AGRICULTURAL SUPPLY RESPONSE FOR THE MAIN CROPS IN EGYPT

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1. INTRODUCTION

Supply response of agricultural products has been the subject of numerous studies in Egypt. In most of these studies, one product is studied and the area response is the object of inquiry. In other words, equations are estimated econometrically that purport to explain the area planted in a particular crop by various explanatory variables among which some measure of the price of the product is usually prominent. This Nerlovian approach, popular as it might be however, suffers from the shortcoming that interactions among the various crops are ignored.

Another particular feature of Egyptian agriculture is that it is highly controlled. The area planted in the major crop is highly related to the acreage allocated to the major crops by the Ministry of Agriculture (MOA) and subsequently translated to regional and village specific allocations. In such a rigid centrally planned area allocation system, supply response could occur in other aspects of the production process and, in particular, yields.

The focus of this paper is on an investigation of supply response in both area and yield for the four major food and cash crops in Egypt, namely, wheat, maize, rice, and cotton. The objective is to investigate supply response by a systemwide approach, namely, recognizing the interrelations among various crops and among area and yield response.

A survey of the principal systemwide supply response studies is conducted first in the next section. Then, a model of supply response under constraints is presented; and, finally, the results of some econometric estimations are exhibited.

2. A SURVEY OF PAST SYSTEMWIDE SUPPLY RESPONSE STUDIES OF AGRICULTURE IN EGYPT

In the past, there has been basically two approaches to the supply response estimation. The first one specifies the area under each crop as a function of a series of exogenous variables and then uses time-series data to estimate the elasticities. We call this time-series estimation.[1] The other approach is a linear programming (LP) one. A typical farm is considered with fixed input-output coefficients and several constraints. Then, the farm's allocation of land is generalized to the economy as a whole. The studies that we will consider are Hansen and Nasnashibi (1975), which uses a time-series estimation of the system, and Cuddihy (1980) and von Braun (1980) which use both approaches.

2.1. Time-Series Estimation

In his well-known work, Nerlove (1958) postulated that:

1. Supply of agricultural products (Q_{it}) responds to the expected prices (P^e_{it}), and
2. The major determinants of the expected prices in year t (P^e_{it}) are the actual prices in year t - 1, $P_{i,t-1}$.

The above statements can be mathematically represented for crop i as:

(1) $$Q_{it} = f_i(P^e_{it})$$

(2) $$P^e_{it} = g_i(P_{i,t-1}).$$

Although P^e_{it} is not observable, the equation:

(3) $$Q_{it} = f_i[g_i(P_{i,t-1})],$$

given the functional forms, can be estimated.

For actual estimation, one can modify both hypotheses: (1) make the output a function of several relevant variables, such as expected prices of other crops, an inertia factor of area adjustment, technical change, etc.; and (2) make the expected prices a suitable distributed lag function of the past prices and other variables if necessary. This is the basic framework within which von Braun and Cuddihy work.

For von Braun, the area planted with crop i in period t (A_{it}) is a function of the deflated previous year's price ($P_{i,t-1}$), the area-weighted price of competitive crops in the respective season ($PC_{i,t-1}$), and--if a strictly government-planned crop—the planned acreage in the respective year on which input supply and sometimes fines for refusing the planting of the respective crop are bound (AP). Therefore, a regression of the following form can be estimated:

(4) $$A_{it} = a_i + b_i P_{it-1} + c_i PC_{it-1} + d_i AP_{it}$$

where $PC_{it-1} = \sum_{j \neq i} A_{jt-1} P_{jt-1} / \sum_{j \neq i} A_{jt-1}$.

The regression was actually estimated for seven crops based on the aggregate data of 1966 to 1978 for Egypt. The correlation coefficients are relatively high for most of the regressions. Durbin-Watson coefficients are not reported; but, since deflated prices are used, we can hope that serial correlation has not been serious. The coefficients have the expected signs and are generally significant.

