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Appendix A

Acreage Response Functions for Eleven Egyptian Field Crops

As a basis for appraising the impact of agricultural cooperatives and government intervention in crop rotation and composition from around 1962–1963 onward, information about supply functions for major field crops was needed. For well-known reasons, our efforts were concentrated on estimating acreage response functions rather than supply functions. Misallocation is discussed in terms of factor input rather than in terms of output.

Reasonably good information about acreage, yields, and prices is available from 1913 onward; it stands to reason that the data are more reliable for later years than earlier ones. On the basis of data for the period 1913 to 1961, response functions are estimated showing cultivators' behavior undisturbed by government intervention. These are then used for predicting acreages for 1962–1968 at actual domestic and international prices. Comparison between predicted and actual acreages yields information on the impact of government interference with acreages. (See Chapter 7 for such comparisons.)

A MODEL FOR CROP ACREAGE RESPONSE

The model to be applied is, indeed, nothing but the production side of the standard foreign trade model under competitive conditions.

Assume that land, A, labor, L, and water, W, are the only inputs in agriculture. For crop i the production function is assumed to be

$$q_i = y_i(t) f_i(A_i, L_i, W_i), i = 1, \ldots, m \qquad (1)$$

where q_i is the quantity of crop i and $y_i(t)$ is a technical progress function.[1] Assume that the total supplies of land, labor, and water are given exogenously and are known. Thus we have:

$$\sum^{m} A_i \leq A$$

$$\sum^{m} L_i \leq L \tag{2}$$

$$\sum^{m} W_i \leq W$$

The distribution of the inputs by crops is unknown except for land (see, however, [9, Tables 3.A, 3.B, and 3.C] on the list of references to Appendix A for the years 1961, 1963, and 1964); thus it is not possible to estimate the production functions (1) individually. Since our problem is one of the optimality of the individual crops we would get no help from an aggregate production function. The lack of information about the distribution of inputs by crops does not prevent us, however, from estimating individual supply functions or, as we prefer, individual acreage response functions.

We shall assume that all agricultural output prices are given exogenously, determined either from abroad or by the government. Both assumptions are reasonably good approximations in the Egyptian context (except perhaps for some of the small crops). Our model is then based on the maximization of total agricultural income,[2] and we have Max $\Sigma p_i q_i$ subject to the constraints (1) and (2).

With the inequality signs in (2) disregarded, maximization leads directly to the necessary conditions, in easily understood notation,

$$\frac{y_i p_i}{y_m p_m} = \frac{f'_{m,A_m}}{f'_{i,A_i}} = \frac{f'_{m,L_m}}{f'_{i,L_i}} = \frac{f'_{m,W_m}}{f'_{i,W_i}},\ i = 1, \ldots, m-1, \tag{3}$$

which with (2) gives us $3m$ equations to determine A_i, L_i and W_i. The q_is could then be determined from (1). The optimal inputs of land, $A_i{}^*$, are seen to be functions of the ratios of output prices times the technical progress function and of the total supplies of land, labor, and water, so that the acreage response functions can be written

$$A_i^* = A_i^* \left(\frac{y_j p_j}{y_m p_m}, A, L, W \right), \begin{cases} i = 1, \ldots, m \\ j = 1, \ldots, m \end{cases} \tag{4}$$

and similarly for the optimal inputs of labor and water, which, however, we are not interested in here.[3]

All the arguments in (4) are directly observable and known, with the exception of the technical progress functions, y_i. As a proxy for $y_i(t)$ we shall use yield per acre of crop i. The optimal input of land for any crop is thus a function of all relative output values per acre and of the given total inputs of land, labor, and water; all the arguments are now observable and known. Yield per acre is, of course, influenced not only by technical progress but also by inputs of labor and water per acre and is, thus, strictly endogenous to our problem. It is clear, however, that for the individual crops in agriculture we cannot rely upon the conventional type of technical progress functions $y_i(t) = \exp(\rho_i t)$, where ρ_i is a constant rate of technical progress.[4] For individual crops, yields will tend to move in jumps at the introduction of new varieties, over and above the effects of other types of technological progress. For agriculture as a whole it may perhaps be true that new varieties are introduced in a more or less continuous stream (for underdeveloped countries even this assumption is certainly dubious), but for individual crops we cannot make such assumptions. Not only do new varieties only appear discretely, but yields may even fall between the appearance of new varieties because old varieties may degenerate. Thus, the yield of Egyptian cotton declined from about 1895 to about 1920 due to degeneration of varieties, soil exhaustion, and an increasing underground water table (an unexpected consequence of the old Aswan dam), and increased again from 1920 to 1940 due to new varieties and improved fertilization and drainage [5, in particular, Fig. 10].

Since the number of crops and thus of relative output values per acre is substantial (eleven) and the number of observations limited (at most forty-eight), we felt that we had to bring down the number of explanatory variables in the acreage response functions. We shall do that through constructing for each crop a *relative output-value-per-feddan index, F_i,* that is defined as

$$F_i = \frac{y_i p_i}{\sum_{j=1}^{m} w_j y_j p_j}, \quad \sum_{j=1}^{m} w_j = 1, \tag{5}$$

where w_j is the weight given to crop j and y is interpreted as crop yield. As weights we shall use the relative crop acreages, averages for the period of estimation.[5] F_i may include all crops or only crops that are particularly competitive in regard to land (see below).

The acreage response function for crop i may then be formulated linearly as

$$A_i = a_{1i} + a_{2i}F_i + a_{3i}A + a_{4i}L + a_{5i}W \tag{6}$$

or as the corresponding log linear function. We used only the linear form in our estimates.[6]

Note, however, that for any arbitrary crop, say crop m, we have

$$A_m = A - \sum_{i=1}^{m-1} A_i$$

$$= - \sum_{i=1}^{m-1} a_{1i} - \sum_{i=1}^{m-1} a_{2i}F_i - A\left(\sum_{i=1}^{m-1} a_{3i} - 1\right) \qquad (7)$$

$$- L \sum_{i=1}^{m-1} a_{4i} - W \sum_{i=1}^{m-1} a_{5i},$$

so that, strictly speaking, (6) can apply to at most $m - 1$ crops. Our formulation of the acreage response functions thus implies an unpleasant lack of symmetry in the functional forms.

The next step is to introduce appropriate lags in the functions. We need a lag specification that will permit us to predict both short- and long-term responses or, to put it another way, to come out with both short- and long-term elasticities of acreage response. Various possibilities are open, but before we consider them a few comments upon the basic model may not be out of place.

For our purposes the present model has the great advantage of permitting us to predict acreages without having to consider possible effects on domestic factor prices; these are themselves endogenous to the problem. Thus, we can predict acreages on the basis of both domestic and international prices, in the short term as well as in the long term, without having to "solve the general equilibrium system," the usual headache in this problem. Identifying long-term response with optimal acreage, our response equations help us, in other words, to directly predict the optimum.

Strictly speaking, we have in fact solved that part of the general equilibrium system that is necessary for our purpose. The point is that the standard neoclassical trade model is dichotomized so that the supply (production) part can be solved without considering the demand side. It is this dichotomization we take advantage of. Its basic assumptions are perfect competition and the absence of nontraded outputs. There are problems with both of these assumptions but we do not consider them important (except for wheat).[7]

Another basic assumption for obtaining this neat result is that total supplies of domestic resources are exogenously given. For land and water this assumption is probably justified. The supply of cultivable land in the Nile Valley and the Delta is highly inelastic, and water supply is ultimately determined by the water flow of the Nile. Efforts to increase water supply for individual crops through a better distribution over the year and to increase the cultivated area have been governmental on the whole.[8] Some private investment in irrigation, drainage, and land reclamation did, of course, take place, particularly before the Great Depression, and the cultivated area did respond (downward) to the low relative profitability of agriculture during the Great Depression. By and large we feel, nonetheless, that it is justified to consider land and water as exogenously determined resources in the Egyptian context. For labor the assumption is less obvious. Until World War II, when urbanization was still slow, the assumption may not be too much out of line with reality. And during the sixties, the military draft may have been the most important determinant. With the rapid urbanization during and after World War II and the opportunities offered outside agriculture, however, labor supply to agriculture may not have been inelastic with respect to urban wages. Little evidence exists, unfortunately, as to the extent Egypt's agricultural labor supply depended upon urban wages, which is what matters in the present context.[9] The pull from the cities may have been of such a nature that urban wages made little difference to the flow of migration out of agriculture.[10] Lacking evidence to the contrary, we assume that the agricultural labor supply has been highly inelastic with respect to urban wages during the whole period.

