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EGYPT'S MULTIPRODUCT AGRICULTURAL TECHNOLOGY AND AGRICULTURAL POLICY

by

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Egypt's Multiproduct Agricultural Technology and Agricultural Policy

Based on the hypothesis that Egyptian farmers maximize economic profits, the multiproduct translog profit function is used to estimate input demand and output supply functions for corn, rice, and cotton crops grown in Egypt's Nile delta. Elasticity estimates indicate a generally high degree of price responsiveness. The estimates are used to evaluate Egyptian agricultural policies concerning labor, mechanization, and output prices. The results show that Egypt's agricultural policies of taxing output and subsidizing certain inputs have had a substantial negative impact on agricultural productivity.

The agricultural technologies in Egypt and many parts of the developing world are multiproduct technologies. Yet, most existing farm-level statistical studies of agricultural production and corresponding policy analyses have been based on single-product production function, cost function, or profit function estimates. For the most part, only normative linear and quadratic programming models have been used to evaluate agricultural policy questions in a multiproduct framework, and such models presuppose knowledge of the technology structure.

Questions of technology structure and input demand and output supply price responsiveness are especially important in view of the price policies that have been, and continue to be, pursued by the Egyptian government. A centralized mandatory crop rotation system, regulated or government monopolized input supply systems, and output price controls and quotas are important elements of Egyptian agricultural policy. Evaluation of these policies' effects requires knowledge of farmers' responses to changing economic conditions. Our recent study (Antle and Aitah 1983b) of Egyptian rice technology was the first farm-level econometric study of Egyptian agricultural technology. That study produced estimates of input demand elasticities, and found that Egyptian farmers respond rationally to opportunity costs. However, there are as yet no micro-level estimates of supply response for Egyptian agriculture. Thus, there is a clear need for more comprehensive measurement and analysis of Egyptian agricultural technology for agricultural policy evaluation.

In this study Egyptian farmers are assumed to maximize the economic returns to their resources, and the multiproduct translog profit function is used to characterize the structure of Egyptian field crop technology in the eastern region of the Nile delta. The model is applied to summer 1981 data from a recent production survey. We use the estimates of input demand and output supply functions to evaluate current agricultural policy questions. In addition, we compare the multiproduct technology estimates of input demand elasticities to those produced by a single-product model with the same data. This comparison provides an example of how the assumptions of single or multiproduct technologies affect estimates of the technology structure.

Section 1 describes the Egyptian summer field crop technologies. Section 2 develops the multiproduct translog profit function and discusses its properties. Section 3 presents the empirical results, and Section 4 discusses their policy implications.

1. Egypt's Summer Field Crop Technologies

Cotton, rice, and corn are the major summer field crops in the East Delta region. The major winter field crops in the East Delta are wheat, broad beans, and berseem, a clover grown for fodder. Other crops include sorghum, sugar cane, vegetables and fruit. Poultry and livestock husbandry are other major agricultural activities. The summer crops are part of a two or three year crop rotation system which is centrally organized by the Ministry of Agriculture to meet various policy objectives, including cotton export goals and domestic food grain consumption [Richards 1982, pp. 183-190].

Major agricultural inputs are human, animal, and mechanical labor; nutrients, both organic (manure) and chemical fertilizers, primarily nitrogen and phosphate; seeds, and land. Human labor consists of both hired workers and family members on most farms, with both family members and hired labor involved in the various crops and operations throughout the season [Richards and Martin, 1983]. Animal labor and mechanical power are both owned and hired, and their services are used primarily for land preparation, irrigation, transportation, and threshing, and are allocated to the various crops over the season [Soliman 1983].

Fertilizer distribution is monopolized by the government through the village cooperatives. Farmers are allocated a fertilizer quota for each major crop on credit at a subsidized price. There is no legal free market for fertilizers but a black market exists at prices which were 50 percent or more above the cooperative price in 1981. The available data suggest that fertilizer availability through the cooperatives has increased in recent years, resulting in a large increase in fertilizer use [Antle and Aitah 1983a]. Because the government's fertilizer allocations usually differ from the quantity that an individual farmer wants to use on a crop, farmers often reallocate their quotas to other crops or trade in the black market [Antle and Aitah 1983b].

The government's centrally planned crop rotation means that acreages of major field crops are not determined primarily by relative prices.[1] Thus, farmers are not able to adjust acreage to maximize economic returns, and must allocate other inputs such as labor and fertilizer to attain desired output rates.

