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I. Introduction

The instability of export earnings in LDCs and its presumably harmful economic effects have been broadly discussed in the economic literature[1] and among policy makers in international meetings. In analyzing these effects, the destabilization of producer incomes and farmers' risk response play a prominent role. Producer incomes may be destabilized by either domestic factors on the supply side (yield instability due to weather, crop diseases, etc.), or by fluctuating producer prices reflecting the instability of international primary commodity markets. If unstable producer incomes induce risk aversion among farmers, the sectoral factor input will be reduced and will be suboptimal from a welfare point of view, thus possibly hampering economic growth.

The purpose of this paper is to quantify the effects of producer income instability on farmers' planting and long-run supply decisions in the coffee, tea, and sisal production of the Kenyan large farm sector. Coffee, tea, and sisal are the

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1 For a survey, see: D. Lim, "Export Instability and Economic Growth: A Return to Fundamentals", Oxford Bulletin of Economics and Statistics, Vol. 38 (1976), pp. 311-322; or: L. Stein, "Export Instability and Development, A Review of Some Recent Findings", Banca Nazionale del Lavoro, No. 122 (1977), p. 279 sqq.

leading Kenyan export crops, the domestic consumption of which is negligible. About half of the Kenyan coffee and tea, and all the sisal are grown in the large farm sector, and nearly always on plantations.[1] Coffee, tea, and sisal are permanent crops the planting of which requires long-run decisions. It is the long-run we shall focus on in this paper; hence the influence of income instability on short-term production planning will be neglected.

The analysis will be based on a time series approach covering the period 1951-1975. In the following section we shall develop the methodological framework of how to measure the risk response of farmers. Next the estimation equations will be specified, and the estimation techniques will be demonstrated. Subsequently, the regression results are presented and interpreted. Some tentative conclusions are drawn in the final section.

II. The Function of Planned Supply

We assume farmers to behave as if they maximized expected utility according to the Mean-Variance-Approach (MVA). In choosing a positive method of investigation it is only of secondary importance whether this behavioural concept is actually valid since almost all approaches which try to explain behaviour under uncertainty imply decision rules

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1 As opposed to the "mixed farms", plantations have been affected only to a minor degree by "Kenyanization" in the post-independence period. For a survey of Kenyan agricultural development see: J. Heyer/J.K. Maitha/ W.M. Senga (eds.), Agricultural Development in Kenya - An Economic Assessment, Nairobi, 1976.

similar to MVA.[1] As unforeseen events, such as changes of weather, crop diseases, etc., influence the outcome of farmers' decisions, it would be inappropriate to take output as a variable describing production decisions. Conventionally, this problem is circumvented by focussing on decisions on inputs, which are much more under the control of farmers. The amount of purchased inputs is directly related to planned supply, and hence can be used as a proxy. In the case of developing countries, our knowledge about product-specific factor inputs is frequently limited to acreage data.

Hazell and Scandizzo showed by linear programming techniques that under utility maximizing behaviour according to MVA the product-specific demand for agricultural land is a function of price and yield expectations, and risk (defined as variance of returns per acre).[2,3] Thus we have to make some assumptions

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1 There are several approaches dealing with rational human behaviour under uncertainty and risk. In all these approaches "profit maximization" is replaced by other assumptions. According to the concepts of "full optimality" or "bounded rationality" (see J.A. Roumasset, Rice and Risk, North Holland, 1976, p. 24, for a definition), one either assumes the maximization of a von Neumann-Morgenstern type utility function of income or the maximization of some objective function (i.e. expected or minimum income) subject to a "safety-first" constraint. As was shown by Pyle and Turnovsky (Safety-First and Expected Utility Maximization in Mean-Standard Deviation Portfolio Analysis, The Review of Economics and Statistics, Vol. 52 (1970), No. 1, p. 75 sqq.) and Levy and Markowitz (Approximating Expected Utility by a Function of Mean and Variance, American Economic Review, Vol. 69 (1979), p. 308 sqq.), the Mean-Variance Approach (representing a special case of expected utility maximization) can be regarded as a helpful approximization to both sorts of approaches.