The problem with von Braun's model is that there does not seem to be a good theoretical model behind the regressions. Theoretical models are very important when interpretation and policy implications of a regression are intended. The fact that planned areas are well correlated with actual areas in his regressions may just suggest that planners were not too far off in their predictions. In the case of cotton, it may be true that, because of the cooperative control, farms are forced to partially respond to the quotas; but the planned area of rice may merely be a proxy for water availability. In the case of long berseem, it is hardly conceivable that decreasing the planned area in the papers of the Institute of Planning would reduce the actual long berseem area. The coefficients of planned areas can as well represent partial adjustment factors. von Braun notices this but prefers the planning process hypothesis (p. 20).

One can go into the details of von Braun's model and see that the coefficients are not as meaningful as they are assumed despite their significance. But, instead, we start looking into Cuddihy's work. His results further reveal the unreliable nature of this type of estimation.

The basic model that Cuddihy uses is as follows:

(5) $$A_{it} = a_{i1} + a_{i2}A_{i(t-1)} + \sum_{j=1}^{n} b_{ij}P_{j(t-1)} + \sum_{j=1}^{n} c_{ij}Y_{j(t-1)},$$

$$i=1,2,\ldots,n.$$

The notation is as before: a_{ij}'s, b_{ij}'s, and e_{ij}'s are regression coefficients; $y_{j(t-1)}$ is the yield of crop j per feddan and is included in the equation as a proxy for varying input use among crops (p. 34). Yields may themselves be a function of prices and revenues:

(6) $$Y_{it} = a_{i1} + \sum_{j=1}^{n} b_{ij}P_{j(t-1)}, \qquad i=1,2,\ldots,n.$$

A somewhat different model is also estimated using revenues per feddan ($R_{i,t-1}$) as explanatory variables.

(7) $$A_{it} = a_{i1} + a_{i2}A_{i(t-1)} + \sum_{j=1}^{n} b_{ij}R_{j(t-1)}, \qquad i=1,2,\ldots,n.$$

The regression results that Cuddihy obtain are quite odd. Cuddihy tries to explain some of the perversities, but he does not seem to be successful. The most bizarre result is the regression for maize area. Wheat price and revenue have positive coefficients, and maize price and revenue have negative coefficients. Cotton price and revenue also have surprisingly positive coefficients. This is in sharp contrast with von Braun's estimates. Cuddihy tries to explain the negative maize price coefficient by the inferiority of maize for Egyptian farmers: "Such an effect fits the common observation in Egypt of substitution of wheat for maize in consumption as real income rises" (p. 38). This does not explain the unusual result found because the retention ratio of maize is high and its income effect is low. Besides, if the above were true, the coefficient of cotton revenue, in particular, should have been negative not only because of the income effect but also because of competition over land. Furthermore, substitution of wheat for maize should have resulted in a positive coefficient for maize price in wheat area regression and a negative coefficient for wheat price in maize area regression. The opposite, however, is what Cuddihy found.

Cuddihy's model, like von Braun's, suffers from aggregate inconsistency. No constraints are placed on the coefficients. Input costs are mainly left out, but a justification is given for this procedure. Cuddihy argues that input prices have been constant for the most part, and the changes in costs have mainly resulted from increases in wages (p. 33). Therefore, he deflates the ouput prices by a real wage index. This approach has several problems. First of all, labor requirements of different crops are different, and the wage index should have been weighted by labor input for each crop. Secondly, the prices of other inputs have not been quite constant. Finally, it is not at all clear that real wage index is a suitable deflator. If nominal prices are used, it seems reasonable to deflate them by nominal wages, too, if at all, wage is an appropriate deflator.

The major problem with Cuddihy's work is that he has left out a great deal of relevant explanatory variables in his regressions. He wants to make the point that prices do matter so he includes prices (or rather revenues) and leaves everything else out. It is not difficult to see that some of these prices can be proxies for other variables and some others measure the behavior of government rather than the farmers! In the rice area regressions, there is no single significant coefficient for revenues or prices. Only yields have significant coefficients. They are merely proxies for water availability.