A summary of relative factor use in cotton, rice, and corn is provided by the variable factor cost shares in Table 1. They show that a major difference is that cotton, with the longest growing season and highest harvest labor requirements, has the highest labor cost share, whereas farmers apply relatively more nitrogen to corn. Due to much greater labor requirements, rice and cotton have much higher total variable cost than corn.

2. The Multiproduct Translog Profit Function

In this section we describe the multiproduct technology used in the empirical analysis. The general representation of the multiproduct profit function is:

$$(1) \quad \pi = G[p,q,z]$$

where $p = (p_1, \ldots, p_m)$ is a vector of output prices, $q = (q_1, \ldots, q_n)$ is a vector of variable input prices, and $z = (z_1, \ldots, z_r)$ is a vector of fixed factors. This function is assumed to satisfy regularity conditions [Lau 1978] including positiveness, continuity, differentiability, and convexity in p and q.

The multiproduct translog profit function is:

$$
\begin{aligned}
\ln \pi = \alpha_o &+ \sum_{i=1}^{m} \alpha_i \ln p_i + \sum_{i=1}^{n} \beta_i \ln q_i + \frac{1}{2} \sum_{i,j=1}^{m} \sum^{m} \alpha_{ij} \ln p_i \ln p_j \\
&+ \frac{1}{2} \sum_{i,j=1}^{n} \sum^{n} \beta_{ij} \ln q_i \ln q_j + \sum_{i=1}^{m} \sum_{j=1}^{n} \gamma_{ij} \ln p_i \ln q_j \\
&+ \sum_{i=1}^{r} \delta_i \ln z_i + \frac{1}{2} \sum_{i,j=1}^{r} \sum^{r} \delta_{ij} \ln z_i \ln z_j \\
&+ \sum_{i=1}^{r} \sum_{j=1}^{m} \Theta_{ij} \ln z_i \ln p_j + \sum_{i=1}^{r} \sum_{j=1}^{n} \tau_{ij} \ln z_i \ln q_j .
\end{aligned}
\tag{2}
$$

As a second-order logarithmic approximation to the general profit function in (1), the translog profit function exhibits the general properties of multiproduct technologies that may be important to accurately estimate the technology's characteristics and to analyze policy questions. Observe that applying Hotelling's lemma to equation (1) shows that the general input demand and output supply functions are:

$$
\begin{aligned}
X_i^* &= \partial G[p,q,z]/\partial qi, \ i=1, \ . \ . \ . \ n \\
Q_i^* &= \partial G[p,q,z]/\partial p_i, \ i=1, \ . \ . \ ., \ m
\end{aligned}
$$

and in general depend on *all* input and output prices. This is not true of single-product technologies or of some restricted forms of multiproduct technologies. The above description of Egypt's agricultural technology suggests that inputs and outputs are interrelated across crops, because multiple-use inputs are prevalent (such as animal labor and machinery), and because there are substitution possibilities across crops. The properties of jointness and separability are related to the interdependence of inputs and outputs in multiproduct technologies. Therefore we briefly discuss the implications of jointness and separability in multiproduct technologies.

Lau [1978] shows that a necessary and sufficient condition for a technology to be nonjoint in inputs is:

$$(3)\quad G[p,q,z] = \sum_{i=1}^{m} G_i[p_i,q,z],$$

that is, the profit function is additive in output prices. Input nonjointness implies that there is a separate input demand function for each input i and each output j,

$$x^*_{ij} = \frac{\partial G_j[p_j,\ q,\ z]}{\partial q_i}\ ;$$

that other output prices have no effect on that demand

$$\frac{\partial x^*_{ij}}{\partial p_k} = \frac{\partial^2 G_j[p_j,\ q,\ z]}{\partial q_i \partial p_k} = 0, \text{ for all } j \neq k;$$

and that cross-elasticities of supply are zero

$$\frac{\partial Q^*_i}{\partial p_j} = \frac{\partial^2\ G_i[p_i,\ q,\ z]}{\partial p_i\ \partial p_j} = 0.$$

The above description of Egypt's agricultural technology suggests that production is joint in inputs because many inputs are utilized across crops. Therefore, both of the two above conditions implied by input nonjointness should not be observed in Egyptian agriculture. The translog function (2) is attractive for modeling Egyptian agricultural technology because it can be shown to represent a joint-in-inputs technology. This follows from the fact that the translog function can never be additive in output prices as condition (3) requires for nonjointness.

