AGRICULTURAL DEVELOPMENT SYSTEMS
EGYPT PROJECT

UNIVERSITY OF CALIFORNIA, DAVIS

COTTON SUPPLY RESPONSE:
A CASE OF A DISTORTED MARKET

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WORKING PAPER

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I. Introduction

Since the early 1960s, when cotton became a virtual government monopoly, there have been many groups interacting to form cotton policy. It has been argued that there is no room for supply response in such an environment, but this paper will suggest several ways market forces can still impact on cotton production. Farmers may adjust their acreage outside the government guidelines and they may alter the variable factors applied to cotton to affect their yields. The government itself may have a positive supply function. Increases in export prices or the demand for domestic consumption could lead the government to raise domestic prices as an incentive for higher outputs.

The issue of supply response in Egypt is an empirical one that has been examined by many authors. Traditional models of supply have identified a strong responsiveness by Egyptian farmers, but the majority of these studies take only a fraction of their data from the 1960s or later. There is no question of Egyptian farmers' abilities in a mildly constrained market, but under a policy regime as rigid as Egypt's has been over the last 20 years, the responsiveness is an open question.

If the government acted like a profit maximizing monopolist and had complete control over the farmers, traditional supply analysis using domestic prices should show little. Equations including international prices and other macro variables should be far superior in explaining cotton acreage. This paper will try to identify those differences by formulating groups of supply equations and comparing their power. All previous supply studies have looked at cotton as a homogenous product. Here a distinction is made according to staple length. One of the most important areas of government involvement in cotton comes from the development of cotton varieties. Extra long staple (ELS), long staple (LS), and medium long staple (MLS) varieties are constantly being developed and evaluated. The last 10 years has seen a dramatic shift toward LS varieties. Some of the reasons are agronomic, but there could be an economic influence as well. Disaggregation by staple length should offer insights into this issue.

There are three blocks of supply equations examined here. First there is the traditional analysis at the aggregate level using farm-gate prices. Potential problems arise from aggregating heterogenous regions, so the second block looks at domestic price governorate level supply. The third exercise examines the aggregate decisions using international prices in an attempt to capture the government's responsiveness. All these, using standard methodologies, look at the period 1964 to 1979 to focus on the years in which the government had its extensive controls in place.

The major studies on cotton supply that have preceded this one can be traced back to Porter (1958) and Stern (1959). The use of international prices and the failure to include prices of substitute crops, prevented Porter from identifying any positive supply response. Stern used domestic wholesale prices of cotton and its substitutes, and found significant positive elasticities in the range 0 to .9. This was the first major evidence of Egyptian farmers' responsivemess.

El-Shaial (1960) showed the power of using lagged versus current priced in the supply analysis. Hazen and Marzouk (1965) used relative profitabilities of crop rotations to test for supply responsiveness and found short run elasticities between .1 and .4.

Several dissertations since 1970 have been completed that build on the above. Shoghrab (1976) developed Nerlove-type models of supply to distinguish between long and short run elasticities. El-Hamawy (1970) examined upper, middle, and lower Egypt separately and discovered significant variation in supply elasticity which he attributed to different degrees of government control. Confirmation of Hansen's study came from Mustafa (1978), who used relative profitabilities to find an elasticity of .3. Khedr (1973) was the first to correct for shifts in production due to variables like pest infestation, and also found elasticities near .5.

Zaki (1976) was the first to examine supply response by governorate. Using a Nerlove model and a relative price variable that was a weighted average of all of a region's competing crops, he found strong acreage supply response over the period 1944-1966. There was little apparent yield elasticity with respect to price.

Several studies have recently emerged that focus more on the period since 1960. Taha (1980), Sarris, et al (1981), and Cuddihy (1980), all find some responsiveness in the aggregate. These papers continue to support the belief in responsiveness of cotton farmers. They did not examine issues of government decision-making, or look at supply by staple length.

This paper is a logical outgrowth of the cited works. It extends Zaki's governorate analysis into the 1960s and 1970s. It also pushes beyond the more traditional analysis to include variables capturing government decision-making. In this way we hope to continue to expand the understanding of the Egyptian cotton economy.

II. The Model and Its Specification

The ideal supply model relates total production to the expected prices of the output and the competing alternatives. Agricultural supply is special in that the decision process can be broken into acreage decisions and yield decisions. An obvious way to adjust production is to change the acreage devoted to the crop. If the acreage decision is constrained by technical conditions or by government policy, farmers may have to adjust production through the application of variable inputs.