Another problem in the area-response equations is inclusion of yields. At the beginning, yields in year, t - 1, are supposed to represent expected yields in year t. But later on, Cuddihy claims that $Y_{i(t-1)}$ is a proxy for input use. Given that he finds strong correlation between prices of year, t - 1, with yields of year t , area and input allocation in year t must be <u>simultaneous</u> decisions. Therefore, expected yields are endogenous and $Y_{i(t-1)}$ is a poor proxy for them. $Y_{i(t-1)}$ may be a proxy for prices in year (t - 2) and receive its significance from left-out distributed lag structure of the price expectations.

Finally, we deal with Cuddihy's yield response equations. The results are very important not only because of high correlation coefficients but also because yields are usually assumed exogenous (see the discussion about Hansen and Nashashibi below). Unfortunately, the results may have inflated significance due to serial autocorrelation and due to use of revenues as explanatory variables. Durbin-Watson coefficients are not reported, but the unusually high correlation coefficients makes one suspicious about this type of error.

If it is true that yield and crop areas are determined simultaneously, then the supply response model should capture this fact. Later on we will develop a model with this property.

Next we will survey the supply response estimated by Hansen and Nashashibi. Their model is closer to the concept of the systems approach than the other two we have surveyed so far. Hansen and Nashashibi recognize three major constaints for the Egyptian agricultural sector as a whole; namely, land (A), labor (L), and water (W). If A_i, L_i, and W_i are land, labor, and water inputs for crop i, respectively, the constraints can be written as:

$$(8) \qquad \sum_{i=1}^{n} A_i \leqslant A$$

$$(9) \qquad \sum_{i=1}^{n} L_i \leqslant L$$

$$(10) \qquad \sum_{i=1}^{n} Wi \leqslant W$$

For each crop, they define a production function

$$(11) \qquad q_i = y_i(t) f_i(A_i, L_i, W_i)$$

where $q_i(t)$ is the output of crop i in year t, and $y_i(t)$ is a technical progress function. Externalities are not considered here, but Hansen and Nashashibi claim they have no consequence for the general form of area response functions.

If total agricultural income $(\sum_{i=1}^{M} p_i q_i)$ is maximized, we get

(12) $$\frac{y_i p_i}{y_m p_m} = \frac{f'_{m,A_m}}{f'_{i,A_i}} = \frac{f'_{m,L_m}}{f'_{i,L_i}} = \frac{f'_{m,W_m}}{f'_{i,W_i}}, \qquad i=1,\ldots,m-1.$$

If the inequalities in (10) are treated as equalities, (10) and (12) give us 3^m equations to determine A_i, L_i, and W_i. The optimal inputs of land, A_i^*, are seen to be functions of the following type:

(13) $$A_i^* = A_i^*\left(\frac{y_1 p_1}{y_m p_m}, \ldots, \frac{y_{m-1} p_{m-1}}{y_m \cdot p_m}, A, L, W\right), \qquad i=1,\ldots,m.$$

So far, the theoretical model is complete. But it has a rather tricky problem. P. A. Samuelson (   ) has made the point that, in this type of model with homogenous production functions or long-run equilibrium, the number of goods actually produced cannot exceed the number of factors! Therefore, on Samuelson's specification, no more than three crops should be produced in this model. Hansen and Nashashibi defend their model by disclaiming any homogeniety or long-term equilibrium. Water is especially distributed free of charge, but its marginal productivity is not zero. However, this does not save them from Samuelson's point because they do assume that water is distributed optimally as though there were a charge on it. The fact that there is no charge on water is just a lump-sum transfer payment from the government to the producers. This remains a theoretical problem of the model. But, the model actually estimated has little to do with the theoretical model anyway. The regression model is what we will deal with next.

The regression model is specified as

(14) $$A_i = a_{1i} + a_{2i}(F_i)_{-1} + a_{3i}A_{-1} + a_{4i}A_{-2} + a_{5i}L + a_{6i}L_{-1} + a_{7i}W_\tau + a_{8i}W_{\tau-1} + a_{9i}K + a_{10i}(A_i)_{-1}, \quad i=1,..,m.$$

where numeral subscripts represent lags. $(F_i)_{-1}$ has substituted for all $y_j p_j / y_m p_m$ terms in equation (13). It is defined as relative output-value-per-feddan index:

$$F_i = \frac{y_i p_i}{\sum_{j=1}^{n_i} w_j y_j p_j}$$

Here, y_j is interpreted as yields (proxies for technical change), and w_j is crop area weights. n_i is the number of relevant crops for the index.