Another important structural property of technology often imposed in production models is separability in inputs and outputs. Following Lau [1978], it can be shown that a technology is homothetically separable in inputs and outputs if and only if:

$$(4) \quad G[p,q,z] = G[g_1(p,z),g_2(q,z)].$$

Separability is important to economic behavior with joint production because it constrains the effects prices have on optimal input and output proportions. Applying Hotelling's lemma to (4),

$$Q_i^* = \frac{\partial G}{\partial g_1}\frac{\partial g_1}{\partial p_i},\ i=1,\ .\ .\ .,\ m$$

and thus optimal output proportions are:

$$\frac{Q_i^*}{Q_j^*} = \frac{\partial g_1(p,z)}{\partial p_i} \Bigg/ \frac{\partial g_1(p,z)}{\partial p_j}\ i,\ j=1,\ .\ .\ .,\ m,$$

and do not depend on q. Similarly (4) implies optimal factor proportions are independent of p under input and output separability. Thus, separability has implications for the allocative effects of price policies. Another implication of separability concerns optimal cost and revenue shares. Noting that (4) implies:

$$\frac{\partial \ln G}{\partial \ln q_i} = \frac{\partial G}{\partial g_2}\ \ \frac{\partial g_2}{\partial q_i}\ \ \frac{q_i}{G} = \frac{-x_i q_i}{G}$$

it follows that the i^{th} optimal cost share is:

$$\frac{\partial \ln G}{\partial \ln q_i} \Bigg/ \sum_{i=1}^{n} \frac{\partial \ln G}{\partial \ln q_i} = \frac{\partial g_2(q,z)}{\partial q_i} \; q_i \Bigg/ \sum_{i=1}^{n} \frac{\partial g_2(q,z)}{\partial q_i} \; q_i$$

which depends only on q, and not on p. Similarly, separability implies optimal revenue shares depend only on p and not on q.

The prevalence of multiple-use inputs and across-crop substitution in Egyptian agriculture suggests that the technology is nonseparable in inputs and outputs. The translog profit function (2) is therefore attractive because it represents a nonseparable technology, and provides a direct test for separability in inputs and outputs. Note that if:

(5) $\gamma_{ij} = 0$ for all i and j

then the profit function (2) can be written in the form:

(6) $\ln \pi = \ln g_1(p,z) + \ln g_2(q,z),$

implying separability in inputs and outputs.

For estimation the following equations were used:

$$(7) \quad C_i = \frac{\partial \ln \pi}{\partial \ln q_i} = \beta_i + \sum_{j=1}^{n} \beta_{ij} \ln q_j + \sum_{j=1}^{m} \gamma_{ji} \ln p_j$$

$$+ \sum_{j=1}^{r} \tau_{ji} \ln z_j, \quad i=1, \ldots, n$$

$$(8) \quad R_i = \frac{\partial \ln \pi}{\partial \ln p_i} = \alpha_i + \sum_{j=1}^{m} \alpha_{ij} \ln p_j + \sum_{j=1}^{n} \gamma_{ij} \ln q_j$$

$$+ \sum_{j=1}^{r} \Theta_{ji} \ln z_j, \quad i=1, \ldots, m.$$

By Hotelling's lemma, $C_i = - x_i^* q_i / \pi$ and $R_i = Q_i^* p_i / \pi$ where x_i^* and Q_i^* are profit maximizing inputs and outputs. Equations (7) and (8) show that homothetic input-output separability constrains the behavior of optimal cost shares as dicussed above.

Using (7) and (8) we can derive input demand functions, output supply functions, and corresponding elasticity formulae. Such formulae are useful for summarizing the economic properties of the technology. For input demand functions we have

$$(9) \quad \frac{\partial \ln x_i^*}{\partial \ln q_i} = \frac{\beta_{ii}}{C_i} + C_i - 1, \; i=1, \ldots, n.$$

$$(10) \quad \frac{\partial \ln x_i^*}{\partial \ln q_j} = \frac{\beta_{ij}}{C_i} + C_j, \; i \neq j, \; i,j=1, \ldots, n.$$

$$(11) \quad \frac{\partial \ln x_i^*}{\partial \ln p_j} = \frac{\gamma_{ij}}{C_i} + R_j, \; i=1, \ldots, n, \; j=1, \ldots, m.$$

