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RATIONAL EXPECTATIONS AND OUTPUT SUPPLY: EVIDENCE FROM THE SUGAR CANE AND COFFEE INDUSTRIES IN JAMAICA

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Economists have long agreed that farmers in Less Developed Countries (LDC's) are responsive to price incentives. This consensus has developed out of the growing evidence of the last twenty-five years, ably summarized in the seminal work of Askari and Cummings, as well as Schultz and Krishna. These results reveal that farmers respond to the expected price they will receive, where the expected price is formulated as an adaptively formed function of past prices received. The expected price variable is used since the prevailing price of the crop at planting time may not be the same as the price received at harvest. Given that price expectations play an important role in determining the price responsiveness of farmers, whether farmers'expectations are adaptive is an important question that has not been addressed by past researchers, with the exception of Shonkwiler and Emerson. Finally from the point of view of marketing board policy, it is important to determine if farmers in fact do respond to prices and the way farmers form their price expectations before setting farmgate prices and establishing board objectives in such areas as gross marketing margins and foreign exchange target earnings. These latter goals are decidedly influenced by the output response of farmers to prices.

In this paper, we directly test whether Jamaican farmers respond to the expected price received and whether price expectations are formed rationally. The rational expectations hypothesis (REH) assumes that farmers use all information available to them when making forecasts about the expected price received (Muth). The Jamaican agricultural subsectors of sugar cane and coffee provide a unique opportunity for testing the REH, since prices are determined by a set of marketing boards for each of these crops and the information used in making these pricing decisions, such as world prices and exchange rates, is published and distributed to farmers at annual meetings.

The REH theoretical model and methodology is presented in the next section. A full information maximum likelihood technique is utilized as the REH implies highly non-linear restrictions across the derived set of equations (Sargent). The statistical results are presented and discussed in the third section of the paper. The final section presents the conclusions and implications of our study. We conclude that farmers formulate expectations rationally and they respond to the expected price. These findings create important implications for marketing board policies in a small, open economy like Jamaica.

II. Analytical Framework

Consider the general form of the output supply function found in the literature (Askari and Cummings):

(1) $Q_t = a_0 + a_1 P_t^e + a_2 Q_{t-1} + u_t$

where Q is the quantity supplied; P_t^e is the expected farmgate price; u is a normally distributed random variable with zero mean and constant variance.

P_t^e is unobserved, but its expectation, if formed rationally, by farmers based on an information set Ω can be expressed as:

(2) $P_t^e = E(P_t | \Omega_{t-1})$

P_t, the observed farmgate price can then be decomposed into an expectational component (P_t^e) and an error component (v_t)

(3) $P_t = P_t^e + v_t$

where $E(P_t^e v_t) = 0$ $\qquad$ $E(u_t u_{t-i}) = \sigma_u^2$ for i=0, 0 for i≠0

$E(v_t v_{t-i}) = \sigma_v^2$ for i=0, 0 for i≠0 $\qquad$ $E(v_t u_{t-i}) = \sigma_{vu}$ for i=0, 0 for i≠0

Eqs. (1) and (3) represent the structural model describing output supplied by farmers. These equations cannot be estimated directly due to the unobservability of P_t^e and lack of knowledge of the variables that make up Ω. This can be overcome by specification of a subset of Ω so that P_t^e can be stated as an expression of exogenous and lagged endogenous variables. The expression for P_t^e can then be substituted into eqs. (1) and (3) and a set of estimable reduced form equations derived. The variables

incorporated into the informational subset of Ω are drawn from the pricing data utilized in setting farmgate prices that marketing board officials have published in interviews, newspaper articles and annual reports. This information is readily available to all farmers.

For example, in the coffee sector, the Coffee Industry Board (CIB) announces a price at the beginning of the crop season with the final price the farmer receives, i.e. the announced price plus a "bonus" payment determined by the board at the end of the season. The bonus payment can vary from zero to any amount the board wishes to pay and therefore the farmer does not know the final price to be paid. We can specify this price setting behavior in the coffee sector in the following manner:

(4) $DP_t^e = b_0 + b_1 EWP_t + b_2 EER_t + b_3 ELM_t$

Substituting eq. (4) into eqs. (1) and (3) gives the following set of equations:

(5) $Q_t = a_0 + a_1 b_0 + a_1 b_1 EWP_t + a_1 b_2 EER_t + a_1 b_3 EELM_t + a_2 Q_{t-1} + u_t$

(6) $DP_t = b_0 + b_1 EWP_t + b_2 EER_t + b_3 ELM_t + v_t$

where Q is the quantity of coffee in boxes (10 lbs. of coffee per box) delivered by farmers to the Board; DP is the difference between the announced price and the final price received by farmers; WP is the nominal F.O.B. price of coffee received by the Board; LM is the percentage share of coffee sold by the Board to domestic coffee brewers; ER is the exchange rate ($J/$US) deflated by the GDP deflator; and E is the conditional expectation operator.