The following considerations should also be noted:

1. Data for the total resources A, L, and W are of widely differing quality. Data for A are for acreage sown and are considered reliable, while those for L are shaky, to put it mildly; as a proxy for L only an index based on agricultural censuses of permanent labor taken every ten years, with interpolation on the basis of annual estimated rural population figures, is available. For W we have data for the monthly discharge of the Nile at Aswan, which may be fairly accurately measured itself but is at best a proxy for the use of irrigation water on the fields. It does not consider water storage below Aswan and this may be an important misspecification.

2. It is usual to divide Egyptian crops into three clearly distinguishable, though somewhat overlapping, groups of competing crops, with limited competition between groups 1 and 2:

Group 1 Summer (Autumn) Crops	Group 2 Winter Crops	Group 3 Perennial Crops
Cotton (lint and grain)	Wheat	Sugar Cane
Rice	Barley	
Corn	Beans	
Millet	Lentils	
	Onions (winter)	
	Helba	

It is not obvious a priori whether for purposes of estimation we should consider groups 1 and 3 together and 2 and 3 together and calculate F_i correspondingly. We experimented with this division, but ended up by considering all crops as competing, so that F_i is defined in the same way for all crops. This may not be the best possible specification for crops like rice, barley, and cane.

3. Our model does not consider inputs of chemical fertilizers and this may be another serious misspecification. If included in the model, relative fertilizer price $p_{fert}/y_i(t)p_i$, $i = 1, \ldots, m$, would appear in equation (8). We would then have eleven relative prices as arguments. Our relative output-value index would now be inadequate because it is based on gross output values and does not deduct imported inputs. If we knew the fertilizer input per acre we could construct a *net* output value (i.e. value added) index for each crop corresponding to F; however, no back figures about fertilizer input per acre by crops are available. Another possibility would be to let the argument p_{fert}/y_ip_i appear in the response function for crop i. We do not have comparable fertilizer prices from 1913 to 1961, and the functional form may have changed over time [8]. In 1913 fertilizer input was negligible and over time a learning process has accompanied the increasing input of fertilizer. We have therefore not been able to include fertilizer prices as a determinant of land inputs. Fortunately, however, we may catch most of the impact of fertilizers through identifying the productivity factor, y_i, with yield.

4. Price information is not available for most of the years of the period of estimation—1913 to 1961—for the largest (by acreage) of all crops, clover (berseem), so that no estimates of the response function could be made for the area of clover. The interdependency of the area response functions expressed by equation (7) is therefore disregarded, and it is assumed that clover is a residual in this sense. This procedure is not very satisfactory, of course, but no other course seems to be open. More serious, perhaps is that the output value per acre for clover does not appear in the denominator of the relative output-value index, F, for the other crops. We have had to disregard clover entirely.[11]

5. No back data were available for output and prices of straw and stalks, important for some crops (wheat, in particular). For cotton, of course, both lint and seeds are included.

In regard to lag specification, we have chosen to follow the approach of an exponentially distributed lag attached to relative output-value. We assume that

$$A_i = a_{1i} + b\sum_{t=1}^{T}(a_{2i})^t\,(F_i)_{-t} + a_{3i}A_{-1} + a_{4i}L + a_{5i}W_T \qquad (8)$$

General reference is made to Koyck's original contribution [12] and Nerlove's contributions [15, 16, and 17], as well as Krishna's [14] and Behrman's [3] modified versions of Nerlove's model. Nerlove came out with prices, exponentially lagged, and the previous year's total acreage as the only explanatory variables. Krishna and later Behrman added relative yield as an independent explanatory variable (among other things). Our derivation implied that crop acreage should be made dependent upon relative output value, that is (relative) price times yield. It might be argued that expectations are formed quite differently for prices and yields [3, pp. 166–168]. A low price last year and a bad crop last year may not affect this year's sown acreage in the same way. A single crop failure may not change the cultivator's notions of what is the "normal" yield, and he may understand that crop failures are erratic events, although, of course, the notion of "normal" yield is subject to change.[12] At the time a new variety is introduced it is natural that yield expectations should shift upward autonomously; indeed, this is the reason for its introduction. Hence, a case can be made for separating prices and yields in the supply function or, at least, treating them differently from an expectations point of view. One way of handling this problem would be to define the yield variable in F, as, say, an average of the last five years and limit the exponential distribution to the price, although price and yield enter in a multiplicative way. Estimates were experimentally made on the basis of this hypothesis, but the results did not improve and the experiment was discarded.

The specification assumes that the present year's prices (and yields, of course) do not affect sown acreages. This is because the prices used in the estimates are those at which crops have actually been sold. For the major crops these tend to be the market prices ruling at the time of sowing next year's crop.

The total acreage, A, enters into (8) with a single lag in line with Nerlove's assumptions (which we keep although it is a bit difficult to see their precise rationale). Labor is naturally assumed to have its effects without lags, while water appears with the time indicator τ. For summer crops (see the list above) τ is taken to be an average of the months May and June, the critical time for rice. The rationale of this choice is that, whereas the other summer crops (cotton, in particular) have always got the water they require at zero prices for water, rice has traditionally (at least until the fifties) been treated by the irrigation authorities as a residual crop. For winter and perennial crops, τ is taken to be September last year (the peak of the flood), which is decisive for water supply at the time winter crops are sown (November and December).

Equation (8) then leads directly to

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

In addition to the Nerlove specification, another one using Almon polynominally distributed lags and a third one with a simple two-lag structure were tried out. However, both t and R^2 and—particularly important for our purpose—standard errors of estimated values for these two specifications were so poor that the Nerlove model was preferred despite its inherent bias at ordinary least squares estimation. For our main purpose, prediction, the bias is a secondary consideration, but for the elasticity values, calculated as a by-product, it may be a serious matter, of course. To avoid the bias, estimation by the instrumental variable method was therefore applied (see below).

So much for the general specifications. One further problem had to be tackled. The government has at times imposed area restrictions for cotton, sometimes accompanied by prescriptions to increase cereals (particularly wheat) production. During the period studied here, cotton area restrictions were imposed for the years 1915, 1918, 1921–1923, 1927–1929, 1931–1933, 1942–1947, and 1953–1960 [5, Table III]. It would be natural simply to exclude these years from the estimates. However, the loss of observations is serious; also, the area restrictions may have merely imposed what the cultivators would have tended to do on their own; or, the restrictions may have been evaded.

Two considerations usually guided successive governments in their area restriction policies. In earlier years, it was always claimed by the Ministry of Agriculture that peasants tended to cultivate more cotton than was socially profitable in the long run (since cotton tends to exhaust the soil). Rightly or wrongly, with this motivation the government has felt it necessary in years of high profitability to hold back cotton cultivation, forcing peasants onto the three-year rotation system. In other years, the government has ordered production to be cut down because the market abroad was considered to be weak. This motivation was certainly behind the restrictions in 1931–1933. It is difficult to know a priori whether such restrictions led the cultivators to cut down the area more than they would have done otherwise, but they clearly did not work "against the market" in such years. For the 1942–1947 period much the same could be said. With European markets cut off, prices would obviously have fallen sharply had everything been left to the market forces, and a steep decline in cotton acreage would probably also have occurred without area restrictions. But there was the additional consideration that, cut off from nitrate fertilizer supplies from abroad during several years, the risk for soil exhaustion was great, even at a very low cotton acreage. And on top of all that there were, of course, the food requirements of the Allied armies operating from Egypt.

The restrictions from 1953 to 1960 are more difficult to rationalize. In 1953 they certainly tended to work in the same direction as the market forces, considering the collapse of the Korean boom. But relative profitability was by no means low, even after the cotton price drop in 1952 and despite the heavy cotton export taxes levied in these years (see Chart A–1). The restrictions were eased somewhat in 1954, but evasion must have become widespread, too; the cotton area increased despite a further decline in relative output value until 1956. After 1956, evasion was massive (see Chapter 6, p. 151). The increasing need for food grain imports, related to population growth, was one reason why the government tried to keep down the cotton area during these years; hence the simultaneous prescriptions for the wheat acreages from 1955 onward. It should be noticed, finally, that the optimum tariff argument has always played a role in policy debate in Egypt although opinions about its applicability have differed widely [4].

To keep the number of observations as large as possible (that is, forty-eight), an attempt was made to quantify the area restrictions rather than delete all years with controls. In a sense that is a relatively simple matter because the laws imposing the restrictions have always specified an upper limit, expressed as a percentage of his holdings, to the individual cultivator's cotton acreage. The laws were published in the *Journal Officiel du Gouvernement Egyptien,* from which the following details about the restrictions were compiled.

