Title
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Publication Date
1984-02-01

Working Paper No. 294

AGRICULTURAL OUTPUT AND EFFECTIVENESS OF GOVERNMENT POLICY

by

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Giannini Foundation of Agricultural Economics
February, 1984

ABSTRACT

A model is presented to assess the effects of changes in agricultural target prices, support prices, diversion payments and eligibility requirements on farmer's production decisions. Hypothesis tests are constructed to test the statistical significance of various policy and economic variables. The central features of this paper are: 1) complete incorporation of the past and current program offerings into the farmer's objective function, and 2) the use of Zellner's seemingly unrelated regression (SUR) model to estimate the aggregate acreage and yield responses for wheat, feed grains and soybeans. These features, along with an expanded data set, differentiate the present study from the previous literature.

INTRODUCTION

Since the first Agricultutal Act, in 1933, the king pin of U.S. agricultural policy has been and remains production controls. Over the decades, whenever agricultural commodity surpluses have arisen, the government response was to require mandatory acreage reductions or to offer incentives to reduce input use, primarily land. Since 1963, the government has not imposed any kind of mandatory controls on production and has instead relied solely on voluntary programs.

During the past twenty years, the particular provisions contained in farm programs for restricting production have changed from farm act to farm act. However, even with the large number of programs that have been enacted, the basic features of each program have remained amazingly similar. The principal policy techniques for controlling crop production are: 1) support and target price protection, and other benefits which are contingent on reducing acreage planted, and 2) direct payments made to farmers who reduce their acreage planted of specified crops. The general concensus in the literature is that these voluntary programs have been fairly successful from the standpoint of reducing excess supplies, but they have also been costly to U.S. taxpayers.

The purpose of this paper is to establish a model of farmer response to the various policies that have been offered to farmers since 1961. The theoretical structure is built up from the individual farmer level so that it provides an understanding of the incentive structure that each farmer faces in deciding whether to participate in the programs being offered and how mùch to produce. Empirical models are developed for the feed grains (corn and grain sorghum), wheat and soybeans at the national level. Hypothesis tests are constructed to test the statistical significance of the policy and economic variables. Estimated elasticities of supply for changes in prices and policy levels are reported.

These models differ substantially from their predecessors. First, each model includes specific elements of each government program. Second, the entire period of estimation is over a time in which program compliance was voluntary. Third, Zellner's seemingly unrelated regression (SUR) method of estimation was used to estimate the entire system of equations.

MAJOR AGRICULTURAL POLICY FEATURES SINCE THE 1950'S

Since the early 1930's, agricultural policy has been oriented toward stability and raising farm incomes. The government directed supply by offering price support protection through non-recourse loans and other program benefits to farmers who planted within their acreage allotment. Price support protection is achieved by allowing a program participant to receive a non-recourse loan when he places any amount of grain produced on the allowable acreage allotment in approved storage. The dollar value of the non-recourse loan is equal to the loan rate multiplied by the quantity placed in storage. If the price then falls below the loan rate, a farmer can forfeit the stored grain in lieu of repaying the loan. If the market price goes above the loan rate, a farmer can repay the loan and sell the grain at the higher market price. The overall effect is to offer the participating farmer a minimum guaranteed price for his production.

A more stringent method for controlling supply was the marketing quota. Marketing quotas restricted the quantity of grain any farmer could sell on the market for cash. Marketing quotas could only be implemented by a producer referendum initiated by the Secretary of Agriculture. If a farmer planted in excess of his allotment when a marketing quota was in effect, he lost not only his eligibility to receive price supports and other payments, but could also be charged financial penalties on excess production.

Non-compliance with acreage allotments for a number of years resulted in the complete loss of the farmer's allotment, and thus his eligibility for future programs.

Clearly, the programs of the 1950's were not truly voluntary in nature. First, a farmer's decision not to participate in any particular year could result in his not being able to participate in future programs. Second, in years with a marketing quota in effect, he could decide not to participate only at the risk of having to pay penalties to the government.

Authorization for the feed grain allotment program was terminated in 1959. Farmers faced no restrictions on production again until 1961.