K in equation (14) is the index of cotton area restriction. τ, the time indicator of water, is different for summer and winter crops. The model is estimated with 1913-1961 data.

There is a long way from equation (13) to equation (14), and the steps are explained in detail in Hansen and Nashashibi (p. 319-329). The lags are introduced due to the deviation of actual acreage from the desired acreages and, as a result, the adjustment process. F_i replaces all relative prices "since the number of crops and thus of relative output value per acre is substantial (eleven) and the number of observations limited (at most forty-eight)"

(p. 319). The total area, A, inters into equation (14) with lags following Nerlove although Hansen and Nashashibi acknowledge that "it is a bit difficult to see the precise rationale" (p. 323).

As Hansen and Nashashibi recognize, yields are functions of inputs and determined simultaneously with crop areas. Using them as proxies for technical change is quite problematic. Ignoring the technical change story, the use of lagged yields in F_i has little justification. They may be proxies for expected yields which depend on expected prices as well as other variables. But, F_i itself is not a good explanatory variable. Why should revenues per feddan be used rather than prices or net prices? Why should the weights be areas under each crop? These weights do not reflect competition between crops, and cross elasticities cannot be determined in this way.

The results, however, are quite instructive. $(F_i)_{-1}$ has generally significant coefficients, except in the case of staple food grains. Area, labor, and water, with their lagged values, have generally insignificant coefficients. Water is important for rice. K, area restriction index, is significant for the major crops with the right sign. Area adjustment coefficient is significant for nonstaple crops. The significance and sign of some coefficients are difficult to explain such as W_{t-1} barley area regression and L in millet area regression.

2.2. Linear Programming Models

Both von Braun and Cuddihy define their objective functions in terms of total value added. von Braun specifies the model for the economy as a whole, but Cuddihy specifies it for a typical farm of three feddans. As usual, a set of constraints are specified and prices are given. The model finds the optimal allocation.

LP models are systemwide approaches, especially if as Cuddihy mentions the models are run for different farm sizes and the results aggregated. The aggregate inconsistencies of time-series models are overcome in LP models. But, LP models suffer from loss of information on dynamic adjustments, which are measured in econometric models. Fixed coefficients is another problem of LP models. This latter problem leads to a flip-flop phenomenon as a result of price changes. The values of variables jump between the exogenously fixed limits as prices change. Profitable crops tend to occupy the whole land and nonprofitable ones tend to vanish, hence, ad hoc constraints should be imposed on their areas for the result to look realistic.

Both Cuddihy and von Braun have detailed LP models, and solve them for different scenarios of prices and government controls. von Braun compares the model with the actual data using the current prices and government policies and looks quite successful.

3. A MODEL FOR SYSTEMWIDE, TIME-SERIES ANALYSIS OF AGRICULTURAL SUPPLY RESPONSE

Consider n agricultural products, the production of which is given by the following relations

(15) $$q_i = A_i y_i(f_{1i}, \ldots, f_{(m-1)i}), \qquad i = 1, \ldots, n.$$

where q_i is the total output of crop i, A_i is the land area allocated to the production of the crop, and f_{ki} is the amount of the k'th input per unit of land used in the production of the i'th crop. (There are m factors altogether, of which m - 1 are nonland factors.)

Total crop area is given by $\bar{A}$, and total amount of some of the other inputs is given as well. Also, some of the crops (say, the first S) are cultivated in areas that are preset by government fiat. Therefore, the constraints of the model are

(16) $$\sum_{i=1}^{n} A_i = \bar{A}$$

(17) $$A_k = \bar{A}_k, \qquad k = 1,\ldots,s; \quad s < n.$$

(18) $$\sum_{i=1}^{n} A_i f_{ji} = \bar{F}_j, \qquad j = 1,\ldots,L; \quad L < m-1.$$

The other m-L-1 factors are available in unlimited supplies at fixed prices, π_j. A perfectly competitive internal market would result in the maximization of total output, namely,

(19) $$\max \sum_{i=1}^{n} \left(p_i q_i - A_i \sum_{j=L+1}^{m-L-1} \pi_j f_{ji}\right)$$

subject to equations (16), (17), and (18).