Until the end of the twenties the restrictions were simple. In each of the years 1915, 1918, 1921–1923, and 1927–1929, the upper limit was one-third, applying to any cultivator of land.[13]

During the period from 1931 to 1933 things became a bit more complicated. In 1931 the restrictions were directed exclusively toward the then leading long staple variety, Sakellarides. Prices on long staple cotton had fallen particularly sharply and the government tried to make cultivators keep long staple production below the private optimum. For that purpose a distinction was made between a "Zone Nord" of the Delta, including most districts in the governorates Behera, Gharbeya, and Daqhaleya, and the rest of the agricultural lands in the Delta and Upper Egypt. In the Zone Nord the upper limit for Sakel was 40 percent; in the rest of the country it was simply forbidden. For all other varieties there were no restrictions. The division between Zone Nord and the rest is interesting because it was in the former that the large cotton estates were situated. In 1932 restrictions were tightened. In Zone Nord the upper limit was 30 percent for all varieties, including Sakel. In the rest of the country the limit was 25 percent, with Sakel forbidden. In 1933 restrictions were relaxed again and limited to Sakel for Zone Nord, with an upper limit of 40 percent; for the rest of the country there was a general maximum of 50 percent, with Sakel forbidden.

The next period of restrictions was caused by World War II. For 1942 the upper limit in Zone Nord was 27 percent for all varieties; for the rest of the lands it was 23 percent. Cotton cultivation was entirely forbidden on basin-irrigated lands unless cotton had been grown there earlier. It was also prescribed that cotton must be preceded by clover, and that it was not permitted for two consecutive years on the same land. Certain long staple varieties (Zagora and Malaki) were forbidden or subject to special limits. This set of restrictions was in force for the years 1942, 1943, and 1944. For 1945 and 1946, the limits were unchanged at 27 percent for Zone Nord, but a further reduction to 18 percent was decreed for the rest of the country. A special limit of 14 percent was introduced for old basin lands that had been converted to summer irrigation and cotton cultivation was forbidden completely in the Aswan governorate. We were not able to find any law in the *Journal Officiel* for 1946 and 1947 applying to the 1947 crop or abrogating earlier laws, so we have assumed that the rigorous limits of 1946 applied here too (supported by [5, Table III]).

From the agricultural year 1942–43 (November–October) to 1945–46, there were area prescriptions for wheat and barley. For 1942–43, Zone Nord had a lower limit of 45 percent for wheat and barley (with at least 20 percent wheat) and the rest of the lands, 60 percent (with at least 50 percent wheat). These limits were applied also to 1944–45 and continued through 1945–46 with a minor modification.

For 1953 the upper limit for cotton was 30 percent for all cultivators and varieties. From 1954 to 1958 the upper limit of 30 percent remained in force for Zone Nord, but was increased to 37 percent for the rest of the Delta and Upper Egypt. For 1959 and 1960, finally, it was 33 percent for all cultivators and varieties.

Note, in addition, that from 1955 to 1959 there was a lower limit to wheat identical with the upper limit to cotton.

Although there have been restrictions for cotton and, for some years, also prescriptions for wheat and barley, we shall use only a single variable to express the impact of the controls on actual acreage. The rationale of this decision is mainly that the prescriptions for wheat have been highly correlated with those for cotton. We hope, therefore, that a variable based on the cotton acreage restrictions alone will capture the impact of all the controls on all the crops.

The question is now how to translate the upper limits for individual cultivators into a constraint on the total cotton acreage. What complicates matters is, of course, that cotton is cultivated by farmers who do not grow it exclusively but as one crop in rotation with others.

As an extreme case, assume first that half the total land in Egypt is on a three-year rotation and the other half, on a two-year rotation, and that all cultivators apply a simultaneous-consecutive rotation system, so that a cultivator grows cotton each year on one rotating part of his land. With a three-year rotation, a cultivator would thus always have one third of his land planted with cotton; on a two-year rotation, half his land would always be planted with cotton.

It is immediately clear that with this model an upper limit ≦50 percent would imply no reduction at all in the total cotton acreage, for no cultivator would at any time use more than 50 percent of his land for cotton.

At an upper limit ≦50 percent but ≧33⅓ percent, cultivators with a two-year rotation would be forced to cut down their cotton acreage, but cultivators with a three-year rotation would be unaffected. It is easily seen that in this interval each percentage point for which the maximum is below 50 will force a cultivator on a two-year rotation to limit his actual cotton acreage by two percent of the acreage he would choose were there no limitations. And since half the land is assumed to be on two-year rotation, the reduction of the total cotton acreage is simply 2 times 0.6 (because 60 percent of the cotton land at no restrictions is in two-year rotation), or equal to 1.2 percent. The total reduction caused by the maximum percent would thus be 50 *minus* the maximum percent times 1.2. At a maximum of 33⅓ percent, the reduction would be 20 percent of the free acreage.

At an upper limit ≦33⅓ percent, cultivators with three-year rotation will have to cut down their cotton acreages, too. A fall in the upper limit by one percentage point will now force cultivators on three-year rotation to cut down their cotton acreage by 3 percent of their cotton acreage at no restrictions. Cultivators with two-year rotation will have to reduce their cotton acreage, as before, by a further two percent measured upon their acreage at no restrictions. The combined effect is a reduction by 2.0 times 0.6 + 3.0 times 0.4, or by 2.4 percent of total cotton acreage without controls.

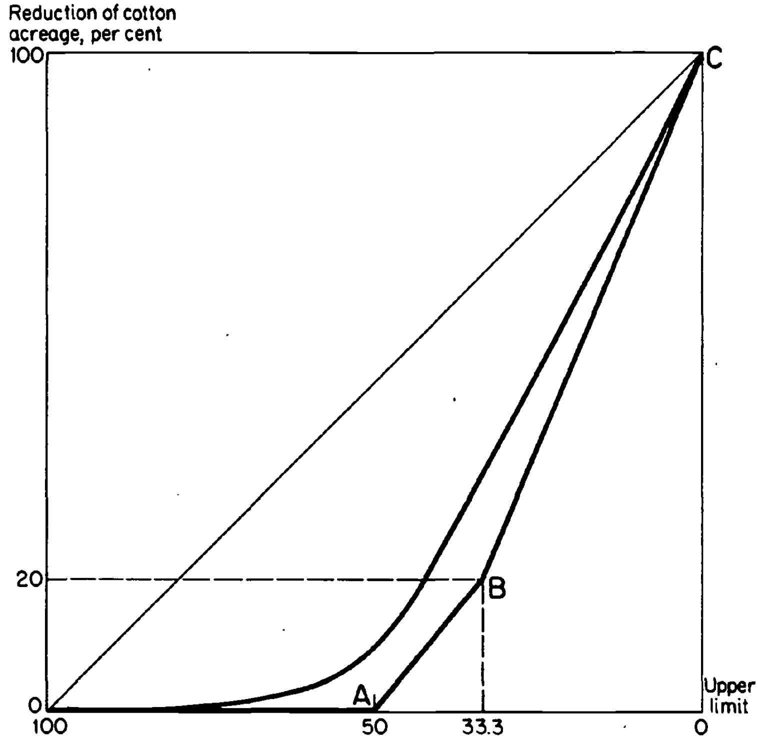
The relation between upper limit for the individual cultivator and reduction of total cotton acreage is thus nonlinear. It has a kink at 50 percent and another one at 33⅓ percent. In the intervals between 100 and 50, 50 and 33⅓, and 33⅓ and 0 it is linear as shown in Chart A–1 (the broken line OABC).

As another extreme model, we could imagine that all farmers, whether on two- or three-year rotation, rotate consecutively so that at any time they have only one crop on all their land. In any particular year we should then expect one third of the farmers on three-year rotation and half the farmers on two-year rotation to cultivate all their land with cotton and the remainder to have no cotton at all that year. In this case the total cotton acreage would simply be reduced to the upper limit and the area reduction would be represented in Chart A–1 by the 45° line through the origin, OC.

Our assumption that half the land of those who cultivate cotton at all is on three-year rotation and half on two-year rotation may not be entirely unrealistic (see Chapter 6, note 8).[14] Moreover, peasants usually follow the patterns of the first model with simultaneous-consecutive rotation. But big cultivators might, for reasons of large-scale economies, prefer the system with consecutive, nonsimultaneous rotation. It stands to reason, therefore, that the

CHART A–1

Limits to and Reduction of Cotton Acreage



aggregate relationship between individual maximum limit and total acreage reduction is a nonlinear relationship similar to the curve in Figure A–1 passing through the origin and the point C (0, 100) and running between the 45°-line and the broken line OABC. Calling the rate of acreage reduction K, and the maximum limit (expressed as a ratio) x, a relationship such as $K = (1 - x)^4$ might be reasonable, considering the actual maximal ratios and the actual reduction in cotton acreage in the years when limits are imposed. At $x = 0.5$, the cotton acreage reduction would be about 6 percent; at $x = 0.33$, about 20 percent; and at $x = 0.25$, about 35 percent.