2 P.B.R. Hazell and P.L. Scandizzo, "Competititve Demand Structures under Risk in Agricultural Linear Programming Models", American Journal of Agricultural Economics, Vol. 56 (1974), No.2, p. 235 sqq.

3 Input costs are assumed to be constant in our analysis.

about price and yield expectations of farmers and their corresponding risk feelings in order to specify an econometric model of planned supply. Regarding the time lags between input decisions (supply planning), actual supply, and demand which are inherent to agricultural production, it seems unlikely that farmers' expectations are rational in Muth's sense.[1] Rather we suppose them to have adaptive expectations.[2] Since coffee, tea, and sisal are permanent crops, plantings in year t are not only a function of price, yield expectations and subjective risk in t, but also of the age structure of the existing stock from previous years. Unfortunately, data to construct a vintage model are not available in the case of Kenya. In order to approach this problem in a different way, it is helpful to distinguish between the actually planted and the desired area in t. As outlined above, the latter is exclusively determined by the expected price, the expected yield and the subjective risk of farmers in year t. Yet, decisions from previous years prevent its complete realization. Therefore, only a part of the cultivated area is in fact disposable to the farmers and could be allocated according to the planned supply in t. Hence, changes of the total planted area can be described by a partial adjustment scheme.[3]

Given these assumptions, the following model of supply response emerges:

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1 See John F. Muth, "Rational Expectations and the Theory of Price Movements", Econometrica, Vol. 29 (1961), No. 3, p. 315 sqq.

2 See J. Johnston, Econometric Methods, Tokyo 1972, p. 300 sqq. For the same reason single equation methods are applicable to the estimation of the planned supply function without a simultaneous equations bias.

3 See, for example, Johnston (1972), p. 300.

$$(1) \qquad Y_t^d = \beta_0 + \beta_1 X_t^* + \beta_2 V(X)_t$$

$$(2) \qquad Y_t = Y_{t-1} + \gamma(Y_t^d - Y_{t-1}) + u_t \qquad 0 < \gamma \leq 1$$

$$(3) \qquad X_t^* = \sum_{k=0}^{\infty} a^k (1-a) X_{t-k-1} \qquad 0 < a < 1$$

$$(4) \qquad V(X)_t = \sum_{k=0}^{\infty} b^k (1-b) (X_{t-k-1} - X_{t-k-1}^*)^2 \qquad 0 < b < 1$$

with

Y_t^d = desired area

Y_t = planted area

X_t^* = expected return per acre

X_t = realized return per acre

$V(X)_t$ = subjective risk

u_t = stochastic disturbance term

t = time subscript

Equation (1) describes the desired area as a function of expected return per acre and subjective risk. Price and yield expectations are gathered in one term. This is unavoidable to achieve a consistent specification for both expectations and risk. Furthermore, a decomposition of subjective risk into its components, i.e. price and yield fluctuations, leads to a non-linear function,[1] the estimation of which poses serious problems. Equation (2) specifies the partial-adjustment scheme for the area planted. According to the concept of adaptive expectations, equation (3) describes expected return per acre as a weighted moving average of previous returns with geometrically declining weights. In equation (4), the same adaptive expectation approach was used with respect to risk.[2]

This system of equations describes supply decisions of a representative farmer. As was shown by Just, the homogeneity of the group of decision makers is essential to obtain an unbiased estimate of the risk parameter.[3] It is for this

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[1] Define p = price, q = yield per acre and

