PRICE RESPONSIVENESS OF TROPICAL AGRICULTURAL EXPORTS: A CASE STUDY OF JAMAICA, 1954–72

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ECONOMISTS and policymakers have long been interested in the relationship between price changes and the supply response of primary products. The need to develop policies and incentives designed to stabilize the earnings of agricultural exports from developing countries is becoming more urgent in view of the chronic balance of payments deficits of most developing countries, the continued deterioration of their commodity terms of trade, the revived interests and debates in restructuring international trade and payments, and the call for a new international economic order.

This paper is an attempt to add to the stock of empirical knowledge concerning the supply response of tropical agricultural exports for Jamaica: a small, open, developing economy, heavily dependent on foreign trade. A study of the supply response of farmers to price changes is not only an empirical matter worthy of independent investigation but a matter of considerable concern, since in Jamaica, as in most developing countries, agriculture accounts for a substantial and significant portion of employment and foreign exchange earnings. The commodities to be analyzed in this paper are of relevance to a number of agricultural exporting countries, and cover the period 1954–72, a sufficiently long enough period for certain tentative conclusions to be drawn.

In the literature, there are essentially three hypotheses dealing with farmers' response to price changes.[1] The first hypothesis states that farmers in developing countries respond positively and significantly to relative price changes. As noted by Professor T. W. Schultz, "The doctrine that farmers in poor countries either are indifferent or respond perversely to changes in prices. . . is patently false and harmful. Price policies based on it always impair the efficiency of agriculture" [6, p. 49]. In discussing the supply response of farmers to price changes, there is a need to distinguish between short-run and long-run elasticities, given the

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[1] See Behrman [1] for a useful survey.

nature of agricultural production (i.e., perennials and cash crops). In this study, we could achieve this by adopting a dynamic stock adjustment supply model. The second hypothesis, according to Krishna [5], Behrman [1], and others, states that the "marketed surplus" of subsistence farmers is inversely related to relative price changes because, according to this hypothesis, as price changes, the farmer's income effect of demand for his own commodity which he produces outweighs the price effects associated with production and consumption. Finally, the third hypothesis states that changes in supply are invariant to relative price changes because of structural, institutional, historical, political, or sociological factors.

The construction of the paper is as follows: Section I provides some background information on the role of agriculture in the Jamaican economy. In Section II, we develop a model of supply response. Problems of estimation are discussed in Section III. Finally, Section IV presents the empirical estimates of the model for sugar, bananas, coffee, and cocoa.

I. AGRICULTURE AND THE JAMAICAN ECONOMY

A brief analysis of the performance of the agricultural sector is offered as an illustration of the pattern of development process which characterizes a number of, if not most, developing countries, in particular, Caribbean economies. Between 1954 and 1972, gross domestic product measured at 1965 prices grew from J$296.9 million in 1954 to J$902.4 million in 1972; in other words, GDP grew at annual rate of 5.7 per cent. Table I provides information relating to the importance of agriculture in the Jamaican economy.

The statistics reveal that real agricultural output grew at a modest rate of 2.5 per cent per annum, while for the same period growth in population averaged 1.8 per cent per annum. Between 1954 and 1972, there was a marked transformation in the structure of the economy, from a traditional agricultural economy to a more complex one, with mining (exports of bauxite-alumina), manufacturing (as a result of import substitution policies), and miscellaneous services (exports of tourism) providing the dynamic for structural change.

In terms of employment, agriculture has always been the most important sector in the Jamaican economy. Thus, according to official statistics published by the Department of Statistics, *Labour Force Survey,* in 1958, 1968, and 1972 agriculture accounted for 34 per cent, 39 per cent, and 31 per cent of the employed labor force, respectively. Throughout the period under review, as noted in Table I, the share of agricultural output was declining. This decline is largely associated with the declining importance of export agriculture (sugar, bananas, coffee, cocoa, and citrus). Export agriculture which accounted for 40 per cent of total agricultural output grew at the disappointing rate of 1.1 per cent per annum, compared with an overall growth of 2.5 per cent for all agricultural output.