For output supply functions we have

$$(12) \quad \frac{\partial \ln Q_i^*}{\partial \ln p_i} = \frac{\alpha_{ii}}{R_i} + R_i - 1, \; i=1, \ldots, m.$$

$$(13) \quad \frac{\partial \ln Q_i^*}{\partial \ln p_j} = \frac{\alpha_{ij}}{R_i} + R_j, \; i \neq j, \; i,j=1, \ldots, m.$$

$$(14) \quad \frac{\partial \ln Q_i^*}{\partial \ln q_j} = \frac{\gamma_{ij}}{R_i} + C_j, \; i=1, \ldots, m, \; j=1, \ldots, n.$$

3. Empirical Results

The data were collected during the summer of 1982. Ten villages were randomly selected from the three governates (Sharkia, Domiatte, Monufia) in village using village land records. Quantity and value data were collected for major field crops, vegetables, and livestock for the 1981-82 summer and winter seasons. Summary statistics for the cotton, rice, and corn data we used to estimate the multiproduct translog profit function are presented in Table 2. One hundred four complete observations were available for use in the multiproduct analysis.

Variable inputs are hired labor, mechanical power (tractors and pumps), nitrogen and phosphate fertilizers, and animal labor. Crop acreages and family labor are specified as fixed factors. This specification seems reasonable for family labor in the short-run. Ideally, a household production model should be used to model family labor supply. Lacking sufficient information to pursue that analysis, we proceeded on the assumption that family labor input is determined exogenously.

Price data required calculations based on the sample data. First, all prices for each input and output category for each observation are those reported by each farmer unless the farmer did not report using an input or growing a crop. In this case, the average village price was used as a proxy for the opportunity cost each farmer faced. Second, in the case of fertilizers and mechanical power, inputs could be hired from several sources (village cooperative, private market, or owned machinery). The appropriate price is the marginal opportunity cost of the input, however, it is not clear how to measure the opportunity cost when a farmer buys, say, fertilizer at different times from various sources for various crops. Our solution was to use quantity-weighted prices, that is, for j=1, . . ., k input sources the i^{th} price is

$$\overline{q}_i = \sum_{j=1}^{k} q_{ij}x_{ij} \bigg/ \sum_{j=1}^{k} x_{ij}$$

where q_{ij} and x_{ij} are the price and quantity of the i^{th} input from the j^{th} source. This price reflects, on average over the season and across all crops, the marginal opportunity cost of the input.

Equations (7) and (8) were transformed into an econometric model for estimation with conventional procedures: we assumed the C_i and R_i are jointly distributed with means $\partial \ln \pi / \partial \ln q_i$ and $\partial \ln \pi / \partial \ln p_i$, and that this distribution satisfies the assumptions of Zellner's seemingly unrelated regression model. That is, random error terms are appended to the system of equations (7) and (8) which are assumed to be independently distributed and homoscedastic across farmers but correlated across equations. If these somewhat stringent statistical assumptions are violated, the parameter estimates nevertheless maintain the desirable properties of unbiasedness and consistency, but the standard errors of the parameter estimates may be biased, suggesting caution in the interpretation of test statistics. Iterating the system to convergence produces maximum likelihood estimates [Magnus 1978]. Because $\sum_{i=1}^{n} C_i + \sum_{i=1}^{m} R_i = 1$, the covariance matrix of the full system (7) and (8) is singular. Therefore, one equation was omitted from estimation. The iterated estimates converge to maximum likelihood estimates and are therefore invariant to which equation is omitted.

To validate estimates of the translog model, we subjected it to tests of three theoretically implied properties. First, we tested cross-equation restrictions implied by symmetry of the α_{ij} and β_{ij} and by the presence γ_{ij} in both equations (7) and (8). The asymptotic test statistic for these parameter restrictions was $\chi^2(21) = 20.83$ which implied nonrejection at conventional significance levels (1 percent critical value is 38.93). Second, profit should be increasing in all p_i and decreasing in all q_i. This monotonicity condition was verified by the negative and positive fitted values of equations (7) and (8). Third, convexity was tested at the point of approximation of the translog function, where $\ln p_i = \ln q_j = 0$ for all i and j, and was satisfied.