The Lagrangian for the problem is

(20) $$\mathcal{L} = \sum_{i=1}^{n} \left(p_i q_i - A_i \sum_{j=L+1}^{m-L-1} \pi_j f_{ji}\right) - \lambda_A\left(\sum_{i=1}^{n} A_i - \bar{A}\right) - \sum_{k=1}^{s} \lambda_{A_k}\left(A_k - \bar{A}_k\right)$$
$$- \sum_{j=1}^{L} \lambda_{F_j}\left(\sum_{i=1}^{n} A_i f_{ji} - \bar{F}_j\right).$$

Recalling (15) and differentiating L with respect to A_i and the input levels, f_{ji}, and setting the derivations equal to zero, we obtain

(21) $$p_i y_i - \sum_{j=L+1}^{m-1} {}_j f_{ji} - \lambda_A - \lambda_{A_i} \cdot d_i - \sum_{j=1}^{L} \lambda_{F_j} f_{ji} = 0,$$

($d_i = 1$ if $i \leq s$, and $d_i = 0$ if $s < i \leq n$).

(22) $$p_i \frac{\partial y_i}{\partial f_{ji}} - \lambda_{F_j} = 0, \qquad i = 1, \ldots, n; \quad j = 1, \ldots, L.$$

(23) $$p_i \frac{\partial y_i}{\partial f_{ki}} - \pi_k = 0, \qquad i = 1, \ldots, n; \quad k = L+1, \ldots, m-1.$$

From (21)-(23) we obtain

(24) $$p_i y_i - \sum_{j=L+1}^{m-1} \pi_j f_{ji} - p_i \sum_{j=1}^{L} \frac{\partial y_i}{\partial f_{ji}} f_{ji} = p_n y_n - \sum_{j=L+1}^{m-1} \pi_j f_{jn} - p_n \sum_{j=1}^{L} \frac{\partial y_n}{\partial f_{jn}} f_{jn},$$

for $i = S + 1, \ldots, n - 1$.

(25) $$p_i \frac{\partial y_i}{\partial f_{ji}} = p_n \frac{\partial y_n}{\partial f_{jn}}, \qquad i = 1, \ldots n-1; \quad j = 1, \ldots, L.$$

(26) $$p_i \frac{\partial y_i}{\partial f_{ki}} = \pi_k, \qquad i = 1, \ldots, n; \quad k = L+1, \ldots, m-1.$$

If $S + 1 + 1 = n$, i.e., if the number of constraints in equations (16)-(18) is equal to the number of products, n, then equations (24)-(26) yield $n(m - 1)$ independent equations which is exactly the number of unknowns, f_{ji}. Hence, the per unit land input ratios, f_{ji}, j = 1 . . ., m − 1, i − 1 . . ., m, can be solved from equations (24)-(26) as functions only of relative prices.

$$f^*_{ji} = f^*_{ji}\left(\frac{p_1}{p_n},\ldots,\frac{p_{n-1}}{p_n};\frac{\pi_{1+L}}{p_n},\ldots,\frac{\pi_{m-1}}{p_n}\right), \quad j \;\; 1,\ldots,m-1; \; i \;\; 1,\ldots,n. \tag{27}$$

Since yields, y_i, are functions of f_{ji}, j = 1 . . ., m − 1, it follows that yields are also functions of relative prices and not of the levels of any of the restrictions.

This result is quite important because it says that, if relative prices stay unchanged but the level of one restriction is changed (e.g., total labor availability), tnen yields will stay unchanged while the area allocations will change. Notice that the area allocations can be found from the restrictions (16)-(18) which reduce to just a set of linear equations once the f_{ji} are specified.

The result of the analysis results in the following estimation equations.