$p \cdot q = x$ = return per acre, then it is

$$V(x) = V(pq) = E(p^2q^2) - E(p)^2 E(q)^2$$
$$= E(p^2) E(q^2) - E(p)^2 E(q)^2 \quad \text{if } p, q \text{ independent}$$
$$= E(p^2) E(q^2) - E(p)^2 E(q^2) + E(p)^2 E(q^2) - E(p)^2 E(q)^2$$
$$= E(q^2) V(p) - E(p)^2 V(q)$$

[2] This specification corresponds to that of R.E. Just, Econometric Analysis of Production Decisions with Government Intervention: The Case of the Californian Field Crops, Giannini Foundation Monograph No. 33, Berkeley, June 1974. Because of the flexible weights, which are to be determined empirically, Just (1974) calls this term "subjective risk".

[3] See R.E. Just, "Risk Response Models and Their Use in Agricultural Policy Evaluation", American Journal of Agricultural Economics, Vol. 57 (Dec. 1975), p. 836 sqq.

purpose that we have chosen the relatively homogeneous group of large farms. Furthermore, our specification neglects the possibility of product diversification as a means of risk aversion. This can be justified, however, in the case of the Kenyan large farm sector which predominantly consists of plantations specializing in one product. Therefore, the potential of diversification is small, and planned supply of one product is assumed to be independent of the price, yield, and risk performance of other products.

III. Estimation Technique

Equations (1) to (4) result in the reduced form of the model

$$(5) \quad Y_t = \gamma\beta_0 + \gamma\beta_1 \sum_{k=0}^{\infty} a^k (1-a) X_{t-k-1} + \gamma\beta_2 \sum_{k=0}^{\infty} b^k (1-b) (X_{t-k-1} - \sum_{j=0}^{\infty} a^j (1-a) X_{t-k-j-2})^2 + (1-\gamma) Y_{t-1} + u_t$$

In equation (5), minimization of $\sum_t u_t^2$ leads to maximum likelihood estimates for the parameters γ, β_j $(j = 0,1,2)$, a and b. In order to solve this problem, the following procedure, introduced by Just, is adopted.[1] Parameters a and b are changed by small amounts in the interval (0,1). For every a and b , $X_t^*(a)$ and $V(X,b)_t$ are calculated according to equations (3) and (4), respectively. These

[1] R.E. Just, "Estimation of a Risk Response Model with Some Degree of Flexibility", Southern Economic Journal, Vol. 42 (1976), No. 4, p. 675 sqq.

hypothesized values are substituted for the non-linear expression in (5) and for every $X^*_t(a)$ and $V(X,b)_t$ an OLS-solution is determined. Those parameters γ, β_j ($j = 0,1,2$), a and b which lead to the global minimum of $\sum_t u_t^2$ finally represent the maximum likelihood solution of (5).

Problems for expected returns and subjective risk arise from short time series for X. Yet a solution is possible by using a priori information. (3) and (4) can be expressed as:[1]

$$(3') \qquad X^*_t = \sum_{k=0}^{t-2} a^k (1-a) X_{t-k-1} + a^{t-1} X^*_0$$

$$(4') \qquad V(X)_t = \sum_{k=0}^{t-2} b^k (1-b) (X_{t-k-1} - X^*_{t-k-1})^2 + b^{t-1} V(X)_0$$

It can be shown that the estimation procedure leads to asymptotically consistent parameters which are independent from any X^*_0 and $V(X)_0$, although a bias might exist in short time series.[2] Keeping this in mind we define X^*_0 and $V(X)_0$ as the arithmetic mean and variance of the three values of X immediately preceding the estimation period, and substitute equations (3') and (4') for (3) and (4).

Iterations for a and b in the (0,1) interval were done in steps of 0.1. After the corresponding 81 steps of iteration, a global maximum of the likelihood function was achieved only in the case of sisal. For coffee and tea we

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[1] For ease of exposition all summations with the lower limit of summation exceeding the upper limit are defined as zero.