Finally, we have to consider the evasion of controls. A glance at upper limits and actual cotton acreages (Chart A–1) reveals immediately what is confirmed by all observers and certainly should be expected in Egypt—that evasion at times has been considerable. It would appear that under "normal" conditions, restrictions are effective the first year after their introduction, but that thereafter, in a sequence of control years, evasion rapidly takes the upper hand. It may take the form of farmers with consecutive, nonsimultaneous rotation shifting to simultaneous rotation. With a three-year rotation, an upper limit of 33⅓ percent would then cut the acreage in the first year but have no effect whatever during the following year. This kind of evasion could even be legal. The years of World War II seem to have been an exception to this rule: not until the war was over did evasion become massive. We have assumed that for 1922 and 1923, 1928 and 1929, 1946 and 1947, and 1955 to 1960 evasion was so general that these years can be considered as having been without controls.

The construction of Table A–1 will now be readily understood. In column 1 we have, on the basis of the information given above, gauged an average figure for the individual cultivator's upper limit. For some years there was, indeed, only a single limit, but for most years an average had to be calculated. In doing so we tried particularly to gauge the importance of Zone Nord. The values for the control variable to be applied in the regressions appear in column 4. Needless to say, the table is based on a certain amount of subjective judgment.

To equation (9) we can now add a new term, $\alpha_{9i}K$, where K is the area reduction calculated in column (4) of Table A–1. We graft the controls variable K directly on (9) rather than on (8) because we have also considered "adaptation," or evasion. But it is not clear whether this is the best method of procedure.[15]

We should expect α_{9i} to be negative for cotton and positive for other crops. Equation (9) then becomes

$$A_i = \alpha_{1i} + \alpha_{2i}(F_i)_{-1} + \alpha_{3i}A_{-1} + \alpha_{4i}A_{-2} \qquad (9')$$

$$+ \alpha_{5i}L + \alpha_{6i}L_{-1} + \alpha_{7i}W_T + \alpha_{8i}W_{T-1} + \alpha_{9i}K + \alpha_{10i}(A_i)_{-1}$$

where the coefficients are related as follows:

$$\begin{aligned}
&\text{(i)} && \alpha_{1i} = a_{1i}(1 - a_{2i}) && (10)\\
&\text{(ii)} && \alpha_{2i} = ba_{2i}\\
&\text{(iii)} && \alpha_{3i} = a_{3i}\\
&\text{(iv)} && \alpha_{4i} = a_{3i}a_{2i}\\
&\text{(v)} && \alpha_{5i} = a_{4i}\\
&\text{(vi)} && \alpha_{6i} = -a_{4i}a_{2i}\\
&\text{(vii)} && \alpha_{7i} = a_{5i}\\
&\text{(viii)} && \alpha_{8i} = -a_{5i}a_{2i}\\
&\text{(ix)} && \alpha_{10i} = a_{2i}
\end{aligned}$$

Relations (iii) to (ix) may be used for testing the quality of the estimate.

For sources of data, see [7], [2], [1], [6], and Table A–1. The series used are presented in [9].

TABLE A-1

The Impact of Upper Limits to Cotton Cultivation

Year	Average Upper Limit to Cultivator's Acreage, x (%) (1)	$1 - x$ (2)	Prescribed Rate of Reduction of Total Acreage $(1 - x)^4$ (3)	Control Variable K (4)
1915	33⅓	0.67	0.20	0.20
1918	(33⅓)	0.67	0.20	0.20
1921	33⅓	0.67	0.20	0.20
1922[a]				0
1923[a]				0
1927	33⅓	0.67	0.20	0.20
1928[a]				0
1929[a]				0
1931	45	0.55	0.09	0.09
1932	25	0.75	0.32	0.32
1933	45	0.55	0.09	0.09
1942	24	0.76	0.33	0.33
1943	24	0.76	0.33	0.33
1944	24	0.76	0.33	0.33
1945	22	0.76	0.33	0.33
1946[a]	20	0.80	0.41	0
1947[a]	(20)	0.80	0.41	0
1953	30	0.70	0.24	0.24
1954	33	0.67	0.20	0.20
1955[a]	33	0.67	0.20	0
1956[a]	33	0.67	0.20	0
1957[a]	33	0.67	0.20	0
1958[a]	33	0.67	0.20	0
1959[a]	33	0.67	0.20	0
1960[a]	33	0.67	0.20	0
All other years	100	0	0	0

SOURCES: *Journal Officiel du Gouvernement Egyptien,* 1915, No. 85; 1921, Nos. 86 and 92; 1927, No. 5; 1931, Nos. 13 and 96; 1932, No. 100; 1941, No. 142; 1942, No. 174; 1942, No. 180; 1943, No. 92; 1944, No. 25; 1944, No. 107; 1946, No. 1; *Economic Bulletin,* N.B.E., various issues; Brown, op. cit., and Hansen and Marzouk, op. cit., pp. 98–99.

a. Characterized by evasion of controls.

METHOD OF ESTIMATION[16]

Multiple least squares regression tends to yield biased estimates of models like ours. This lagged variables model may, however, be considered as belonging to the class of general "noisy" or "errors in variables" model. It is known that the method of instrumental variables yields consistent estimates for general "noisy" models. This method has not found much application in econometrics because the approach has been to obtain the instrumental variables from outside the model, an impractical method that yields estimates with larger variances than those of least squares.

It can be shown, however, that instrumental variables may be obtained from within the model, and that the optimum instrumental variables matrix is the matrix of the noise-free variables of the model multiplied by the inverse variance covariance matrix of the error (disturbance) vector.[17] The term "optimum" is here used in the sense of yielding consistent estimates with the smallest variances. The latter can be shown to approach asymptotically those of the least squares' estimates. These desired properties of unbiasedness and least variances have been proven, theoretically, for the asymptotic case; yet, in all finite sample problems studied so far, the optimum instrumental variables method has, in fact, been always giving better results than least squares.[18]

Mathematically, our model is

$$y_t = \beta_0 + z_{1t}\beta_1 + z_{2t}\beta_2 + \cdots + y_{t-1}\beta_{n+1} + \cdots + y_{t-i}\beta_{n+i} + \epsilon_t$$

and for T observations we can write

$$Y = X\beta + \epsilon,$$

where Y is a T vector, X is a $T \times (n + i + 1)$ matrix, β is a $(n + i + 1)$ vector, and ϵ is a T vector.

Given the model, the optimum instrumental variables are obtained by adaptive, or recursive, estimation using the computer program ESTIMM as follows. First, the program yields the ordinary least squares estimate (L.S.). It then proceeds to obtain a so-called noise-free estimate of the endogenous variables, y_t. The noise-free estimate is obtained as the solution of the model with the y_ts as unknowns, and using the values of the coefficients, β, emerging from the least squares estimate together with the actually observed values of the exogenous variables, z. The lagged endogenous variables, y_{t-1} to y_{t-i}, appearing on the right hand side are, of course, unknown and obtained from the solution (with the exception of those with an earlier dating than 0 for which the actually observed values had to be used). The error term, ϵ, that is the "noise," is deleted (set equal to zero) to obtain a solution of y_t, "free of noise." The noise-free estimate of the endogenous variables is then used in the instrumental variables matrix to replace the "noisy," actually observed, values of the endogenous variables. For the other variables, the actually observed values were used as instrumental variables in this case. On this basis a new estimate of the model is made and this is the instrumental variable estimate, step 1 (I.V.1).

On the basis of the coefficient values obtained in I.V.1, the program then calculates a new noise-free estimate of the endogenous variables to obtain a new instrumental variables matrix in the same way as was done after the L.S. Thereafter, the program checks for first-order correlation among the errors, and estimates the inverse variance covariance matrix on the assumption that the errors follow a first-order autoregressive scheme. The inverse matrix (if obtained) is used with the new step 2 instrumental variables matrix to yield the instrumental variable estimate of the model, step 2 (I.V.2).

Summarizing, the least squares estimate (L.S.) is

$$\beta_{\text{L.S.}} = (X^T X)^{-1} X^T Y.$$

The instrumental variable estimate, step 1 (I.V.1) is

$$\beta_{\text{I.V.1}} = (\breve{X}_1{}^T X)^{-1} \breve{X}_1{}^T Y$$

where $\breve{X}_1$ is the first noise-free estimate of X.

The instrumental variable estimate, step 2 (I.V.2) is

$$\beta_{\text{I.V.2}} = (\breve{X}_2{}^T \Omega^{-1} \breve{X})^{-1} X_2{}^T \Omega^{-1} Y$$

where $\breve{X}_2$ is the second noise-free estimate of X and Ω is the variance covariance matrix of the errors.

For the present model some of the matrices to be inverted turned out to be almost singular because they contained both unlagged and lagged values of exogenous variables that change very slowly over time. In such cases, normal precision of the computer (IBM/360) was insufficient and double precision had to be used. Some matrices were, however, so close to singularity that even double precision did not prevent instability. These cases have been labeled "not applicable" in Table A–2.