Economic theory suggests that a_1, b_1, b_2, b_3 should all be positive.

For sugar cane, specification of the information subset yields:

(7) $P_t^e = b_0 + b_1 EWP_t + b_2 EER_t + b_3 ECSR_t$

where WP is the nominal F.O.B. price of sugar received by the board; ER is the exchange rate ($J/$US) deflated by the GDP deflator; CSR is the cane sugar ratio which defines how much cane is required to make a ton of sugar; E is the expected value operator. Again economic theory suggests that the signs of a_1, b_1, b_2 are positive. The sign of b_3 is negative because the more sugar cane that is required to produce one ton of sugar, the less the value and price of the crop.

Substituting eq. (7) into eqs. (1) - (3) yields:

(8) $Q_t = a_0 + a_1 b_0 + a_1 b_1 EWP_t + a_1 b_2 EER_t + a_1 b_3 ECSR_t + a_2 Q_{t-1} + u_t$

where Q is the quantity of sugar cane in tons.

(9) $P_t = b_0 + b_1 EWP_t + b_2 EER_t + b_3 ECSR_t + v_t$

Eqs. (5) - (6) and (8) - (9) represent the reduced form equations, with the REH imposed, of the "structural" model for output supply in the coffee and sugar cane sectors. This is termed the restricted model as the coefficients of the output equation are in the price equation.[1/]

The output and price reduced form equations without the rationality of farmers' expectations imposed are written as follows (using coffee as our example):

(10) $Q_t = k_0 + k_1 EWP_t + k_2 EER_t + k_3 ELM_t + k_4 Q_{t-1} + u_t$

(11) $P_t = b_0 + b_1 EWP_t + b_2 EER_t\ b_3\ ELM_t + v_t$

A test of the REH is then a test of the equality of the following cross equation restrictions:

(12) $k_0 = a_0 + a_1 b_0$

(13) $k_1 = a_1 b_1$

(14) $k_2 = a_1 b_2$

(15) $k_3 = a_1 b_3$

These restrictions imposed by the REH are highly nonlinear and hence, eqs. (5) and (6) are jointly estimated as our eqs. (10) and (11) by a Full Information Maximum Likelihood (FIML) technique. The validity of the restrictions in eqs. (12) - (15) are then tested by means of a likelihood ratio test statistic (LRTS). The LRTS is equal to $-(2 \log \lambda)$ where $\lambda = L_r/L_u$ and L_r is the value of the log of the maximum likelihood of the restricted model and L_u is the value of the log of the maximum likelihood of the unrestricted model. The LRTS is distributed as a χ^2 with 2 degrees of freedom. A similar procedure is utilized for sugar cane.

III. Empirical Results

The restricted and unrestricted reduced form equations were estimated using annual data over the period 1960-1980. We handle the problem of the expected exogenous variables by utilizing the actual values lagged one period as the expectations of these variables are determined outside the model. The estimated parameters and related statistics of the reduced form equations are presented in Table 1 and the estimated structural parameters are

presented in Table 2. The LRTS is equal to 2.278 with a marginal significance level of .3202. The marginal significance level is equal to the area in the upper tail of a χ^2 distribution with two degrees of freedom cut off by the LRTS. Given this marginal significance level, the restrictions of the REH cannot be rejected. Coffee farmers are responsive to the expected bonus payment received and form such expectations rationally. The results for sugar cane can be interpreted in a similar fashion. The signs of the estimated coefficients in the restricted model, have the expected signs and are significantly different from zero except for b_1. The LRTS is equal to 2.862 with a marginal significance level of .2391 indicating that the REH cannot be rejected.

A more relevant measure to evaluate the impact of the expected price and the variables in the information subset on output supplied are the elasticities rather than the estimated coefficients themselves. The elasticities, reported in Table 3, are all derived at the point of sample means. The values for DP^e and P^e are the predicted values derived from eqs. (4) and (7) respectively. The elasticity of supply with respect to expected price is .205 for coffee and .629 for sugar cane. That is, an expected 10% increase in the bonus payment will raise the output of coffee supplied to the CIB by 2.05% and a correctly anticipated 10% increase in sugar cane price will raise sugar cane output supplied by 6.29%. The calculated elasticity for coffee supply is much less than the value of. 82 reported by Williams

for the supply elasticity of Jamaican coffee over the period 1953-1969, however, he used an adaptive expectations approach and the actual final price received.

Elasticities for the other variables can be interpreted in the same way. For sugar cane, a change in the cane sugar ratio has a strong impact on the supply response of sugar cane producers. This is not surprising as technological improvement in sugar mills in Jamaica has not been undertaken and the cane-sugar ratio has been increasing over time (Annual Report of AICFA, 1983). The insignificance of the coefficient for the nominal world price of sugar implies that farmers do not consider this piece of information when formulating their price expectation and suggests that changes in world sugar prices are not transmitted to farmers by the board. Sugar cane farmers are then "protected" from some uncertainty due to world price fluctuations. The significance of the coefficient for the real exchange rate implies that changes in macroeconomic and trade policies have a positive influence on output supplied. The implication of these findings is that the Sugar Industry Authority can improve incentives for sugar cane farmers only if the government will enhance incentives faced by all exporters (i.e. a devaluation of the exchange rate).