[2] See Just (1976), p. 678.

obtained solutions at the limits of the iteration interval. Therefore, for these products a new iteration procedure was set up in the space determined by the first run with steps of 0.01. After a further 81 steps of iteration an unequivocal maximum of the likelihood function was obtained in each case.

IV. Results

For coffee, tea, and sisal, the following hypotheses are tested:

H1 : Planned supply is solely determined by expected return per acre.

H2 : Planned supply is determined by both expected return per acre and subjective risk.

H1 corresponds to the well-known Nerlove model,[1] i.e. equation (5) is estimated under the restriction $\beta_2 = 0$. This constraint is cancelled in H2, and the risk parameter is determined unrestrictedly. According to the above theoretical considerations, γ is expected to be smaller than 1, β_1 to be positive, β_2 to be negative, and H2 to be superior to H1. Parameters a and b are defined in (0,1). Values of a and b at the lower limit of the interval mean that farmers' expectations are based mainly upon recent experiences. If these values approach the upper limit of

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1 See M. Nerlove, Distributed Lags and Estimation of Long-Run Supply and Demand Elasticities: Theoretical Considerations, Journal of Farm Economics, Vol. 40 (1958), pp. 301-311; and M. Nerlove and W. Addison, Statistical Estimation of Long-Run Elasticities of Supply and Demand, Journal of Farm Economics, Vol. 40 (1958), pp. 861-880.

the interval, on the other hand, expectations are based to a large extent on experiences in the past.

Since, in the period 1964-1972, new coffee plantings were banned under the International Coffee Agreement, we additionally tested:

H3 : Planned coffee supply is held constant during the time of the planting restriction.

In order to test H3, the lagged endogeneous variable (Y_{t-1}) is multiplied with a dummy which takes 1 in the period 1964-1972, and 0 in the other years. If the ban on new plantings had been effective, the coefficients of the dummy and of the lagged endogeneous variable should add up to unity. This would imply that γ was 0 during the phase of restriction.

Data on acreage, output, and producer prices for 1951 to 1975 were taken from official sources.[1] Prices were deflated by the Kenyan consumer price index (1970 = 100).[2] Returns per acre were calculated, and estimation was carried out for the period 1955 to 1975.[3]

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1 Republic of Kenya, Annual Statistical Abstract, Nairobi, various issues.

2 International Monetary Fund, International Financial Statistics, Annual Supplement, Vol. 29, Washington, D.C., 1976.

3 Observations from 1951 to 1953 served as a priori information, the observations in 1954 were dropped due to the lagged endogenous variable.

Regression results for coffee are shown in Table 1.[1] β_1 in H1 and H2, and β_2 in H2 show the expected sign and are significant at least at the 10 per cent level, so that H2 cannot be rejected. In other words, subjective risk in fact reduces the planned supply of Kenyan coffee. Since the dummy variable shows the wrong sign and is insignificant we reject H3. Obviously, the Kenyan Government was not successful in enforcing the ban on new coffee plantings. As the parameter a nearly reaches the value of 1, return expectations per acre are formed over a long time horizon, whilst subjective risk is influenced by more recent events, as is indicated by the relatively low values of b.

Regression results for tea are presented in Table 2. They are subject to collinearity between expected returns and the lagged endogenous variable. Calculations excluding Y_{t-1} show, however, that the order of magnitude of the estimated cofficients is likely to be correct, while their standard deviation may be overestimated, and hence t-values tend to be too low. As in the case of coffee, the expected return per acre and subjective risk parameters show the expected signs and are statistically significant. Again H2 cannot be rejected, i.e. the planned supply of tea is influenced by risk aversion. The expectations about returns per acre are determined by a long period of observations, while subjective risk is based on more recent experiences.

In the case of sisal (see Table 3), the influence of risk on planned supply is confirmed again. In contrast to coffee and tea, the value of a in H2 is rather low

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1 The Durbin-Watson coefficients are biased due to the lagged endogenous variable, thus providing only a little information. The small sample design does not allow for the application of other tests (Durbin's h-test, for example), therefore the serial correlation of the error term remains unknown. This also holds for sisal and tea.