In the United States, supply studies have usually found a strong acreage price response, but little yield price response for the major field crops. This is likely due to two factors. First, the yield response curve may be very steep over the initial range of variable inputs, but then level off dramatically. This would lead to farmers making their optimal acreage decision on the assumption that the variable inputs would be applied to achieve near maximum yields. If the price of the crop fell relative to its substitutes, the opportunity cost of maintaining the acreage, but lowering yields would be very high. The second factor leading to weak yields would be very high. The second factor leading to weak yield equations is the inherent variability due to weather. If this is great enough, the random components will swamp the systematic, camouflaging the yield price response.

In Egypt, with government controlling to a great extent the cotton acreage and generally taxing cotton production by offering low farm-gate prices, yield response could be significant. Zaki discovered little in the way of yield response, but he was examining a much less constrained period.

The issue of expectations is an important one. Ideally, one would have variables stating the farmers' beliefs on what crop prices would be at the harvest time, but these are, of course, unobservable. The Nerlove model of adaptive expectations leads to a functional form that includes lagged prices and acreage. The implicit behavior behind this model is a restrictive one that does not necessarily meet our a priori views of farmers. Gardner (1976) used futures prices as a proxy for expected prices in his supply equations. Petzel (1978) and Shonkwiler and Emerson (1982) construct rational expectations models to form external price variables in their respective studies of soybeans and tomatoes.

The most effective supply equations estimated for Egyptian cotton have used lagged prices or relative profitabilities. Some of these studies have included lagged acreage, others have not. It is therefore difficult to identify if the Nerlove behavioral assumptions are appropriate, or if the lagged price is simply the best expectation variable available.

The most important consideration here is the identification of the key crops with which decisions about cotton are formed. Since cotton substitutes with different crops depending on the area, an aggregate analysis faces several problems. In Minya the key substitute crop might be sugar, while in Beheira it might be rice. A national supply curve would ideally identify all of the important prices, but in fact due to the multicollinearity across crop prices, many of these effects may be hidden.

There are three types of supply responses that may be investigated. There is a yield response by farmers and acreage decisions by both farmers and the government. The independent variables may be either relative prices or relative profitabilities of the crops in question. Both have advantages and drawbacks. If there is a secular change in the yield of any particular crop, the use of prices can distort the relative attractiveness of that crop. On the other hand, if yields have a large random component, there is an error in measurement problem which, with a short time series, will lead toward rejection of the idea that there is supply responsiveness. Both specifications will be tried below.

The data are from official Ministry of Agriculture sources covering the years 1964 to 1979. This has been divided by staple length and governorate to achieve the level of disaggregation desired. The empirical work was broken into three sections: (1) acreage and yield response to domestic prices at the aggregate level, (2) acreage and yield response to domestic prices at the governorate level, and (3) acreage response to international prices and macro variables like the trade deficit. This latter section will test the profit maximizing behavior of the government.

Econometrically, the first two sections will be quite standard. Specifications will include lagged prices and will test for the inclusion of the lagged dependent variable. The final section will look at the acreage decisions of ELS, LS and MLS cotton and will turn to a systems approach to evaluate the overall supply response.

III. Estimation and Results

Since there was no a priori expectation that one behavioral model was superior to another, several specifications were tried. There were two goals throughout the analysis. First, consistency of decisions was important. If one equation performed marginally better with the inclusion of lagged acreage, while the rest in that section did not, the lagged variable was removed. Supply analysis is more than an exercise in maximizing R^2; it is useful only when a broad, consistent pattern of behavior is identified. The second goal was to form specifications that made sense in terms of the agronomic patterns prevailing. It is far from comforting to explain 80 percent of cotton acreage variation using the relative price of a crop that comprises 2 percent of cultivated land in that area. However if enough specifications are tried, and the time series in question are short and trended, this can easily occur.

What follow below are the empirical supply equations that were found to be most effective or interesting. Behind the reported tables lie many more equations that failed for a variety of reasons. Much was gained from these failures including insights on the nature of the true response behavior.

A. Aggregate Supply to Domestic Prices

The first examination is in the spirit of the works cited above, except that the aggregate cotton acreage is divided by staple length. Separate equations were tried to explain ELS, LS, and MLS total acreages and yields. Both relative prices and relative profitabilities were examined.