A different picture emerges in the coffee industry. The coefficient of the nominal world price of coffee is significant, while the coefficient of the exchange rate is insignificant. The Coffee Industry Board does pass on world price increases to farmers, thereby improving incentives faced by farmers, while an improvement of generalized incentives for all exporters (i.e.

exchanged evaluation) has no impact on increasing output supply. Coffee farmers appear to realize that higher world prices are translated into higher bonus payments regardless of general macroeconomic conditions. However, world price fluctuations are apparently passed through to the farmer who is consequently subject to some uncertainty.

IV. Conclusions

The major finding of this paper is that farmers do respond to the expected price received and that farmers use available information to formulate this expectation. Rational expectations of price formation by sugar cane and coffee farmers implies that farmers correctly anticipate board pricing decisions over time and adjust output supplied accordingly.

However, extensive interviews with marketing board officials by the authors indicate that the positive price responsiveness of these farmers has not been recognized by these officials. The sugar and coffee marketing boards in Jamaica should consider the behavior of their respective farmer constituencies when setting farm level prices if desired foreign exchange target earnings are to be attained. The marketing boards cannot set farmgate prices independent of the farmers output response to such prices since farmers respond to the boards' actions. These results indicate there is ample room for improvement in the pricing policy of these Boards.

FOOTNOTES

1/ DP_{t-i} and P_{t-i} are not included in the information subsets for sugar and coffee respectively, because these variables represent price expectation formation under the adaptive expectations hypothesis which cannot be nested within a model incorporating the rational expectations hypothesis. A rejection of the null hypothesis that the restrictions of the REH hold cannot lead one to conclude that the adaptive expectations hypothesis or any other hypothesis is "correct".

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Table 1. FIML Estimates of the Reduced Form Equations for Jamaican Coffee and Sugar Cane Supply, 1960-1980.

	Sugar Cane		Coffee	
Output Equation	Restricted	Unrestricted	Restricted	Unrestricted
Constant	1759440 (776751)	1498900 (1593170)	417994 (93712.2)	518579 (205471)
EWP_t	443.473 (378.647)	227.384 (1266.96)	25.1082 (11.7384)	7.960 (22.657)
EER_t	300360 (155308)	348766 (296609)	-1689.85 (14854.2)	-61561.9 (105305)
$ECSR_t$	-108889 (46696.6)	-76404.8 (91569.0)	n.a.	n.a.
ELM_t	n.a.	n.a.	653.863 (513.144)	1041.08 (1437.73)
Q_{t-1}	.4039 (.2379)	.3567 (.2578)	-.9839 (.2059)	-1.013 (.2534)
Price Equation				
Constant	19.4638 (5.8777)	26.5620 (26.0848)	-.8525 (1.0907)	-1.967 (2.564)
EWP_t	.0048 (.0054)	.0085 (.0157)	.0010 (.00018)	.0012 (.0003)
EER_t	3.2571 (1.9212)	2.5438 (5.7443)	-.0678 (.6125)	.6640 (1.2670)
$ECSR_t$	-1.1806 (.5519)	-1.8558 (1.7280)	n.a.	n.a.
ELM_t	n.a.	n.a.	.0262 (.0110)	.0208 (.0345)
L	-303.833	-302.392	-247.986	-246.847
LRTS	2.862 [.2391]		2.278 [.3202]	

Notes: Asymptotic standard errors in parentheses.
Marginal significance in brackets.

Table 2. FIML Estimates of the Structural Models for Jamaican Coffee and Sugar Cane Supply, 1960-1980

Parameter	Sugar Cane	Coffee
a_0	-335575.6 (50588.9)	439310 (76433)
a_1	92254.4 (58827.0)	24997.4 (13326)
a_2	.4039 (.2379)	-.9839 (.2059)
b_0	19.4638 (5.8777)	-.8525 (1.0907)
b_1	.0048 (.0054)	.0010 (.00018)
b_2	3.2571 (1.9212)	-.0678 (.6125)
b_3	-1.1806 (.5519)	.0262 (.0110)

Note: Asymptotic standard errors in parentheses.

Table 3. Derived Elasticies of Output Supply with Respect to Expected Variables--Restricted Model

Elasticity of Supply with Respect to:	Sugar Cane	Coffee
P_t^e	.629	n.a.
DP_t^e	n.a.	.205
EWP_t	n.s.	.182
EER_t	.206	n.s.
$ECSR_t$	-.577	n.a.
ELM_t	n.a.	.114

Note: Calculated at the point of sample means