Table 1 - Coffee Acreage in the Large-Farm Sector of Kenya, 1955 - 1975

Hypothesis	Estimated Equation[a]	a	b	$\bar{R}^2$	SEE	F-value	D.W.
H1	$Y_t = 1.205 + \underset{(8.832)}{0.774}\, Y_{t-1} + \underset{(1.190)}{0.841\cdot 10^{-2}}\, X_t^*$	0.90	-	0.825	0.822	48.164	2.06
H2	$Y_t = 0.436\cdot 10^{-1} + \underset{(6.256)}{0.666}\, Y_{t-1} + \underset{(1.746)}{0.161\cdot 10^{-1}}\, X_t^* - \underset{(-1.713)}{0.132\cdot 10^{-4}}\, V(X)_t$	0.92	0.23	0.841	0.784	36.20	2.16
H3	$Y_t = 0.414 + \underset{(4.783)}{0.678}\, Y_{t-1} - \underset{(-0.155)}{0.287\cdot 10^{-2}}\, DY_{t-1} + \underset{(1.224)}{0.149\cdot 10^{-1}}\, X_t^* - \underset{(-1.667)}{0.132\cdot 10^{-4}}\, V(X)_t$	0.92	0.23	0.831	0.808	25.597	2.20

[a] t-values (two-tailed t-test) in brackets.

Source: Own calculations based on Republic of Kenya, Statistical Abstract, Nairobi (various issues).

Table 2 - Tea Acreage in the Large-Farm Sector of Kenya, 1955 - 1975

Hypothesis	Estimated Equation[a]	a	b	$\bar{R}^2$	SEE	F-value	D.W.
H1	$Y_t = -0.306 \cdot 10^2 + \underset{(1.702)}{0.415}\, Y_{t-1} + \underset{(2.236)}{0.673 \cdot 10^{-1}}\, X^*_t$	0.97	-	0.987	0.559	790.272	2.21
H2	$Y_t = -0.351 \cdot 10^2 + \underset{(1.308)}{0.311}\, Y_{t-1} + \underset{(2.677)}{0.779 \cdot 10^{-1}}\, X^*_t - \underset{(-1.770)}{0.264 \cdot 10^{-5}}\, V(X)_t$	0.97	0.09	0.989	0.529	590.323	2.07

[a] see Table 1

<u>Source</u>: See Table 1.

Table 3 - Sisal Acreage in the Large-Farm Sector of Kenya, 1955 - 1975

Hypothesis	Estimated Equation[a]	a	b	$\bar{R}^2$	SEE	F-value	D.W.
H1	$Y_t = 2.348 + \underset{(6.469)}{0.815\, Y_{t-1}} + \underset{(1.498)}{0.135\, X^*_t}$	0.9	-	0.694	7.815	23.688	2.07
H2	$Y_t = 0.212 \cdot 10^2 + \underset{(4.510)}{0.588\, Y_{t-1}} + \underset{(3.061)}{0.256\, X^*_t} - \underset{(-3.330)}{0.164 \cdot 10^{-2}\, V(X)_t}$	0.3	0.3	0.780	6.634	24.576	2.04

[a] see Table 1

Source: See Table 1.

indicating that sisal producers' expectations are governed by a relatively short time horizon. This, however, is not the only difference in the behaviour of coffee and tea producers on the one hand and sisal growers on the other. Table 4, which shows the short-run and long-run average elasticities[1] of planned supply with respect to changes in expected returns and subjective risks, reveals a drastic

Table 4 - Short and Long-Run Average Elasticities of Planned Supply, with Respect to Expected Returns and Risk[a]

Crop	Expected Returns		Risk	
	Long Run	Short Run	Long Run	Short Run
Coffee	1.048	0.084	-0.035	-0.027
Tea	3.723	0.112	-0.017	-0.015
Sisal	0.571	0.400	-0.13	-0.091