In all estimates we used the standard formula for R^2

$$R^2 = (\Sigma y_t^2 - \Sigma e_t^2)/\Sigma y_t^2$$

where e_t are the residuals. This formula applies strictly to the L.S. and we have, of course, $0 \leqq R^2 \leqq 1$. Applying the same formula to the I.V., we can only be sure, however, that $R^2 \leqq 1$, so that the computations may yield negative values of R^2.

Durban-Watson statistics were not computed because the program corrects automatically for the presence of autocorrelated errors in I.V.2; in the case of L.S., the Durban-Watson statistic is uninteresting because L.S. of this model yields biased estimates in any case. It might have been useful, however, to use them for I.V.1 where I.V.2 failed.

RESULTS OF ESTIMATIONS

In most cases the three methods—L.S., I.V.1, and I.V.2—gave very similar results, implying that the bias involved in L.S. cannot be very serious in this particular case. For the lagged crop area there is, however, a substantial difference between the coefficients obtained for some crops (onions, beans, lentils); here the unbiased estimates give much larger coefficients than L.S.

For theoretical reasons we prefer to use the results of I.V.2 whenever available. For several crops the I.V.2 had to be abandoned, however, for computational reasons or because the coefficient of the lagged area variable was > 1, implying instability. In these cases I.V.1 was used. In one case I.V.1 also led to instability, and the L.S. results were used.

The findings are shown in Table A–2. Acreages are measured in thousands of feddans and water, in billions of cubic meters; labor is expressed as an index, with average labor force 1950–1955 = 100; F is a pure number defined by equation (5); and K is defined in Table A–1. Figures in brackets under the coefficient values are the corresponding t values. R^2 values and SER values (standard error of estimate) are given in columns 13 and 14, while column 15 indicates which estimate has been selected for calculating elasticities—shown in Table 6–3—and for the area predictions. Although our main interest is in the predictions, a few remarks about the details of the estimates are warranted. (We limit ourselves to the estimates selected for prediction.)

The R^2 values differ considerably, from 0.95 for cane to 0.39 for lentils. For five crops, R^2 exceeds 0.80. The standard error of regression, SER, is generally about 5–10 percent of the actual acreage at the end of the period of prediction; barley is an exception, with more than 35 percent. Thus, the fits cannot claim any high degree of accuracy, but compared with similar estimates for other countries they are not too bad.

Concerning coefficients, we note first that that of the control variable, K, has the expected sign for all summer crops and wheat—negative for cotton and positive for rice, corn, millet, and wheat—and is significantly different from zero at the 1 percent level. For other crops the sign of the coefficient of K is erratic and insignificant, as should be expected.

The coefficient of the relative output-value variable, F, has in all cases a positive sign, except for corn. The sign of the coefficient is significant at the 1 percent level for cotton, barley, onions, beans, lentils, and helba, and at the 5 percent level, for rice and cane. For the important food grains, corn, wheat, and millet, it is insignificant.

TABLE A–2

Results of Estimates of Acreage Response Functions

Crop (*i*) (1)	Estimation Method (2)	Coefficient of: $F_{i,-1}$ (3)	$\bar{A}_{-1}$ (4)	$\bar{A}_{-2}$ (5)	L (6)	L_{-1} (7)
Cotton						
	L.S.	245.48	0.17	−0.02	2.31	−2.22
		(3.24)	(1.08)	(−0.12)	(0.85)	(−0.83)
	I.V.1	252.22	0.14	0.01	2.65	−2.54
		(3.39)	(0.89)	(0.08)	(0.96)	(−0.95)
	I.V.2	293.44	0.16	0.00	2.23	−2.13
		(4.02)	(1.08)	(0.00)	(1.15)	(−1.11)
Rice						
	L.S.	177.92	0.12	−0.09	−3.11	3.37
		(2.19)	(1.22)	(−1.00)	(−1.68)	(1.84)
	I.V.1	174.99	0.10	−0.08	−2.71	2.96
		(2.20)	(0.97)	(−0.83)	(−1.31)	(1.43)
	I.V.2	Not applicable				
Corn						
	L.S.	−136.69	0.04	0.19	4.64	−4.96
		(−0.77)	(0.21)	(1.30)	(1.70)	(−1.82)
	I.V.1	−78.48	0.40	0.13	7.33	−7.97
		(−0.42)	(1.81)	(1.09)	(2.31)	(−2.46)
	I.V.2	Not applicable				
Millet						
	L.S.	28.02	0.01	−0.05	−2.92	3.10
		(0.40)	(0.17)	(−0.69)	(−2.22)	(2.39)
	I.V.1	28.55	0.01	−0.05	−2.93	3.11
		(0.40)	(0.18)	(−0.67)	(−2.04)	(2.17)
	I.V.2	Not applicable				
Wheat						
	L.S.	75.44	0.09	−0.03	1.92	−1.41
		(0.63)	(0.73)	(−0.26)	(1.14)	(−0.88)
	I.V.1	78.80	0.05	−0.01	2.18	−1.67
		(0.68)	(0.36)	(−0.06)	(1.32)	(−1.06)
	I.V.2.	83.24	0.05	0.01	1.31	−0.86
		(0.80)	(0.47)	(0.06)	(0.83)	(−0.58)
Barley						
	L.S.	112.38	−0.05	0.03	1.08	−1.13
		(1.96)	(−1.24)	(0.65)	(1.53)	(−1.65)
	I.V.1	114.96	−0.05	0.03	0.85	−0.36
		(1.97)	(−1.17)	(0.65)	(1.16)	(−1.20)
	I.V.2	144.97	−0.02	0.02	−0.13	0.10
		(3.63)	(−0.74)	(0.69)	(−0.18)	(0.15)

(continued)

TABLE A–2 (continued)

Coefficient of:					Statistics		Selected for the Predictions
W_τ (8)	$W_{\tau-1}$ (9)	K (10)	$A_{i,-1}$ (11)	Constant (12)	R^2 (13)	SER (14)	(15)
−73.11	10.02	−1,901.50	0.27	−37.00	0.86	138.86	
(−1.71)	(0.23)	(−9.21)	(3.67)	(−0.07)			
−73.22	6.66	−1,947.16	0.22	−11.30	0.86	139.54	
(−1.70)	(0.15)	(−9.42)	(2.78)	(−0.02)			
−67.29	−4.37	−1,910.95	0.18	−19.46	0.85	142.00	x
(−1.87)	(−0.11)	(−10.01)	(2.41)	(−0.03)			
169.37	8.11	318.18	0.08	−742.50	0.87	83.03	
(6.54)	(0.24)	(2.85)	(0.52)	(−2.08)			
167.87	−4.61	327.14	0.16	−685.06	0.87	83.18	x
(6.63)	(−0.11)	(3.45)	(0.73)	(−1.82)			
−44.98	34.72	658.69	0.29	77.00	0.64	129.29	
(−1.13)	(0.85)	(3.23)	(1.33)	(0.12)			
−51.31	22.00	933.82	−0.24	−700.15	0.61	134.05	x
(−1.23)	(0.51)	(4.76)	(−0.63)	(−1.11)			
21.58	1.18	388.73	0.43	217.97	0.87	59.45	
(1.16)	(0.06)	(2.89)	(3.47)	(0.97)			
21.64	1.34	390.20	0.43	217.01	0.87	59.45	x
(1.15)	(0.07)	(3.79)	(2.59)	(0.99)			
−6.19	−7.89	576.43	0.14	593.00	0.69	96.47	
(−1.51)	(−1.78)	(3.93)	(0.99)	(1.49)			
−6.24	−7.40	556.91	0.23	599.24	0.69	95.96	
(−1.53)	(−1.66)	(3.74)	(1.16)	(1.52)			
−6.37	−7.60	529.94	0.25	534.38	0.69	96.67	x
(−1.68)	(−1.85)	(3.92)	(1.45)	(1.65)			
−1.56	−4.39	12.87	0.74	328.31	0.88	39.05	
(−0.94)	(−2.50)	(0.19)	(8.99)	(2.00)			
−1.66	−4.30	−8.56	0.86	248.28	0.88	39.84	
(−0.99)	(−2.40)	(−0.13)	(8.57)	(1.44)			
−2.32	−3.55	−77.63	0.95	102.14	0.86	43.38	x
(−1.63)	(−2.42)	(−1.41)	(15.10)	(1.12)			

(continued)

TABLE A–2 (concluded)