These tests suggest that the restricted model is a valid representation of the technology. Estimates of the restricted model are in Table 3. Using these estimates we tested parameter restrictions (5) implied by input-output separability. The asymptotic test statistic is $\chi^2(18) = 70.16$ which indicates rejection of separability (1 percent critical value is 34.80).

The parameters of the translog model do not have a direct economic interpretation, so we use them to calculate the demand and supply elasticities defined in equations (9) - (14) at the sample means of the data. When the sample means of the revenue and cost shares are used in these formulae to compute the demand and supply elasticities, the elasticity estimates are linear functions of the α_{ij}, β_{ij}, and γ_{ij} parameters. Thus the elasticity estimates have the same statistical properties as the parameter estimates and their standard errors can be computed using the parameters' standard errors. These elasticities are presented in Tables 4 and 5. We note the following properties of these estimates. First, all own-price input demand elasticities are greater than one in absolute value, indicating substantial input price responsiveness. Second, all own-price output supply elasticities are positive and approximately 1 and 2 for rice and corn and 3.75 for cotton. Thus, there is evidence of a marked difference in supply response across crops. Third, inputs are generally complements as indicated by the negative signs of the cross-price input demand elasticities. Fourth, the elasticities of output with respect to input prices are negative but their magnitudes vary across crops. Fifth, input demand is increasing in output prices, but the effects are much greater for corn and rice than cotton. Sixth, the cross-price supply elasticities show all three outputs are complements, although corn and rice are much stronger complements than cotton. A final result of interest is that cotton supply responds significantly to rice and corn prices but not vice versa.

4. Policy Implications

The estimates of input and output response in Tables 4 and 5 provide a basis for analysis of the wide spectrum of government policies. Egypt has a long history of intervention in agriculture, including input markets, production, and output markets. The reader can find detailed treatments of these policies in Ikram [1980], Antle and Aitah [1982], and Richards [1982]. Our discussion deals with output policies and input policies.

The Nasser, Sadat, and Mubarak governments inherited and further developed policies aimed at taxing agriculture through a system of price policies, production quotas, and cropping rotation. Farmers are required to grow mandated acreages of crops such as cotton, rice, and wheat. All or part of their output must be sold to the government at low (below market equilibrium and world market) prices. Table 2 shows in 1981 farmers reported receiving an average cotton price of .27 Egyptian Pounds (LE) per kilogram, whereas the world price was about 2.23 LE for long-staple Egyptian cotton at the official exchange rate. Farmers reported receiving .10 LE for rice compared to a world price of about .33 LE per kilogram. The corn price is not controlled by the government but is depressed by heavy consumer subsidies to wheat.

The own-price supply elasticities in Table 5 suggest that these price policies, and especially the cotton price policy, have had a substantial negative impact on production. It should be emphasized that these elasticities were estimated subject to given acreages, so the measured supply response is due to reallocation of other resources in response to price changes. The cotton supply response also is due to late planting. The practice became common as the government price policy reduced the incentive to produce cotton, and berseem (which precedes cotton in the rotation) became increasingly profitable due to higher livestock prices.

Time series data show that after the marked yield increase in the mid-1960s, due to the introduction of fertilizers, pesticides, and mechanization, cotton yields continuously declined despite increased availability of the new technology (Richards 1982, p. 203). Our results suggest that the yield decrease is explained, at least in part, by the policy-created price disincentives and the high degree of cotton supply response. Moreover, this supply response is high even with controlled acreage.

The importance of price policy to overall agricultural productivity is suggested by the complementarity between cotton, rice, and corn shown in Table 5. This complementarity is explained by cotton's long growing season which encompasses the rice and corn seasons. Cotton also requires large inputs of human labor, animal labor, and mechanical power which are complementary to the other field crops. The evidence suggests that the agricultural policy based on low output prices to farmers has had significant adverse effects on resource allocation to and productivity of the major field crops. Table 5 also shows that the rice and corn prices have a large positive and significant effect on cotton supply, but the cotton price has much smaller effects on rice and corn production. An explanation for this phenomenon can be deduced from Table 4 and is consistent with informal interviews with farmers. Due to the cotton price policy, farmers do not want to grow cotton and Table 4 shows that, indeed, input demand responds marginally to the cotton price, in contrast to rice and corn. Farmers use means such as late planting as well as input reallocation to regulate cotton supply. Since corn and rice are less heavily taxed, farmers do increase input use in response to corn and rice prices (Table 4). Because those inputs complement cotton production, cotton supply does respond to corn and rice prices (Table 5).