(28) yields $$y^*_i = y^*_i\left(\frac{p_1}{p_n},\ldots,\frac{p_{n-1}}{p_n};\frac{\pi_{L+1}}{I_n},\ldots,\frac{\pi_{m-1}}{p_n}\right),$$

(29) areas $$A^*_i = A^*_i\left(\frac{p_1}{p_n},\ldots,\frac{p_{n-1}}{p_n};\frac{\pi_{L+1}}{p_n},\ldots,\frac{\pi_{m-1}}{p_n};\bar{A},\bar{A}_1,\ldots,\bar{A}_s;\bar{F}_1,\ldots,\bar{F}_L\right).$$

4. SOME EMPIRICAL RESULTS

Estimations of yield and area equations were carried out for the four major Egyptian food and cash crops--namely, wheat, maize, rice, and cotton. The data on areas, yields, and prices were obtained from Cuddihy; they span the period 1950-1975. All nominal price series for the products were deflated by the nominal rural wage to convert them to real prices. Unfortunately, at this stage we are unable to collect data on total availability of cultivable land, water, and labor—the major constraints in the production of Egyptian agriculture. Also, at this stage we were unable to obtain data for the prices of the major variable inputs such as fertilizer.

To capture the dynamic adjustment effects, lags on the prices and the area variables were used. Several structural specifications were tried such as linear, log-linear, and log-log as well as various lag structures. We report below the results for those specifications that, in our judgment, exhibit reasonably correct a priori expected signs, significant coefficients, and high explanatory power.

The following conventions were made. Y and A will stand for yield and area, respectively; W, M, R, C, and B will stand for wheat, maize, rice, cotton, and berseem, respectively; and P will stand for real price. (Sometimes, R is used for real revenue instead of price.) T will stand for a time trend.

4.1. Yield Regressions

A. Wheat

The following two equations for wheat yields are reported (figures in parentheses are t ratios).

(30)
$$\log YW = \underset{(30.48)}{6.793} + \underset{(11.8)}{.024}\,T + \underset{(4.73)}{0.324}\log PW_{-1} - \underset{(-2.86)}{0.240}\log PR_{-1}$$
$$R^2\ .91$$

(31)
$$\log YW = \underset{(40.03)}{6.398} + \underset{(13.83)}{0.039}\,T + \underset{(1.54)}{0.107}\log PW_{-1} \underset{(-2.53)}{-0.171}\log PM_{-1}$$
$$\underset{(-4.36)}{-0.271}\log PR_{-1} + \underset{(5.77)}{0.637}\log PC_{-1}$$
$$R^2 = .97$$

These equations strongly support the model outlined in the previous section. The price variable has a positive sign. Crops competing for inputs, such as rice and maize, have strong negative coefficients. No easy story can be told about the strong positive sign of the price of cotton.

B. Maize

The best estimated equation for maize yield is the following.

(32)
$$YM = \underset{(6.30)}{1694.5} + \underset{(3.16)}{23.98}\,T \underset{(-1.79)}{-4811.1}\,PW_{-1} + \underset{(.01)}{39.46}\,PM_{-1} \underset{(-0.19)}{-885.47}\,PR_{-1}$$
$$\underset{(-1.815)}{-1926.23}\,PC_{-1} \underset{(-1.91)}{-2398.13}\,RB_{-1}$$
$$R^2 = .95$$

The price of maize comes in with a positive sign but is not significant. Significant substitutions are observed with the prices of wheat, cotton, and berseem.

C. Rice

The best estimated equation for rice yield is

$$(33) \qquad \underset{(.419)}{YR = 131.41} + \underset{(5.36)}{48.97}\, T + \underset{(4.39)}{19543.76}\, FW_{-1} + \underset{(1.63)}{10057.06}\, FR_{-1} \underset{(-.542)}{-1171.61}\, FC_{-1}$$

$$R^2 = .86$$

While the coefficient of the rice price is almost significant and of the right sign, that of wheat price is surprisingly positive.