One of the primary factors responsible for the decline in agricultural output and agricultural exports is the significant reduction in farms by land use. According to the 1968 *Census of Agriculture,* the total acreage in farms by land use declined from 1.9 million acres in 1954 to 1.5 million acres in 1968, a decline

TABLE I

GDP AND AGRICULTURAL OUTPUT AT 1965 PRICES FOR SELECTED YEARS

(J$ million)

	1954	1957	1962	1968	1972	Annual Average Rate of Growth 1954–72 (%)
Agriculture, forestry & fishery	51.4 (17.3)	53.6 (12.9)	61.3 (12.4)	69.3 (10.4)	82.9 (9.2)	2.5
GDP at factor cost	296.9	414.2	494.7	664.8	902.4	5.7

Source: Adapted from Gafar [4, Tables 1.1 and 1.2].
Note: Figures in parentheses represent percentage distribution of GDP.

TABLE II

TRENDS IN EXPORTS FOR SELECTED YEARS

(J$ million)

SITC Sec.	Classification	1954	1957	1962	1968	1972
0, 1, 4	Agricultural commodities	45.5 (74.2)	52.4 (52.0)	52.6 (40.5)	67.4 (36.8)	71.4 (24.4)
2	Crude materials	12.4 (20.2)	43.8 (43.5)	62.1 (47.8)	90.0 (49.2)	190.8 (65.1)
3, 5–9	Others	3.4 (5.6)	4.6 (4.5)	15.1 (11.7)	25.6 (14.0)	30.8 (10.5)
	Total	61.3 (100)	100.8 (100)	129.8 (100)	183.0 (100)	293.1 (100)

Source: Adapted from Jamaica, Department of Statistics, *External Trade of Jamaica.*
Notes: 1. Figures in parentheses represent percentage distribution of exports.
2. Crude materials consist mainly of exports of bauxite-alumina.
3. Others include mainly manufactured goods.

of approximately 22 per cent. Cultivated acreage declined by 27.3 per cent between 1954 and 1968 which reflects a shift in emphasis and resources away from agriculture.

Shown in Table II is the growth of agricultural exports and its importance measured as a share of total commodity exports for selected years. The statistics provide an impressive picture of the substantial increase and growth of total commodity exports for 1954–72, due mainly to the phenomenal increase in the value of bauxite-alumina exports. Agricultural exports, like real agricultural output, grew modestly during 1954–72. The percentage contribution of agricultural exports declined considerably from 74.2 per cent in 1954 to 24.4 per cent in 1972. A look at the percentage distribution of exports for the period reveals a marked transformation in the structure of commodity exports (similar to the changes in structure and composition of GDP). Since the economy is export-propelled, changes in the commodity composition of exports will affect the structure and composition of GDP.

II. THE MODEL

The model which follows is developed and discussed in Gafar [4]. We assume that the level of output produced by the farmer can be expressed as:

$$Q_t = F(K_t, L_t), \tag{1}$$

where

Q = level of output measured in physical units,
K = flow of capital services assumed to be proportional to the number of acres cultivated,
L = number of man-hours spent in cultivating and harvesting, and
t = time.

The function $F(K, L)$ is assumed to be nonnegative, single-valued, and twice differentiable. For simplicity we assume that the price of output and the prices of the factors of production are given. We assume that farmers behave rationally and seek to maximize profits. The necessary conditions for profit maximization require that:

$$p(\partial Q/\partial L) = w, \tag{2}$$

$$p(\partial Q/\partial K) = r, \tag{3}$$

$$Q = F(K, L), \tag{4}$$

where w, r, and p denote the wage rate, rental rate on capital, and the price of the commodity paid to farmers, respectively. Using equations (2)–(4), we can solve for the input demand functions in terms of the parameters, w, r, and p, respectively. The solutions are:

$$K = K(w, r, p); \tag{5}$$

$$L = L(w, r, p). \tag{6}$$

Straightforward manipulation of equations (4)–(6) yield

$$Q = Q(w, r, p). \tag{7}$$

By aggregating over all farmers would in principle yield the industry output function in terms of the parameters, w, r, and p, respectively.