In Table 4 the elasticities of input demand with respect to output price show that price policies have differential impacts on input use. The rice and corn prices have a substantial effect on labor demand. This means that increasing these prices would markedly increase the demand for labor and, hence, the wage rate. This is an important consideration for policy makers in view of the so-called agricultural labor shortage of recent years. This labor shortage was apparently due to the out-migration of agricultural labor to nonagricultural employment in Egypt and other Middle-East countries [Richards and Martin 1983]. Consequently, the average agricultural wage increased several fold relative to other input and output prices from 1976-77 to 1981-82 in the East Delta region [Antle and Aitah 1983a].

Our data also show that no less human labor was used relative to mechanical power or animal labor in 1981 than in 1976 despite the dramatic wage rate increase. The cross-price input demand elasticities in Table 4 provide the explanation: human labor complements both animal power and mechanical labor; there are no substitutes for human labor with the existing technology. Thus, the only option available to farmers as wage rates increase is to reduce output and to bear the high labor costs. This situation has been especially damaging to farmers because the government has not increased output prices to compensate for the increased cost of production. Table 5 shows that wage rate increases did indeed induce farmers to reduce output substantially.

Our field observations indicate that the lack of input substitution shown in Table 4 is reasonable. Since widespread mechanization began in Egypt in the 1960s, the emphasis has been almost exclusively on large (60-70 h.p.) tractors and small to medium sized irrigation pumps. These relatively large tractors are useful only for a limited number of farm operations, primarily plowing, powering threshers, and transportation. These tractors, as well as the irrigation pumps, replace primarily animal labor. Planting, transportation, fertilizing, weeding, pest control, and harvesting still require large amounts of human and animal labor input.

Egypt's mechanization policy has been and continues to be based on government subsidies for import of these large tractors which are available as rentals from village cooperatives or purchase through government channels. No private tractor industry is allowed. The evidence presented above overwhelmingly suggests that this policy has led to an inflexible technology and that continuing this policy will not solve the labor market problems. In our view, appropriate policy is to allow new mechanical and biological technology to be introduced or developed which will save labor in the highly labor-intensive operations. Recent experience shows a massive wage increase did not significantly alter factor proportions with the existing technology. As long as the government forces the existing technology to be maintained, it seems unlikely that much reduction in labor requirements will be induced through technical change. Therefore, farmers will be induced to save on labor by distorting the cropping patterns, seeking alternative production such as livestock, or reducing production and turning to nonagricultural production.

5. Comparison to Single-Product Analysis

Until recently, most econometric attempts to characterize farm-level agricultural technologies in developing countries have been based on single-product production function studies. With the advent of applied duality theory, single-product cost and profit functions have been introduced [e.g., Lau, Lin, and Yotopoulos 1979, Sidhu and Baanante 1981, Antle and Aitah 1983b]. These single-product analyses can be viewed as first order approximations to what is typically a multiproduct technology. A relevant question is how the implicit technology restrictions of the single-product model affect the estimates of the technology's economic properties.

Some evidence on this matter can be obtained by a comparison of the input demand elasticities produced with the single-product homothetic translog cost function used in Antle and Aitah [1983a]. The same crop data were used in that study. For purposes of comparison, the uncompensated input own-price demand elasticities produced by the single-product analysis are presented in Table 6. Comparison to Table 4 shows that the multiproduct model implies a much higher degree of demand elasticity than the single-product models do for hired labor, mechanical power, and nitrogen; a lower elasticity for phosphate; and a similar value for animal labor. Thus, there does not appear to be a systematic difference in the elasticity estimates, although the absolute differences in magnitude are substantial. These differences presumably can be attributed to the technological constraints imposed by the cost function model, including nonjoint production, separability, and homotheticity. We can conclude that imposing those restrictions significantly alters the quantitative measurement of the technologies.

6. Conclusion

The multiproduct translog profit function was used to characterize the summer field crop technology in Egypt. This technology exhibits joint production and nonseparability in inputs and outputs. The estimated model implies a high degree of price responsiveness with respect to both input and output prices. In addition, inputs and outputs were generally found to be complements. These findings imply Egypt's agricultural price policies have had substantial adverse effects on productivity. In particular, the policy of taxing agricultural output through forced deliveries to the government at low prices has reduced production and exacerbated the problem of rapidly increasing wage rates. The complementarity between human labor, animal labor, and mechanical inputs has meant that the government's policy of subsidizing mechanization has not and cannot resolve the labor problem with the existing technology.