The acreage equations were quite unsuccessful using either prices or profitabilities. The inclusion of lagged acreage raised the R^2s, but added little to the understanding of supply response. The yield equations were more successful. Table 1 gives the three best equations for the staple lengths.

ELS yields were affected, as expected, by the profitability of clover/maize and tomato/maize rotations. This would suggest that as maize became more profitable, some of the variable inputs normally applied to cotton were diverted. The partial elasticities of .26 and .11 are quite high for yield adjustments. LS yields were similarly affected by clover/groundnuts and clover/maize rotations.

Table 1.--Aggregate Relative Profitability Yield Equations
1964-1979

I. ELS Cotton

$$ELSY = 31.17 - .26X_1 - .11X_2$$

(5.44) (2.35)

$R^2 = .84$ $F = 5.50$

II. LS Cotton

$$LSY = 25.86 - .19X_3 - .12X_4$$

(2.24) (1.55)

$R^2 = .57$ $F = 2.33$

III. MLS Cotton

$$MLSY = 1.05 - .56X_5 + .39X_6$$

(2.98) (1.75)

$R^2 = .56$ $F = 3.01$

Note: All equations are in double log form. ELSY, LSY, and MLSY are average yields of ELS, LS, and MLS cotton respectively.

Xs are relative profitability of rotation variables.

X_1 = Permanent clover and maize to temporary clover and ELS cotton

X_2 = Tomato and maize to temporary clover and ELS cotton

X_3 = Permanent clover and groundnuts to temporary clover and LS cotton

X_4 = Permanent clover and maize to temporary clover and LS cotton

X_5 = Lentils and sorghum to temporary clover and MLS cotton

X_6 = Lentils and sesame to temporary clover and MLS cotton

Equation III in Table 1 demonstrates one of the common problems in time series analysis. The rotations of lentils/sorghum and lentils/sesame are highly correlated, due to the common element. The equation says the lentils/sesame and cotton are complementary. Both elasticities are extremely high individually. The total elasticity of MLS yields to change in cotton prices is the sum of these two values, .17, which is more reasonable.

The importance of geographical location is evident in these regressions as the important substitute crops change with staple length. This geographical distinction will be expanded in the next section.

B. Governorate Supply to Domestic Prices

For the three staple lengths under investigation, key governorates were identified and estimation of yield and acreage responses made. Two methods of estimation were tried. Traditional single equation models were first estimated, and then, in hopes of expanding the degrees of freedom, a pooled cross section time series model was applied to each staple length. Here it was believed that information across space, as well as across time, could be used to refine the estimates.

The traditional acreage equations using relative prices (Table 2) performed best. The overall equations were quite strong and showed two things. First, identifying the relevant substitute crops is much easier at the governorate level than at the aggregate, and second that the acreage responsiveness is remarkably high for period of heavy government control. Comparison of the equations within staple length also suggests reasons for the aggregate acreage equations' failure. There is a unique price in almost every equation. For ELS, Beheira responds to rice and tomatoes, Kafr Al-Sheikh to maize, and El Daqahliya to wheat, potatoes, and maize. Aggregating these acreages and then trying to find one or two key prices is bound to lead to failure.

In a few of the governorates investigated, adding lagged acreage raised the R^2 considerably and lowered somewhat the short run elasticity estimates. The effect was not consistent however, and there was no a priori reason to expect a Nerlove-type model to apply in one location and not another, so these variables were dropped. Supply equations without trend or lagged dependent variables rarely have as much explanatory power as equations including those variables have, which is a strong testament to the supply responsiveness round.

The yield equations for the governorates were at the opposite extreme. No specification produced reasonable results, which poses a question about the aggregate results. However, the consistency of expected signs and relevant crops in the aggregate equations suggests that yield variation within governorates has a large random component which may be mitigated upon aggregation. A good year in governorate A could cancel a bad year in B, to reveal that both sets of farmers had tried to reduce yields in the face of falling prices. The governorate

Table 2.--Governorate Area Supply Functions 1964-1979

I. ELS Cotton

A. Beheira

ELSA = 9.27 - .59 P rice - .24 P tomato
(22.94) (-8.18) (-4.18)

R^2 = .90 F = 51.91

B. Kafr Al-Sheikh

ELSA = 8.15 - 1.09 P maize
(-3.09)