Before proceeding further, a few remarks regarding equation (7) are necessary. Data on the variable r cannot be measured directly; and there is no consistent and up-to-date series on wage rates for the period. Besides, the price paid to farmers takes into account the cost of producing the commodity. For example, in order to arrive at the "negotiated" export price of sugar, the costs of growing cane and producing sugar are taken into consideration. Given these factors, it could be argued a priori that the price paid to farmers and the variables w and r would be highly correlated; and, if this assumption is correct, as indeed it is quite possible in the circumstances, we would be faced with the problem of multicollinearity. Largely for this reason, as well as the lack of appropriate data,

the model is reformulated in terms of distributed lags.[2] The model is cast within a stock adjustment framework. Given the price of the commodity, we assume that farmers would supply an amount, denoted by Q^*, which depends on p, according to the long-run supply equation:

$$Q^*_t = a + bp_t . \tag{8}$$

It is reasonable to postulate that farmers do not immediately move to Q^*, as p changes, but they respond by the following process:

$$Q_t - Q_{t-1} = k(Q^*_t - Q_{t-1}) , \tag{9}$$

where k is the speed of adjustment of supply, and $0<k<1$. Substituting equation (9) in equation (8) we get

$$Q_t = ka + kbp_{t-1} + (1-k)Q_{t-1} \tag{10}$$

Lag equation (10) and obtain an expression for Q_{t-1}; then lag Q_{t-2}, etc. After repeating the process, the solution for Q_t reduces to:

$$Q_t = a + kb \sum_{i=1}^{n} (1-k)^i p_{t-1} . \tag{11}$$

Given this formulation of the model, the short-run price effect on supply is given by kb, while the long-run effect is b. The mean lag of adjustment is $(1-k)/k$.

The model embedded in equations (5), (10), and (11) can be arrived at in another way depending on the assumption which we make regarding expectations. For example, suppose that the supply function is given by

$$Q_t = a + bp^*_t , \tag{12}$$

where p^* is the expected long-run price. Suppose that the formation of p^* is described by the following process:

$$p^*_t - p^*_{t-1} = k(p_t - p^*_{t-1}) . \tag{13}$$

Equation (13) postulates that the adjustment in price expectations is based on current and past expectations. The value k in this context is the speed of adjustment of past expectations. The solution for p^*_t is:

$$p^*_t = kb \sum_{i=1}^{n} (1-k)^i p_{t-1} . \tag{14}$$

Substitute equation (14) in equation (12) and we get equation (11). It follows that the final solution for Q_t is the same for both formulations. However, the stock adjustment formulation is preferred to the adaptive expectations hypothesis because in the case of coffee and other export crops, adjustments in production are likely to take considerable time. Moreover, since the price of the major agricultural exports (for example, sugar) are negotiated, price expectations are not likely to be determined by the process implicit in equations (13)–(14).

[2] For a similar formulation see F. M. Fisher et al. [3] and Williams [7].

III. PROBLEMS OF STATISTICAL ESTIMATION

Economic theory tells us that besides its own price (or input factor prices) the supply of an agricultural commodity depends on other factors (e.g., technological change, rainfall, natural disasters, uncertainties, etc.) which may not be subject to precise quantification. Exclusion of these factors from equation (10) is unrealistic. To account for these omitted factors, rewrite equation (10) as:

$$Q_t = ka + kbp_{t-1} + (1-k)Q_{t-1} + u_t , \tag{15}$$

where u_t represents the error term. Since equation (15) includes a lagged dependent variable, and since autocorrelation is quite possible, direct application of ordinary least squares to equation (15) will lead to inconsistent and inefficient parameter estimates. Again, since it is not possible to treat satisfactorily a general model of autocorrelation, we shall postulate that u_t is assumed to follow a first order auto-regressive process, that is,

$$u_t = \lambda u_{t-1} + e_t , \tag{16}$$

and

$$\lambda < |1| ,$$
$$E(e) = 0 ; \; Cov(e) = \sigma^2 I .$$

All the estimated equations in this paper have been estimated by the method of auto-regressive least squares using a search technique. The final estimates of λ were obtained by searching over alternating values of λ ranging from -1 to $+1$ by steps of 0.01, and choosing those results for which the sum of squares minimized is the least. Dhrymes [2] has shown that this technique is a consistent estimator, and if e_t is normally distributed, it is also a maximum likelihood estimator.

IV. THE EMPIRICAL ESTIMATES

A. *The Supply Response of Sugar Exports*

Production of sugar is the oldest organized export industry in Jamaica. Sugar is by far the single largest employer of labor in the economy, accounting for approximately 8.4 per cent of the total employed labor force in 1972. Apart from its vital importance to the economy in terms of employment, sugar has been one of the principal earners of foreign exchange. In recent years, its leading position as the primary source of foreign exchange earnings has been overtaken by exports of bauxite-alumina and tourism, respectively. The percentage share of sugar exports to total exports declined appreciably from 36 per cent in 1954 to 9 per cent in 1972, averaging 22 per cent for 1954–72.