While the multiproduct analysis in this study produced results substantially different from those of a single product analysis, and while this multiproduct model appears to be a more valid representation of the technology, it nevertheless ignores other important dimensions of the farmer's production system, most notably livestock. This is an important but difficult topic we hope to investigate in future research.

A final important issue is how best to model and measure agricultural production at the farm level. Our experience with the econometric approach utilized in this study suggests to us that it is a promising and fruitful alternative to single-product econometric models and programming models.

Notes

[1] There is evidence, however, that many farmers frequently do deviate from the official crop rotation. Fines may be levied for such infractions but the actual degree of enforcement seems to be variable.

References

Antle, J. M. and A. S. Aitah, 1982, 'Annual Report of the Farm Efficiency Activity,' Davis, California: Agricultural Development Systems/Egypt, Working Paper No. 76.

__________________, 1983a, 'Agricultural Technology and Agricultural Policy in Egypt: 1976-77 and 1981-82,' Davis, California: Agricultural Development Systems/Egypt, Working Paper No. 143.

__________________, 1983b, 'Rice Technology, Farmer Rationality, and Agricultural Policy in Egypt,' American Journal of Agricultural Economics 65:667-674.

Binswanger, H. P., 1974, 'The Measurement of Technical Change Biases With Many Factors of Production,' American Economic Review 64:964-976.

Ikram, K., 1980, 'Economic Management in a Period of Transition,' Baltimore: World Bank.

Lau, L. J., 1978, 'Applications of Profit Functions' in: M. Fuss and D. McFadden, eds., Production Economics: A Dual Approach to Theory and Applications, Amsterdam: North Holland Publishing Co..

Lau, L. J., W. L. Lin, and P. A. Yotopoulos, 1979, 'Efficiency and Technological Change in Taiwan's Agriculture,' Food Research Studies, XVII, Ch. 3.

Magnus, J. R., 1978, 'Maximum Likelihood Estimation of the GLS Model With Unknown Parameters in the Disturbance Covariance Matrix,' Journal of Econometrics 7:281-312.

Richards, A. and P. L. Martin, 1983, 'The Laissez-Faire Approach to International Labor Migration: The Case of the Arab Middle East,' Economic Development and Cultural Change 31:455-474.

Richards, A., 1982, *Egypt's Agricultural Development, 1800-1980: Technical and Social Changes*, Boulder: Westview Press, Inc..

Sidhu, S. S. and C. A. Baanante, 1981, 'Estimating Farm-Level Demand and Wheat Supply in the Indian Punjab Using a Translog Profit Function,' *American Journal of Agricultural Economics* 63:237-246.

Soliman, I., 1983, 'Livestock Working Power in Egyptian Agriculture,' Davis, California: Agricultural Development Systems/Egypt, Working Paper No. 123.

TABLE 1

Mean Factor Cost Shares and Total Variable Cost of Egyptian Crops, 1981

	Crop		
Cost Shares	Corn	Rice	Cotton
Hired Labor	.32	.39	.51
Mechanical Power	.19	.29	.15
Nitrogen	.33	.19	.20
Phosphate	.03	.02	.06
Animal Labor	.13	.11	.07
Total Variable Cost	184.79	398.30	360.16

TABLE 2

Summary Statistics for Egyptian Field Crop Data, 1981
(Means with Standard Deviations in Parentheses)

	Inputs		
	Price[a]	Quantity	Unit
Hired Labor	2.61 (.56)	84.36 (164.55)	man-days[b]
Mechanical Power	1.48 (1.12)	83.37 (109.62)	hours
Nitrogen	.28 (.07)	165.60 (215.53)	kilograms
Phosphate	.06 (.10)	72.98 (120.74)	kilograms
Animal Labor	.55 (.34)	25.37 (23.66)	days
Family Labor	----	26.67 (23.79)	man-days
Corn Area	----	1.37 (1.13)	feddan[c]
Rice Area	----	1.95 (1.81)	feddan
Cotton Area	----	1.62 (2.13)	feddan
	Outputs		
Corn	.094 (.024)	1,226.6 (2,065.1)	kilograms
Rice	.102 (.023)	2,355.4 (5,304)	kilograms
Cotton	.271 (.040)	902.2 (1,698)	kilograms