Crop (*i*) (1)	Estimation Method (2)	Coefficient of: $F_{i,-1}$ (3)	$\bar{A}_{-1}$ (4)	$\bar{A}_{-2}$ (5)	L (6)	L_{-1} (7)
Onions						
	L.S.	2.31	0.01	0.00	0.11	−0.12
		(1.89)	(1.80)	(0.44)	(0.85)	(−1.00)
	I.V.1	4.41	0.02	−0.01	−0.08	0.07
		(3.12)	(1.99)	(−0.93)	(−0.45)	(0.38)
	I.V.2	Not applicable				
Beans						
	L.S.	48.99	−0.03	0.05	1.01	−1.18
		(0.74)	(−0.56)	(1.02)	(1.21)	(−1.49)
	I.V.1	109.00	−0.02	0.03	0.57	−0.68
		(1.57)	(−0.35)	(0.59)	(0.62)	(−0.75)
	I.V.2	Not applicable				
Lentils						
	L.S.	13.26	−0.02	0.02	0.39	−0.37
		(1.29)	(−1.64)	(1.71)	(2.37)	(−2.33)
	I.V.1	19.07	−0.02	0.02	0.35	−0.34
		(1.59)	(−1.70)	(1.71)	(1.75)	(−1.87)
	I.V.2	Not applicable				
Helba						
	L.S.	36.81	−0.04	0.04	0.56	−0.56
		(3.10)	(−3.16)	(3.00)	(2.13)	(−2.26)
	I.V.1	39.53	−0.04	0.04	0.49	−0.49
		(3.25)	(−2.92)	(3.08)	(1.43)	(−1.55)
	I.V.2	38.59	−0.04	0.04	0.12	−0.15
		(3.97)	(−2.76)	(3.95)	(0.28)	(−0.39)
Cane						
	L.S.	2.32	0.01	−0.00	−0.18	0.18
		(1.59)	(1.25)	(−0.88)	(−1.48)	(1.53)
	I.V.1	2.25	0.01	−0.00	−0.14	0.14
		(1.53)	(0.97)	(−0.78)	(−1.02)	(1.04)
	I.V.2	3.37	0.01	−0.00	−0.38	0.37
		(2.71)	(1.40)	(−0.41)	(−2.66)	(2.71)

NOTE: *t*-values are in parentheses.

TABLE A–2 (concluded)

Coefficient of:					Statistics		Selected for the Predictions
W_T (8)	W_{T-1} (9)	K (10)	$A_{t,-1}$ (11)	Constant (12)	R^2 (13)	SER (14)	(15)
0.69	0.34	−11.70	0.47	−112.95	0.69	6.76	x
(2.41)	(1.07)	(−1.11)	(2.83)	(−3.69)			
0.69	0.26	4.32	1.12	−64.52	0.52	8.42	
(1.96)	(0.66)	(0.28)	(3.13)	(−1.43)			
1.26	−1.29	83.01	0.39	215.50	0.60	47.11	
(0.61)	(−0.61)	(1.00)	(2.46)	(1.05)			
2.07	−1.01	65.33	0.75	0.22	0.57	49.14	x
(0.99)	(−0.46)	(0.75)	(2.49)	(0.00)			
1.00	−0.42	−4.87	0.18	13.00	0.43	8.76	
(2.68)	(−1.00)	(−0.36)	(1.06)	(0.38)			
0.91	−0.63	−5.85	0.44	8.87	0.39	9.01	x
(2.19)	(−1.00)	(−0.42)	(0.73)	(0.25)			
0.73	−0.37	−12.97	0.64	19.75	0.70	11.74	
(1.48)	(−0.67)	(−0.73)	(4.83)	(0.38)			
0.71	−0.47	−16.10	0.72	3.36	0.70	11.80	
(1.42)	(−0.80)	(−1.03)	(3.05)	(0.05)			
0.63	−0.63	−21.87	0.91	−39.73	0.66	12.51	x
(1.31)	(−1.15)	(−1.56)	(4.05)	(−0.87)			
−0.10	0.18	18.19	0.90	−14.30	0.95	5.13	
(−0.46)	(0.75)	(2.49)	(14.02)	(−0.64)			
−0.14	0.14	17.69	0.94	−9.25	0.95	5.15	
(−0.61)	(0.59)	(2.42)	(12.55)	(−0.43)			
−0.06	0.20	16.72	0.87	−28.64	0.95	5.36	x
(−0.30)	(0.84)	(2.72)	(13.90)	(−1.92)			

The coefficients for the lagged and unlagged primary inputs, land, labor, and water, are generally insignificantly different from zero. Only in the case of water input in rice do we have definite expectations a priori with respect to sign, i.e., a positive sign for the unlagged water variable; the sign is, in fact, positive and highly significant. For the input coefficients a test was indicated on p. 329, according to which the product of the coefficient of the lagged variable and the coefficient of the lagged crop area should be equal to the coefficient of the unlagged variable with opposite sign. Since the coefficient of the lagged variable in all cases is positive, except corn, we should, as a minimum, require the lagged and the unlagged coefficients to have opposite signs (except for corn). According to this sign test, the estimates are satisfactory in 23 out of 33 cases.

The coefficient of the lagged crop area falls between 0 and 1 in most cases and is < 1 in all cases selected for predictions; only in one case (corn) is it negative. The significance of the sign of this coefficient is generally high. For seven crops it is significant at the 1 percent level, and only for three (rice, corn, and wheat) is it insignificant at the 5 percent level.

PREDICTIONS OF ACREAGES, 1962–1968

Three different predictions were made for the years 1962 to 1968.

Two were made on the basis of equation (9′), with estimated coefficient values inserted and $K = 0$.[19] In *prediction 1*, actual domestic ex-farm prices were used for calculating F, the relative profitability index; in *prediction 2*, actual international prices (f.o.b. or c.i.f., depending upon whether the commodity is exported or imported) were used for F. These predictions were sequential in the sense that the acreages forecast for one year were used for predicting acreages for the following year. *Prediction 3*, finally, was made on the basis of the stationary form of equation (9), with $K = 0$ for all years, and with actual international prices used for calculating F.

The data used for the predictions are presented in [9, tables], and the calculated F-values are shown in Table A–4. The results of the predictions appear in Table A–3 and are depicted, with the actual acreages, in Charts 7–1 to 7–11.

TABLE A–4

Relative Value of Output per Feddan, F_i, 1961–1968

(at actual ex-farm and international prices)

Crop	Type of Price (1)	1961 (2)	1962 (3)	1963 (4)	1964 (5)	1965 (6)	1966 (7)	1967 (8)	1968 (9)
Cotton									
	Ex-farm	1.38	1.77	1.79	1.96	1.70	1.43	1.51	1.74
	International	1.66	2.06	1.97	2.11	1.84	1.86	2.04	2.20
Rice									
	Ex-farm	1.13	1.03	0.93	0.75	0.82	0.93	1.03	1.11
	International	1.53	1.48	1.42	1.25	1.38	1.34	1.46	1.54
Corn									
	Ex-farm	0.78	0.59	0.65	0.62	0.80	0.95	0.95	0.77
	International	0.68	0.45	0.51	0.53	0.76	0.72	0.64	0.55
Millet									
	Ex-farm	0.98	0.66	0.72	0.71	0.78	0.85	0.90	0.78
	International	0.94	0.65	0.57	0.49	0.58	0.60	0.59	0.57
Wheat									
	Ex-farm	0.87	0.73	0.71	0.65	0.68	0.72	0.70	0.63
	International	0.65	0.57	0.60	0.60	0.56	0.55	0.47	0.39
Barley									
	Ex-farm	0.65	0.56	0.65	0.63	0.48	0.52	0.48	0.39
	International	0.70	0.60	0.54	0.50	0.52	0.55	0.41	0.35
Beans									
	Ex-farm	0.74	0.98	0.78	0.87	0.79	0.90	0.56	0.75
	International	0.44	0.59	0.44	0.44	0.50	0.64	0.31	0.58
Onions									
	Ex-farm	2.59	2.96	2.52	2.15	3.08	2.46	2.63	2.20
	International	3.48	5.03	3.82	3.61	4.58	4.44	7.90	5.09
Lentils									
	Ex-farm	0.93	1.11	0.81	0.53	0.64	0.51	0.45	0.70
	International	1.04	0.75	0.64	0.56	0.72	0.69	0.47	0.72
Helba									
	Ex-farm	0.67	0.75	0.73	0.71	0.75	0.75	0.71	0.62
	International[a]	(0.70)	(0.65)	(0.60)	(0.57)	(0.65)	(0.68)	(0.64)	(0.50)
Cane									
	Ex-farm	2.57	2.17	2.07	1.71	1.99	2.03	1.92	1.99
	International	1.91	1.38	3.48	1.92	0.75	0.71	0.68	0.62

SOURCE: Our calculations. For definition of F_i, see p. 319.

a. In all calculations involving relationships between Helba and other crops values for Helba are at ex-farm prices. This, however, is of importance only for the "international" F_i-value of helba itself.