Denoting the quantity of sugar exported (1,000 tons) by S_t at time t; and the price index of sugar exports (P_s) divided by an index of the world price pre-

vailing in the London market (P_w), by $P=100$ in 1965; the estimated supply regression equation for the period 1954–72 is:

$$S_t = \underset{(1.58)}{105.09} + \underset{(2.36)}{1.97}p_{t-1} + \underset{(2.68)}{0.64}S_{t-1} + \underset{(0.12)}{0.10}t .$$

$$\bar{R}^2=0.55, \quad DW=1.62, \quad \lambda=0.19,$$

$$SE=41.74, \quad k=0.36,$$

Mean lag = 1.78 years.

In this, as in all later equations, the figures in parentheses below the estimates of the coefficients are the estimated Student's t statistic. The goodness of fit of the regression equation is measured by the adjusted coefficient of determination. The Durbin-Watson statistic, denoted by DW, has been used to test for both serial correlation and model specification. The figure denoted by SE is the estimated standard error of the regression equation.

An attempt was made in the initial phases of this study to include the price of banana exports to indicate the degree of substitution between sugarcane cultivation and banana production in the supply equation, but the results were poor. The estimated coefficients of lagged price and lagged output are positive and statistically significant at the 5 per cent level. The use of the trend variable to capture the influence of other omitted factors was found to be insignificant at the 5 per cent level. The speed of adjustment, k, is 0.36 and significant, which indicates that a little more than a third of the difference between desired production and actual production is closed each year.

A repeated point in this paper, and which is borne out by the results, is that speeds of adjustment for agricultural exports are indeed low. The average lag is around 1.8 years, which means that it takes nearly two "sugar-crops" for farmers to adjust to prevailing market conditions. A plausible explanation for this slow adjustment may well lie in the life cycle of a cane ratoon, which is usually between 2.5–3 years.

The short-run estimated price elasticity computed at the point of sample means is 0.40, but the long-run price elasticity is 1.11; a result which suggests that farmers are insensitive to price changes in the short run, but, nevertheless, are price sensitive in the long run.

B. *The Supply Response of Exports of Bananas*

During our period of investigation, export of bananas was the second largest agricultural exports. Measured as a share of total commodity exports, the percentage share of banana exports to total exports declined considerably from 17.1 per cent in 1950 to 3.8 per cent in 1972; averaging around 9 per cent of total commodity exports during 1954–72.

Banana cultivation is concentrated on farms less than 5 acres, with the average farm size for approximately 96 per cent of the peasant farmers being 1.52 acres; an average size which may well be considered too small to benefit from economies of scale. Farms in the group under 5 acres consist mainly of mixed cropping

(yams, coffee, bananas, citrus, and other cash crops for subsistence) with coffee being the principal export substitute for bananas.

The supply response of banana exports for 1954–72 is:

$$B_t = \underset{(0.47)}{18.71} + \underset{(2.01)}{0.21}P_{t-1} + \underset{(3.78)}{0.72}B_{t-1}.$$

$$\bar{R}^2 = 0.71, \quad DW = 2.03, \quad \lambda = 0.40,$$

$$SE = 12.97, \quad k = 0.28,$$

Average lag = 2.57 years.

B = quantity of banana exports (1,000 tons).
P = $P_b/P_{xc} = 100$ in 1965.
P_b = price index of banana exports, 1965 = 1.
P_{xc} = price index of coffee exports, 1965 = 1.

The results are quite satisfactory. Both the price variable and the lagged dependent variable are positive and statistically nonzero at the 5 per cent level. The speed of adjustment is 0.28 which suggests that farmers do not respond immediately to price changes. A plausible reason why it takes the farmer nearly 2.5 years to react positively to relative price changes is that even though banana may be described as a "cash crop," once the farmer plants a banana sucker he can get with proper farming techniques as much as three crops from the offshoots of the original planting.

The short-run price elasticity of supply evaluated at the point of sample means is 0.16, while the long-run price elasticity is 0.57. Emphasis on small-scale peasant farming, and the need for the farmer to produce a minimum quantity of bananas for his own consumption (since green bananas constitute an important element of the peasant's diet), may be factors responsible for the low long-run supply price elasticity.

