentially cultivatable. Given the fact that cotton is an annual crop (field crop) we should therefore expect the marginal rate of transformation between cotton and food crops to be high. On the other hand, although the food acreage of the other three regions has also been expanding, because of the relatively greater availability of land, the trade-off between cotton and food crops has not been so rigid. The regression results uphold this view.

Some Policy Implications

The analysis and results presented in this paper bear directly on a number of issues that policy makers in Uganda might address themselves to.

First, there is the implication of price responsiveness to cotton production policy. The price responsiveness indicates the potential for breaking bottlenecks in agriculture via the price mechanism. Moreover such price responsiveness also suggests that it is possible to shift the composition of agricultural output by changing the relative prices within agriculture. Thus, development plans which stipulate agricultural production targets for specific crops have also to consider the kind of changes in the respective producer prices that would be consistent with the required output increases. One of the objectives of the Lint Marketing policy has been to stimulate and encourage production. This has been so because cotton, unlike Uganda's other

major export, coffee, is less vulnerable to fluctuations in the world commodity market. In May 1972, the government of General Idi Amin Dada launched a "Double production" campaign for cotton; a policy target that has been reiterated in the Third Five Year Development Plan. A priori, there is nothing unrealistic about this target. What is odd, however, is the fact that such a high target for cotton output could be set without any mention whatsoever of the cotton producer price and related supply conditions. It is not surprising, therefore, that the "double production" campaign seems to be achieving "halved production" results.

With cotton production in Uganda fairly responsive to producer price, one way of implementing the "Double Production" policy embodied in the Third Five Year Plan is to pay cotton growers in the country not a uniform producer price, as is done presently, but prices based on transport and marketing cost differentials. In other words, farmers growing cotton in areas where transport and marketing costs are lower should receive a higher cotton producer price than those growing cotton in districts where these costs are relatively higher. In so doing while cotton cultivation in the latter areas would be discouraged, other agricultural crops which make sense economically would be grown in the place of cotton. However, this is merely looking at the problem from the point of view of cotton production. For the growing of any agricultural crop on an economically remunerative scale would not be worthwhile in areas which are remote and inaccessible. Thus discouraging the growing of cotton in high cost areas by cutting the cotton producer price would not, per se, lead to production of other crops on a commercial scale until and unless the problem of inaccessibility of the areas concerned is ameliorated. Unfortunately the trend in the second republic now has shown a continuing breakdown of the transportation system and consequent inaccessibility of more areas of the country that were recently accessible. This transportation problem has even so effectively made Kampala and other major towns so inaccessible to upcountry food producers that food prices in the cities have become ridiculously high.

It was found in the estimation results that supply elasticity in Uganda varies from region to region; highest in Buganda, next highest in Western, next highest in Eastern and lowest in the Northern region. This opens up the possibility of instituting regional price differentials in favor of Buganda, Western, Eastern and Northern

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regions in that order.¹⁰ This would increase short run output of cotton. In the long run this price differential should narrow until it disappears as the regional economic inequalities narrow. But if the government may want to keep down food prices in the industrial urban centers, then cotton producer price differentials would have to be weighted against Buganda.

Another present concern of policy makers is the rate of internal migration. In Uganda, there is evidence attesting not only to the existence of rural-urban migration but also to the existence of rural-rural migration across regional boundaries. Cultivators have been known for a long time to migrate from Eastern, Western, and Northern Uganda to Buganda, either to work on a muganda-owned small farm or to lease some land from a muganda landlord and grow crops. The crops they grow are not necessarily cotton or coffee. Often, these are annual food crops which are readily saleable. This rural-rural migration across regional boundaries into Buganda is a reflection of better agricultural opportunities resulting from a high demand for food crops. This high demand is a result not only of the relatively higher level of urbanization, but also of the existence in Buganda's rural areas of a non-land owning migrant agricultural worker. Thus better agricultural opportunities in Buganda encourage migration, but are at the same time a result of the migratory process.

To conclude, we may state that Uganda desperately needs foreign exchange and cotton exports are looked at traditionally as vital to this goal. Production is very much an economic phenomenon and to set production targets without production incentives at the farm level is to do the wrong job. It is even more wrong to use the "instrument" of expanding the Ministry of Agriculture bureaucracy to achieve "Double Production". Only a carefully planned consistent pricing and marketing policy measures in an economic environment of peace, certainty of life, rationality and stability can achieve stated production targets.

10. This policy statement does not take into account regional differentials in transportation costs.

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