TABLE A–3

Acreage Predictions, 1962–1968

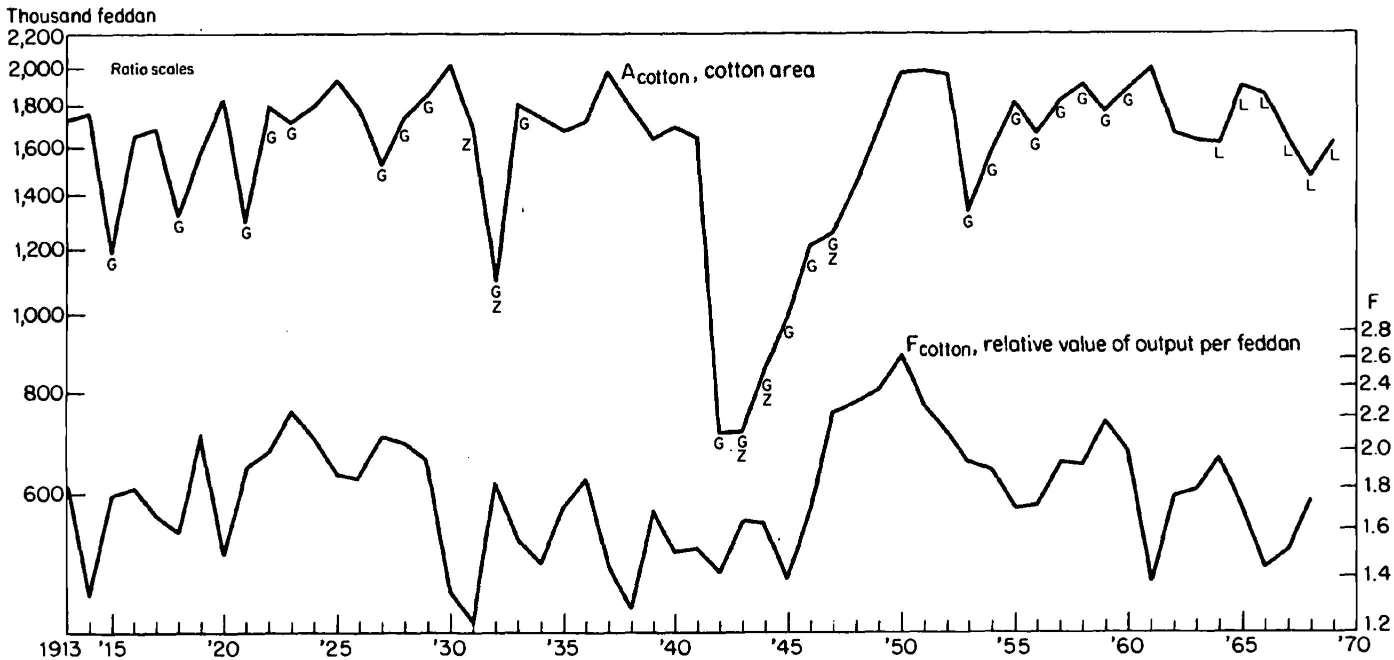
(000 feddan)

Crop (1)	Prediction (2)	1962 (3)	1963 (4)	1964 (5)	1965 (6)	1966 (7)	1967 (8)	1968 (9)
Cotton[a]								
	1	1595	1637	1691	1693	1551	1388	1376
	2	1677	1755	1792	1782	1626	1543	1585
	3	1796	1740	1800	1539	1495	1485	1539
Rice[b]								
	1	674	720	677	859	1126	1316	1458
	2	745	822	787	966	1242	1408	1557
	3	834	852	786	1111	1314	1432	1549
Corn[b]								
	1	1705	1725	1763	1783	1725	1662	1667
	2	1719	1752	1821	1850	1783	1735	1755
	3	1810	1765	1745	1607	1659	1613	1694
Millet[b]								
	1	438	433	415	400	462	548	597
	2	437	434	407	384	443	528	577
	3	453	464	460	547	581	612	616
Wheat[a]								
	1	1462	1456	1506	1523	1588	1706	1757
	2	1444	1444	1502	1526	1585	1696	1744
	3	1410	1486	1109	1434	1694	1700	1715
Barley[a]								
	1	148	138	155	159	154	207	257
	2	156	147	146	132	135	193	233
	3	(−108)	187	167	(−273)	1279	1089	961
Beans[b]								
	1	385	404	399	422	388	376	332
	2	352	335	312	312	277	268	223
	3	320	231	218	237	248	87	217
Onions[c]								
	1	53	50	47	50	48	40	39
	2	55	57	56	61	59	52	60
	3	70	54	49	55	36	42	36
Lentils[b]								
	1	87	89	87	89	72	64	58
	2	90	81	79	87	73	68	59
	3	78	73	70	78	71	63	71
Helba[a]								
	1	66	68	68	73	61	61	57
	2	(67)	(61)	(56)	(58)	(47)	(47)	(40)
	3	(92)	(61)	(39)	(51)	(75)	(42)	(1)
Cane[a]								
	1	107	102	94	82	79	82	86
	2	105	98	97	86	79	79	80
	3	88	133	89	52	46	35	44

NOTE: Prediction 1: Short-term, based on actual ex-farm prices.
Prediction 2: Short-term, based on actual international prices.
Prediction 3: Long-term, based on actual international prices and stationary form.
For Helba, predictions 2 and 3 were made at actual ex-farm prices (for Helba).

a. Estimation method: I.V.2.
b. Estimation method: I.V.1.
c. Estimation method: L.S.

CHART A–2
Response to Area Restrictions



G = General area restrictions
Z = Restriction on special varieties and/or zones
L = Area allotments

NOTES

1. With complementarities (externalities) between crops, such as the important externality between clover and cotton (see Chapter 6), the production function should be written as $y_i(t)f_i(A_i, L_i, W_i, A_j)$. This reformulation, important for the determination of land rentals, for instance, is of no consequence for our problem because it does not change the general form of the area response functions.

2. It would make no difference for our purpose if we assumed that maximization took place at the individual farm level.

3. Paul A. Samuelson [20, p. 5f] has made a fundamental point about models of the type applied here: With commodity prices determined exogenously, with homogeneous production functions, or long-term equilibrium (in the sense that there is no surplus or loss in any line of actual production when factors have been paid according to their marginal productivity), and with the number of commodities exceeding that of factors, the number of commodities actually produced in equilibrium (if it exists) cannot exceed the number of factors. We work in principle with 12 commodities (including clover) and 3 factors; on Samuelson's specifications, 3 crops should be cultivated at most. But the 12 crops we are studying have, in fact, been cultivated during the whole period.

From a purely theoretical point of view, in the case of agriculture, Samuelson's point is not terribly damaging. If we insist upon disaggregating commodities there is no good reason why we should not disaggregate factors as well. A classification of land by fertility and of labor by age and sex would supply us with a large number of factors; land prices and rentals do in fact differ according to fertility, and wages, according to age and sex. Indeed, going to the extreme and considering each person and each acre as a special factor of production, we would end up with about 10 million factors—much more than what even the finest actual market classification of commodities would produce (in 1961 cotton was marketed in 9 varieties and 13 grades, making altogether 117 cotton commodities). All this does not help the present model, however, because we have chosen to work with 12 actually produced commodities and 3 factors.

Samuelson's point, nonetheless, does not apply to our setup—not just because we have not explicitly assumed either homogeneity of production functions or long-term equilibrium, but, rather, because in our case not all factors are paid according to their marginal productivity. Water is delivered free of charge but is not generally available to the point where its marginal productivity is zero. In this sense agriculture is not in full market equilibrium and this circumstance saves us from Samuelson's point. The optimum that we are defining does, however, assume the best possible distribution of water; since market forces do not take care of the distribution of water, the assumption is clearly that the authorities distribute water optimally, and that is, of course, a rather bold assumption.

4. Our specification, that technical progress is Hicks-neutral, may, of course, be misleading.

5. Estimates were first made with variable weights, based on previous years' acreages. However, government restrictions on cotton acreages led to violent fluctuations in actual acreages which strongly affected the relative output value index. To make the index independent of such restrictions, constant weights were chosen.

6. In specifying the area response functions as linear in F_i we have, in effect, made them nonlinear in the (relative) prices. The nonlinearity follows directly from the definition of F_i. With two crops we would, for instance, have

$$F_1 = \frac{y_1 p_1}{w_1 y_1 p_1 + w_2 y_2 p_2} = \frac{1}{w_1 + w_2 y_2 p_2 / y_1 p_1}.$$

If the coefficient of F_1 is positive, the area, A_1, is an increasing function of p_1. As p_1 goes from 0 to $+\infty$, F_1 goes from 0 to $1/w_1$, which means that A_1 goes from a certain lower value to an upper limit. The area response curve, depicting the area as a function of its own crop price, is thus concave as seen from the price axis, which is in line with the traditional assumption of decreasing returns in agriculture. Furthermore, the existence of an upper limit to the crop area is consistent with traditional notions about the conditions of cotton and rice cultivation in Egypt (see Chapter 6, pp. 145–146).