R^2 = .42 F = 9.56

C. El Daqahliya

ELSA = 9.22 + 1.93 P wheat - .84 P potato - 1.88 P maize
(3.10) F = 18.76

R^2 = .84

II. LS Cotton

A. Sharqiya

LSA = 11.76 - .60 P maize - .37 P rice - .55 P potatoes
(14.42) (-5.95) (-2.03) (-8.52)

R^2 = .96 F = 30.65

B. Minufiya

LSA = 18.28 - 3.63 P beans
(5.01) (-3.87)

R^2 = .54 F = 14.96

C. El Qalyubiya

LSA = 7.83 - .85 P potatoes
(6.42) (-3.52)

R^2 = .49 F = 12.42

[continued on next page]

III. MLS Cotton

A. Beni Suef

MLSA = 7.42 - .89 P maize

(10.67) (-4.28)

R^W = .60 F = 18.23

B. El Minya

MLSA = 13.56 - 1.07 P sugar - 1.68 P sorghum

(6.43) (-4.42) (-2.81)

R^2 = .74 F = 13.24

Notes: All dependent variables are the logrithms of acreage. All independent variables are the logrithms of lagged prices of the listed crop relative to the relevant staple lenght cotton price. t statistics are in parentheses.

response analysis at every other level is superior. It is easier to identify the relevant crops, and the variation in prices is a regional one, so key movements are not masked by averaging at the aggregate level.

C. Aggregate Export Price Supply

The models presented below suggest the behavior of a government that has a monopoly on production of cotton, and looks, at least in part, to the international market for guidance on how to maximize profits. Since acreage decisions are coordinated across staple lengths, it is appropriate to build a system across the three staple lengths' acreages. LS cotton can be considered pivotal in that it can substitute in production for ELS and MLS cottons. Since ELS and MLS varieties do not compete for the same land, their interaction will have to be indirect working through the LS acreage decision. It is also important to note that MLS cotton is totally consumed at home while ELS cotton is largely exported. If this situation is taken as a given, then there is little reason to expect shifts in the export price of MLS varieties to impact on acreage. Other variables that were considered potentially important in a model of macro-level decision making included the stocks of cotton (by staple length) on hand prior to planting, and the balance of trade deficit. Many specifications of these models were tried to see if key factors could be identified.

In Table 3, two systems were presented. The first system of three equations examines absolute acreage. ELS cotton acreage is a function of LS acreage, the lagged relative (ELS/LS) export price, and the trade deficit. LS acreage depends on both ELS and MLS acreage, an index of spinning activity in the country, and the lagged relative export price. MLS is only a function of LS acreage and its lagged price relative to that of LS cotton. Estimation was by three-stage least squares.

Table 3.--Government Supply Equation Systems 1964-1979

A. Acreage system

1. ELSA = 11.26 - .75 LSA - .68 P (ELS/LS) - .08 trade deficit
   (8.09) (-3.34) (-1.25) (-1.30)

2. LSA = -.19 + .64 ELSA - .39 MLSA + .85 spinning + .28 P (ELS/LS)
   (-.02) (1.19) (-2.36) (.70) (.40)

3. MLSA = 21.15 - 2.50 LSA - .29 P (MLS/LS)
   (7.10) (-5.17) (-.45)

Weighted R^2 for system = .83

B. Share system

1. ELSP = .49 - .25 P (ELS/LS) - .02 trade deficit
   (14.80) (-1.90) (-1.23)

2. LSP = -2.46 - .13 P (ELS/LS) + .45 spinning
   (-6.26) (-.89) (7.07)

3. MLSP = .25 - .09 P (MLS/LS)
   (9.50) (-.53)

Weighted R^2 for system = .62

Notes: All variables are logrithms. t statistics are in parentheses. ELS, ELSP are total ELS acreage and percentage of total cotton acreage in ELS varieties respectively. All independent variables are lagged.

The weighted R^2 is high, but the individual results are not impressive. The key variables are the other acreages which says only that as LS acreage has expanded it has been largely at the expense of MLS and to a lesser extent ELS. The economic variables in this and other specifications perform poorly. Spinning activity in the LS equation appears appropriate, but in fact, since a much greater fraction of MLS cotton is spun domestically, the spinning variable is more appropriately placed in the MLS equation. When this happens the coefficient is negative and significant. Obviously, all that is being captured is simultaneous trends.