[a]Calculated from Regression equation H2 in Tables 1,2,3.

difference in the absolute magnitudes of the risk elasticities. While changes in subjective risk induce only very small reactions of planned supply in the case of coffee and tea, planting decisions of sisal growers are

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1 Long-run elasticities were obtained by dividing the respective regression coefficients by γ and multiplying with the quotient of average expected returns (or risk, respectively) and average area (see equation (5) for illustration). "Long-run" refers to global effects whilst "short-run" considers effects within one year. Short-run elasticities are calculated by multiplying long-run elasticities with expectation parameters (1-a), and (1-b), respectively. All elasticities are related to the desired area Y_t^d as a proxy for planned supply.

influenced by risk to a considerable degree. Furthermore, coffee and tea producers seem to respond to changed return expectations mainly in the long run; sisal growers, however, react mainly in the short run, as is indicated by the only slightly differing long-run and short-run average supply elasticities. This pattern of results is substantiated by our estimates about the maximum long-run and short-run point elasticities of planned supply with respect to expected returns and subjective risks (Table 5).

Table 5 - Maximum Long-Run and Short-Run Point Elasticities of Planned Supply, with Respect to Expected Returns and Risk[a,b]

Crop	Expected Returns		Risk	
	Long Run	Short Run	Long Run	Short Run
Coffee	1.16 (1956)	0.093 (1956)	-0.141 (1956)	-0.109 (1956)
Tea	6.23 (1955)	0.187 (1955)	-0.088 (1955)	-0.080 (1955)
Sisal	2.19 (1975)	1.53 (1975)	-2.041 (1975)	-1.434 (1975)

[a]Values in brackets denote the year for which the maximum point elasticities were measured.

[b]Calculated from Regression equation H2 in Tables 1,2,3.

V. Conclusions

To sum up, risk aversion cannot be rejected in any of the observed cases. This implies, even in an otherwise perfect world, an inefficient factor allocation and a suboptimal output in case of income instability. However, risk aversion has a major impact only in sisal production. Sisal growers are more sensitive to changed expectations of return in the short run; their expectations are based on more recent experiences, and they are more risk averse than tea and coffee producers.

The size of the various parameters may also reflect the different conditions under which coffee and tea producers on the one hand and sisal growers on the other hand have to make their decisions. First, coffee producers may have been protected from excessive price fluctuations by the International Coffee Agreement since 1962.[1] This is likely to have diminished farmers' income fluctuations and, subsequently, their risk aversion. Secondly, some tea plantations are owned by two big international tea companies, the planned supply of which is presumably less influenced by Kenyan return risk. This may have a mitigating effect on the degree of risk aversion of the average producer. Thirdly, the life-span for African sisal trees is considerably shorter than for coffee and tea trees. For this reason planting decisions for coffee and tea require a much wider time horizon and are determined by longer-term experience than planting decisions for sisal. Fourthly, as compared to coffee and tea, sisal export prices and revenues were extremely unstable during the 1955/75 period (see Table 6) as measured by simple indices of instability calculated as

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[1] With soaring prices due to frost damages in Brazil the ICA was suspended in 1973.

average annual percentage deviations from a three year moving average. Thereby heavy fluctuations have increased the probability of losses and correspondingly the magnitude of risk aversion.

Table 6 - Average Percentage Annual Instability[a] of Export Prices, Export Returns, and Output per Acre for Coffee, Tea, and Sisal in 1955 to 1975

	Coffee	Tea	Sisal
Output per acre	11.5	12.6	5.6
Export price	5.5	2.4	10.9
Export revenue per acre	9.7	8.5	15.8

[a] average percentage deviations from a three year moving average.

Source: Own calculations based on official data in: Republic of Kenya, Annual Statistical Abstracts, various issues.

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