7. Strictly speaking, a further assumption is that domestic prices are independent of whether commodities are exported or imported. Even without trade taxes, this assumption means disregarding the c.i.f.-f.o.b. gap, which, however, is relatively small for most agricultural products. The assumption is much more dubious in respect to trade taxes, since it implies that a given commodity is either taxed at import or subsidized at export at the same rate. It so happens that in our case this assumption is fulfilled to some extent because the government has kept ex-farm prices independent of whether export or import takes place. (A case in point is rice.) In any case, we assume that we know in advance whether a commodity will be exported or imported.

8. The possibility cannot be excluded, however, that in distributing water over the year, the government may actually have reacted to international prices; see Chapter 7, p. 176. Also, in its investment policies for agriculture the government may have taken into account private profitability.

9. If rural labor supply depends upon relative wage levels, we should replace L by the ratio between urban wage rate and agricultural output prices in our area response functions. The rural wage rate would be endogenous to our problem. Depending upon the nature of the labor supply function, other variables might have to be included in the response functions, such as time, prices of manufactured consumer goods, unemployment risks, et cetera.

10. A special study made in connection with the ILO-I.N.P. Rural Employment Survey did not single out wages as a particularly important motive for migration; see [19].

11. Since clover is complementary to cotton, it should have a negative weight in F_{cotton}; and vice versa for cotton in F_{clover}. Since we have used positive weights for all crops in all F, we have in fact assumed away all complementarities. Here is another possible misspecification of the model.

12. An experiment was made with predicting the 1962 cotton area on the basis of the actual yield in 1961 (which was about ⅔ of the "normal") and a "normal" yield. The actual yield predicted more accurately than the "normal" yield.

13. The *Journal Officiel* is not available in any U.S. library for the years 1917 and 1918. We have assumed that for 1918 the limit was one-third, as it actually was in all the other restriction years until 1929.

14. Note: our assumption that half the land is on two-year rotation and half on three-year rotation is of importance only for the ordinate of the kink at 33⅓ percent. At a higher proportion of land on three-year rotation the kinked curve would run a little lower, between 50 and 0.

15. If there were no problem of evasion of controls, the K variable should undoubtedly appear in equation (8) and thus appear in (9′) both lagged and unlagged like the other variables. For, assume that K appears unlagged in (9′), as is the case now, and that area restrictions were introduced for one single year and then removed. With (9′) there would then be a fall in the crop area in the period of control, as there should be; but there would also be a negative effect (diminishing over time) on the area during the following periods from the lagged crops area, $(A_i)_{-1}$. The actual reactions of the farmers might, in fact, even be the opposite: after a year of restriction they might tend to cultivate more cotton that they otherwise would. A lagged K variable would take care of that. To that extent (9′) is clearly misspecified.

We are, however, also confronted with the problem of evasion. We have "solved" that problem simply by deciding a priori that in a series of control years, evasion will be complete in all or at least some of the later years in the series. It stands to reason that evasion will increase gradually from year to year. The actual specification does take care of that problem: when we set the control variable at 0 despite its continued existence, its effects for the previous years will continue (at a diminishing rate) through the lagged crop area. Considering our assumptions about evasion years in Table A–1, it will be seen that the specification of (9') therefore makes sense for the control periods 1921–1923, 1927–1929, 1942–1947, and 1953–1960, but hardly for the single control years 1915, 1918, and the years 1931–1933. And there is always a problem with the years immediately following a series of control years.

For most of the control years our specification may thus be defended, but it is clearly not fully satisfactory. With a more complicated lag structure for the control variable the specification could perhaps be improved.

16. This section was written by Rabab A. Kreidieh.

17. For details, see [13].

18. Ibid.

19. It was not possible to use the K variable for the period of prediction because the controls here took on other forms. For the period of estimation the cotton area restriction always fixed an upper limit to the acreage and left it to the cultivators to decide the area below this limit. During the period of prediction the government imposed a certain acreage upon the cultivators.

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Appendix B

Definition of Concepts and Delineation of Phases

DEFINITION OF CONCEPTS USED IN THE PROJECT

Exchange Rates.

1. *Nominal exchange rate:* The official parity for a transaction. For countries maintaining a single exchange rate registered with the International Monetary Fund, the nominal exchange rate is the registered rate.

2. *Effective exchange rate (EER):* The number of units of local currency actually paid or received for a one-dollar international transaction. Surcharges, tariffs, the implicit interest forgone on guarantee deposits, and any other charges against purchases of goods and services abroad are included, as are rebates, the value of import replenishment rights, and other incentives to earn foreign exchange for sales of goods and services abroad.

3. *Price-level-deflated (PLD) nominal exchange rates:* The nominal exchange rate deflated in relation to some base period by the price level index of the country.

4. *Price-level-deflated EER (PLD-EER):* The EER deflated by the price level index of the country.

5. *Purchasing-power-parity adjusted exchange rates:* The relevant (nominal or effective) exchange rate multiplied by the ratio of the foreign price level to the domestic price level.

Devaluation.

1. *Gross devaluation:* The change in the parity registered with the IMF (or, synonymously in most cases, de jure devaluation).

2. *Net devaluation:* The weighted average of changes in EERs by classes of transactions (or, synonymously in most cases, de facto devaluation).

3. *Real gross devaluation:* The gross devaluation adjusted for the increase in the domestic price level over the relevant period.

4. *Real net devaluation:* The net devaluation similarly adjusted.

Protection Concepts.

1. *Explicit tariff:* The amount of tariff charged against the import of a good as a percentage of the import price (in local currency at the nominal exchange rate) of the good.

2. *Implicit tariff* (or, synonymously, tariff equivalent): The ratio of the domestic price (net of normal distribution costs) minus the c.i.f. import price to the c.i.f. import price in local currency.

3. *Premium:* The windfall profit accruing to the recipient of an import license per dollar of imports. It is the difference between the domestic selling price (net of normal distribution costs) and the landed cost of the item (including tariffs and other charges). The premium is thus the difference between the implicit and the explicit tariff (including other charges) multiplied by the nominal exchange rate.

4. *Nominal tariff:* The tariff—either explicit or implicit as specified—on a commodity.

5. *Effective tariff:* The explicit or implicit tariff on value added as distinct from the nominal tariff on a commodity. This concept is also expressed as the effective rate of protection (ERP) or as the effective protective rate (EPR).

6. *Domestic resource costs (DRC):* The value of domestic resources (evaluated at "shadow" or opportunity cost prices) employed in earning or saving a dollar of foreign exchange (in the value-added sense) when producing domestic goods.

DELINEATION OF PHASES USED IN TRACING THE EVOLUTION OF EXCHANGE CONTROL REGIMES

To achieve comparability of analysis among different countries, each author of a country study was asked to identify the chronological development of his country's payments regime through the following phases. There was no presumption that a country would necessarily pass through all the phases in chronological sequence.

Phase I: During this period, quantitative restrictions on international transactions are imposed and then intensified. They generally are initiated in response to an unsustainable payments deficit and then, for a period, are intensified. During the period when reliance upon quantitative restrictions as a means of controlling the balance of payments is increasing, the country is said to be in Phase I.

Phase II: During this phase, quantitative restrictions are still intense, but various price measures are taken to offset some of the undesired results of the system. Heightened tariffs, surcharges on imports, rebates for exports, special tourist exchange rates, and other price interventions are used in this phase. However, primary reliance continues to be placed on quantitative restrictions.

Phase III: This phase is characterized by an attempt to systematize the changes which take place during Phase II. It generally starts with a formal exchange-rate change and may be accompanied by removal of some of the surcharges, etc., imposed during Phase II and by reduced reliance upon quantitative restrictions. Phase III may be little more than a tidying-up operation (in which case the likelihood is that the country will re-enter Phase II), or it may signal the beginning of withdrawal from reliance upon quantitative restrictions.

Phase IV: If the changes in Phase III result in adjustments within the country, so that liberalization can continue, the country is said to enter Phase IV. The necessary adjustments generally include increased foreign-exchange earnings and gradual relaxation of quantitative restrictions. The latter relaxation may take the form of changes in the nature of quantitative restrictions or of increased foreign-exchange allocations, and thus reduced premiums, under the same administrative system.

Phase V: This is a period during which an exchange regime is fully liberalized. There is full convertibility on current account, and quantitative restrictions are not employed as a means of regulating the ex ante balance of payments.