D. Cotton

The best cotton yield equation was the following.

$$(34) \qquad \underset{(1.58)}{YC = 496.93} + \underset{(1.625)}{20.601}\, T \underset{(-1.05)}{-3742.83}\, FW_{-1} \underset{(-.643)}{-2535.4}\, FM_{-1} \underset{(-.113)}{-558.75}\, FR_{-1}$$

$$+ \underset{(.839)}{2009.72}\, PC_{-1} \underset{(-.859)}{-1314.77}\, RB_{-1}$$

$$R^2 = .61$$

Although no coefficient is significant, all are of the correct sign. The nonsignificance is expected since cotton production and, hence, yields are highly supervised and controlled operations.

4.2. Area Regressions

A. Wheat

(34)

$$AW = 1043.88 + 11795.38\ PW + 5820.87\ FW_{-1} - 9481.13\ FW_{-2}$$
$$(11.47) \quad (5.82) \quad (1.87) \quad (-3.85)$$

$$- 5889.58\ PR + 3423.73\ PR_{-1}$$
$$(-1.521) \quad (.87)$$

$$R^2 = .87$$

B. Maize

(36)

$$AM = 720.86 + 0.512\ AM_{-1} - 324.09\ FE_{-1} + 2687.96\ PM$$
$$(2.37) \quad (2.39) \quad (-.199) \quad (.823)$$

$$R^2 = .45$$

(37)

$$AM = 1156.99 + 6855.25\ PM - 4369.28\ PM_{-1} + 5259.47\ PM_{-2}$$
$$(5.23) \quad (1.17) \quad (-.707) \quad (1.15)$$

$$+ 3465.39\ PR + 612.67\ PR_{-1}$$
$$(.384) \quad (.062)$$

$$R^2 = .35$$

C. Rice

(38) $$AR = 805.24 + 0.381\, AR_{-1} + 11530.7\, PR_{-1} - 3727.38\, PC_{-1}$$
$$(2.897) \quad (1.98) \quad (1.714) \quad (-2.78)$$

$$R^2 = .82$$

D. Cotton

(39) $$AC = 1525.44 + .113\, AC_{-1} - 3139.53\, PW_{-1} - 362.91\, PR_{-1}$$
$$(2.92) \quad (.94) \quad (-.468) \quad (-.043)$$
$$+ 1791.05\, PC_{-1} - 3346.73\, RB_{-1}$$
$$(.95) \quad (-1.67)$$
$$R^2 = .39$$

The area equations, although largely exhibiting correct signs and some significance (the best equation is for rice), suffer from the lack of inclusion of important explanatory variables such as total cultivated land, water, etc.

All of the above estimations are to be regarded as very tentative and suggestive of the direction to be taken in subsequent research.

TABLE (1)

ELASTICITIES OF YIELDS WITH RESPECT TO PRICES

FOR WHEAT, MAIZE, RICE, AND COTTON

Yield of:	Eq.	Price of; Wheat	Maize	zRice	Cotton	Revenue of; Berseem
Wheat	30	0.324		-.24		
Wheat	31	0.107	-0.17	-0.271	0.637	
Maize	32	-0.22	0.0015	-0.028	-0.31	-0,114
Rice	33	0.528		0.189	-0.11	
Cotton	34	-0.276	-0.159	-0.030	0.518	-0.100

TABLE (2)

ELASTICITIES OF CROP AREAS WITH RESPECT TO PRICES

FOR WHEAT, MAIZE, RICE, AND COTTON

Area of:	Eq;	Price of: Wheat SR*	Wheat LR**	Maize SR*	Maize LR**	Rice SR*	Rice LR**	Cotton SR*	Cotton LR**	Revenue of: Berseem SR*	Berseem LR**
Wheat	35	.48	.33			-.16	-.16				
Maize	36			.07	.07					-.01	-.01
Maize	37			.19	.23	.08	.09				
Rice	38					.53	.53	-.86	-.86		
Cotton	39	-.11	-.11			-.01	-.01	.21	.21	-.12	-.12

*SR: Short Run.
**LR: Long Run.

FOOTNOTES

1/ It has been alternatively called "positive estimation" (see Shumway and Chang, 1977).

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