Notes: a. prices in Egyptian pounds per unit

b. includes women and children weighted by .5

c. 1 feddan equals 1.04 acre

TABLE 3

Restricted Seemingly Unrelated Regression Estimates of the Multiproduct Translog Profit Function, Egypt, 1981

	Inputs					Outputs		
PRICES	Hired Labor	Mechanical Power	Nitrogen	Phosphate	Animal Power	Corn	Rice	Cotton
Hired Labor	.114 (1.012)							
Mechanical Power	.776 (.746)	.751 (.720)						
Nitrogen	.030 (.303)	.314 (.196)	-.035 (.213)			(Symmetric)		
Phosphate	-.019 (.034)	.019 (.018)	-.040 (.027)	.003 (.009)				
Animal Power	-.908 (.639)	-.659 (.523)	-.177 (.187)	-.007 (.016)	.508 (.710)			
Corn	-.037 (1.591)	-.045 (1.221)	.103 (.492)	-.025 (.040)	.655 (1.507)	.773 (3.942)		
Rice	-.084 (1.321)	-1.355 (1.304)	-.289 (.385)	-.091 (.043)	.763 (1.009)	1.796 (2.480)	-2.973 (2.840)	
Cotton	-1.028 (.545)	-.658 (.449)	-.399 (.132)	-.009 (.009)	-.833 (.479)	-2.538 (1.139)	-.926 (.840)	3.464 (1.357)

Note: Standard errors in parentheses

TABLE 4

Input Demand Elasticities Based on Multiproduct Translog Profit Function

	Inputs				
Prices	Hired Labor	Mechanical Power	Nitrogen	Phosphate	Animal Power
Hired Labor	-3.495 (.398)	-2.109 (.415)	-2.490 (.510)	-3.096 (.996)	-3.550 (.711)
Mechanical Power	-1.493 (.294)	-2.381 (.401)	-1.271 (.330)	-1.242 (.535)	-2.531 (.582)
Nitrogen	-.583 (.119)	-.421 (.109)	-1.654 (.359)	-1.755 (.774)	-.792 (.208)
Phosphate	-.042 (.014)	-.024 (.010)	-.102 (.045)	-.955 (.270)	-.035 (.018)
Animal Power	-1.257 (.252)	-1.265 (.291)	-1.196 (.313)	-.921 (.462)	-1.334 (.790)
Corn	2.818 (.626)	2.807 (.679)	3.006 (.826)	2.102 (1.164)	3.561 (1.676)
Rice	3.024 (.520)	2.304 (.725)	2.572 (.647)	.405 (1.255)	3.906 (1.123)
Cotton	.573 (.215)	.612 (.250)	.307 (.222)	.702 (.272)	.051 (.533)

Note: Elasticities based on equations (9), (10), and (11) and parameter estimates in Table 3, calculated at sample means of the C_i and R_i. Standard errors are in parentheses.

TABLE 5

Output Supply Elasticities Based on Multiproduct Translog Profit Function

	Outputs		
Prices	Corn	Rice	Cotton
Hired Labor	-2.527 (.562)	-2.512 (.432)	-3.469 (.558)
Mechanical Power	-1.782 (.431)	-1.355 (.427)	-3.028 (.460)
Nitrogen	-.631 (.173)	-.501 (.126)	-.689 (.135)
Phosphate	-.0256 (.014)	-.004 (.014)	.004 (.009)
Animal Power	-1.130 (.532)	-1.148 (.330)	.366 (.490)
Corn	2.105 (1.392)	3.419 (.811)	2.796 (1.139)
Rice	3.692 (.876)	1.083 (.929)	5.210 (.859)
Cotton	.081 (.393)	.645 (.275)	3.752 (1.509)

Note: Elasticities based on equations (12), (13), and (14) and parameter estimates in Table 3, calculated at sample means of the C_i and R_i. Standard errors in parentheses.

TABLE 6

Uncompensated Own-Price Input Demand Elasticities Based On Estimates of the Single-Product Homothetic Translog Cost Function

	Crop		
Input	Corn	Rice	Cotton
Hired labor	-.85	-.33	-.49
Mechanical power	-.80	-.77	-.96
Nitrogen	-.80	-1.31	-.68
Phosphate	-2.35	-3.06	-2.50
Animal labor	-1.08	-1.07	-1.11

Source: Antle and Aitah [1983a].