C. *The Supply Response of Coffee Exports*

Exports of coffee valued approximately 1 per cent of total commodity exports for 1954–72. The preferred regression equation is:

$$XC_t = \underset{(0.078)}{0.227} + \underset{(4.12)}{8.50}P_{t-1} + \underset{(1.20)}{0.20}XC_{t-1} - \underset{(-3.36)}{0.38}t.$$

$$\bar{R}^2 = 0.83, \quad DW = 2.00, \quad \lambda = 0.10,$$

$$SE = 1.91, \quad k = 0.80,$$

Average lag = 0.25 years.

XC = exports of coffee (1,000 lbs.).
P = $P_{xc}/P_c = 1$ in 1965.
P_{xc} = export price index of coffee, 1965 = 100.
P_c = general price level, 1965 = 100.

The estimated price coefficient is positive and statistically significant at the 5 per cent level. The coefficient of the lagged dependent variable is positive but

not significant at the 5 per cent level. This means that the speed of adjustment, the average lag, and the long-run price elasticity would not be significant at the conventional 5 per cent level.

The short-run supply price elasticity evaluated at the point of sample means is 0.92, while the long-run price elasticity is 1.15. For the period 1953–68, Williams [8] found that the short-run supply price elasticity at the point of sample means was 0.82, a result which is indeed very close to our own estimate. The mean lag is 0.25 years, which is surprising in view of the fact that it takes about five years for coffee trees to mature.

D. *The Supply Response of Cocoa Exports*

During the period 1954–72, exports of cocoa valued approximately 0.5 per cent of total commodity exports. The supply response of cocoa exports is given by the following regression equation:

$$CA_t = \underset{(-1.38)}{-4.66} + \underset{(1.53)}{2.34}P_{t-1} + \underset{(2.62)}{0.84}CA_{t-1} + \underset{(1.93)}{0.25}t\,.$$

$$\bar{R}^2 = 0.79\,, \quad DW = 2.60\,, \quad \lambda = 0.38\,,$$

$$SE = 2.12\,, \quad k = 0.16\,,$$

Average lag = 5 years.

CA = exports of cocoa (1,000 lbs.).
P = $P_{ca}/P_c = 1$ in 1965.
P_{ca} = export price index of cocoa, 1965 = 100.

The estimated price coefficient is positive but only statistically significant at the 10 per cent level, while the lagged dependent variable is positive and significant at the 5 per cent level. The trend factor is important at the 10 per cent level.

The short-run price elasticity computed at the point of sample means was found to be 0.41, while the long-run price elasticity is 2.56. The speed of adjustment was found to be 0.16, which is quite plausible, in view of the fact that cocoa—a perennial—takes around four to five years for cocoa trees to produce.

CONCLUSION

In this paper, we showed that the growth in real agricultural output and nominal agricultural exports grew sluggishly throughout the period 1954–72. In fact, like a number of developing countries, the percentage share of agricultural exports declined substantially and significantly during the period under review. The econometric results dealing with the supply response of various commodities are indeed promising, and must be viewed with satisfaction. The principal findings of this study are that supply of agricultural exports responds positively and significantly to price changes; and that lagged output is also an important factor influencing the supply response of farmers. The short-run supply price elasticities were generally low, as might be expected in case of perennials, since it takes time for the farmer to adjust to instantaneous price changes. The long-run supply

price elasticities were, in nearly all cases greater than 1, which suggests that in the long run remunerative prices can be relied upon as one of the policy instruments to stimulate agricultural output, and deal with the problem of resource allocation and output mix in the economy. Given that supply is invariantly price inelastic in the short run, the empirical results suggest that, in addition to price policies, the policymaker may have to use other stabilization policies (e.g., guaranteed purchases, credit facilities, etc.) to stimulate growth of agricultural exports in the short run.

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APPENDIX

THE DATA

The data used in this study are taken from various publications of the Department of Statistics, Jamaica, and referred to in the body of the paper. Data on GDP were obtained from the *National Income and Product Accounts* published by the Department of Statistics. Data on the London price of sugar were obtained from various publications of the International Sugar Council. The export price indices used in this study are unit value indices computed by the author from publications of the annual *External Trade,* Department of Statistics, Jamaica. These series are available upon request.