An alternative system explaining the share of cotton output devoted to a particular staple length is also presented. Here the estimation technique constrained the estimators so that the shares would always sum to 1. The hope was to eliminate some of the trends in the raw data, but it was not successful. There is no evidence to suggest that the government is looking systematically at export prices, trade deficits or stocks is setting cotton acreage.

IV. Summary and Conclusions

This paper has expanded supply analysis of Egyptian cotton in many directions. Separate decision-making by farmers and the government was discussed and explored empirically. Not all of the findings were robust, but many important factors have been identified. The importance of treating cotton by disaggregating it geographically and by staple length was certainly demonstrated. Strong acreage supply response was found at the governorate level, a weak yield response was evident at the aggregate level. This was not unlike the conclusions of Sarris, et al (1981) who have done a broad study of agricultural supply for the similar period.

What is surprising is how large the acreage elasticities are given the seemingly tight control of the government in setting acreages. Also surprising is the failure to identify any government response to external or macro forces. The conclusions and policy implications have to be based as much on these negative results as on the positive.

It is possible that the high elasticities of supply from the governorate equations capture not only the farmer's response, but that of an inward looking government. Acreage and prices are set so that when profitability of growing cotton increases to the farmer one year, the government feels it can increase the required quotas for the next. This shift in policy would show up as a supply response in our equations, and would seem to be the only kind of behavior that would produce such large elasticities.

The complete failure of the aggregate systems says that the government has ignored profit opportunities in cotton exports, by failing to take advantage of shifting market conditions. This policy of neglect is shown additionally by the dramatic decline in cotton's share of Egypt's exports.

From a policy perspective two conclusions can be reached. First, if a government insists on setting acreages, it is good that they work in the direction of the farmer's natural inclination and not against it. Unfortunately, the cotton policy has downplayed a very important sector, and that is the export market. It seems terrible to overlook the profit opportunities that would be available if the government were as responsive to world prices as they and the farmers are to the domestic situtation.

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Name: Richard L. Nelson Expected Completion Date: June 1983
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Dissertation Title: "An Economic Analysis of Residue Management Alternatives to Open-Field Burning of Rice Straw in the Sacramento Valley Air Basin"

Dissertation Chair: Del Gardner Other Committee Members: Chet McCorkle, Bob Webster (Plant Path.)

Two-Sentence Abstract: This research will determine the economic impacts on the Sacramento Valley rice industry of a reduced reliance on open-field burning of rice straw by developing an economic model of the valley's rice industry and simulating policy alternatives.

Preferred Teaching Interests: Production Economics, Natural Resource Economics, Environmental Economics and Policy.

Teaching Experience (TA or Other): limited to TA position for land economics class, natural resource conservation policy class, and production theory class; also several "guest" lectures.

Future Research Interests:
Natural Resource Economics, Environmental Economics and Policy, Energy Economics, etc.

Publications or Papers in Preparation: "Rice Straw Burning and Crop Residue Management: An Economist's Viewpoint," with B.D.Gardner; "Rice Straw Burning: Alternative Policy Implications," with P.K.Thor, & C.R.Heaton.

Job Preference - Teaching; Teaching/Research; Other: Research

Institutional Preference: University (Ag. Econ., Econ., Other) Private
Government, Private

Fields: (In order of preference) Natural Resource Economics, Environmental Econ. & Policy

How would you describe yourself: (i.e. production economist, econometrician, etc.)

Natural Resource Economist

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Name: Mary Ott Expected Completion Date: 7-83
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Dissertation Title: The Role of the Private Sector as a Provider of Industrial Training: The Case of the Honduran Furniture Industry

Dissertation Chair: Hansen Other Committee Members: Martin, Green

Two-Sentence Abstract: Study looks at on-the-job training in carpentry in ~~[illegible]~~ furniture firms of 12 to 153 workers, to compare with formal vocational programs, and to analyze benefits of training to workers.

Preferred Teaching Interests: Microtheory, Economic Development, International Economics, Macrotheory (undergraduate)

Teaching Experience (TA or Other): TA 200A (twice), 147 Nat. Res Economics, 100B Microtheory

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Publications or Papers in Preparation:

Job Preference - Teaching; Teaching/Research; Other: Teaching/Research

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Government, Private

Fields: (In order of preference) International Trade, Development

How would you describe yourself: (i.e. production economist, econometrician, etc.)

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