A fundamental change in policy direction came in with the 1960's. In 1961, a new voluntary feed grain program was implemented. In order to obtain price support protection (non-recourse loans), farmers were required to divert land from corn and grain sorghum production. As an added incentive, acreage diversion payments were offered to producers of feed grains who idled land beyond the minimum required diversion. These new programs amount to bribing farmers not to produce. Those farmers who decided not to plant within the program's acreage limits faced neither fines, penalties nor potential loss of opportunities to participate in future programs.

This represented a dramatic change in the nature of farm programs.

Similar programs were established for wheat in 1963.

The Agriculture Acts of 1963 and 1964 continued further in the direction of the 1961 feed grain program. The 1963 and 64 Acts implemented price support payments which were direct income supplements given to wheat and feed grain farmers who diverted a specific acreage to conservation uses. The new programs maintained the old provisions that producers must comply with acreage reductions to receive price support protection through non-recourse loans. The 1963 and 64 policy did away with all of the remaining mandatory features of the programs of the 1950's for both wheat and feed grains. All parts of the programs became strictly voluntary.

The 1973 Agriculture Act introduced the target price concept for wheat and feed grains that is still in effect today. The target price concept guarantees a certain minimum income level to farmers who participate in any acreage reduction program. This is done through direct payments to producers, called deficiency payments. When the market price slips below an established level (the target price), participating farmers receive the difference between the target price and the higher of the market or the support price on their normal production. In some years, a market allocation factor, which is not known to farmers in advance, is multiplied by the deficiency payment to determine the total payment. The allocation factor is legislated to be between .8 and 1.0.

The 1973 Act maintained the concepts of non-recourse loans and additional paid voluntary land diversions. Also, compliance with acreage reductions, when they are in effect, is required to receive any of the program benefits.

The major features of feed grain and wheat programs have remained essentially unchanged from 1973 through 1982. Developments since 1982 are not considered in this paper.

From the 1950's onward, soybean producers were eligible for price support protection through non-recourse loans. Unlike the feed grain and wheat programs, the soybean program is permissive. Soybean producers are eligible for price support payments without any obligation to restrict acreage. However, with few exceptions, the market price for soybeans has remained above the support level so the program has been largely unused.

PREVIOUS LITERATURE

Previous studies have focused on constructing models capable of predicting the impact of government programs on farmers' aggregate acreage response. Houck and Ryan, 1972 [1] produced the first such study. In that paper, Houck and Ryan estimate an equation for corn acreage response for the U.S. The most interesting components of their model are variables which reflect the effects of government price support and acreage restriction programs.

Refined versions of these policy variables are presented in a study by Houck, Abel, Ryan, Gallagher, Hoffman and Penn, 1976 [2]. The policy variables defined by Houck, et al, have become the standard government variables on which most subsequent studies rely. Houck, et al's, basic model is formulated in Equation 1:

$$A = f(M, G, Z) \tag{1}$$

where

A represents acreage planted,

M represents the composite of all open market economic forces affecting the aggregate decision to plant,

G represents all relevant government policy provisions which affect planting decisions, and

Z represents all other supply-determining factors.

The components of M include the historical prices for the crop under consideration, the substitutes for that crop and the prices of factor inputs. The elements of Z include weather, crop production technology and past decisions concerning crop rotations. Two variables are formulated for each crop to represent the various government policies G. These are the effective support rate PF and the effective diversion payment DP. These policy variables are explained below.

Assume that farmers are facing a given set of historical prices and other supply shiftors. Suppose that the government announces a price support to raise farm income, but attaches no acreage restrictions to eligibility for the support. Then, as can be seen in Figure 1, farmers will want to plant A_1 acres. With an increase in the support price without accompanying acreage restrictions, farmers will want to plant additional acreage, giving S its upward slope. The exact position and slope of S are related to the previous market prices M, the other supply shifters Z and the government program variables G.

Now, if the government desires that farmers plant only A_2 acres (based on the belief that this is the acreage necessary, assuming some yield per acre, to just equate supply and demand) the government can achieve this acreage by imposing an acreage restriction on farmers as a prerequisite to support price protection. This has the impact of reducing the effective support price a farmer can receive

Figure 1

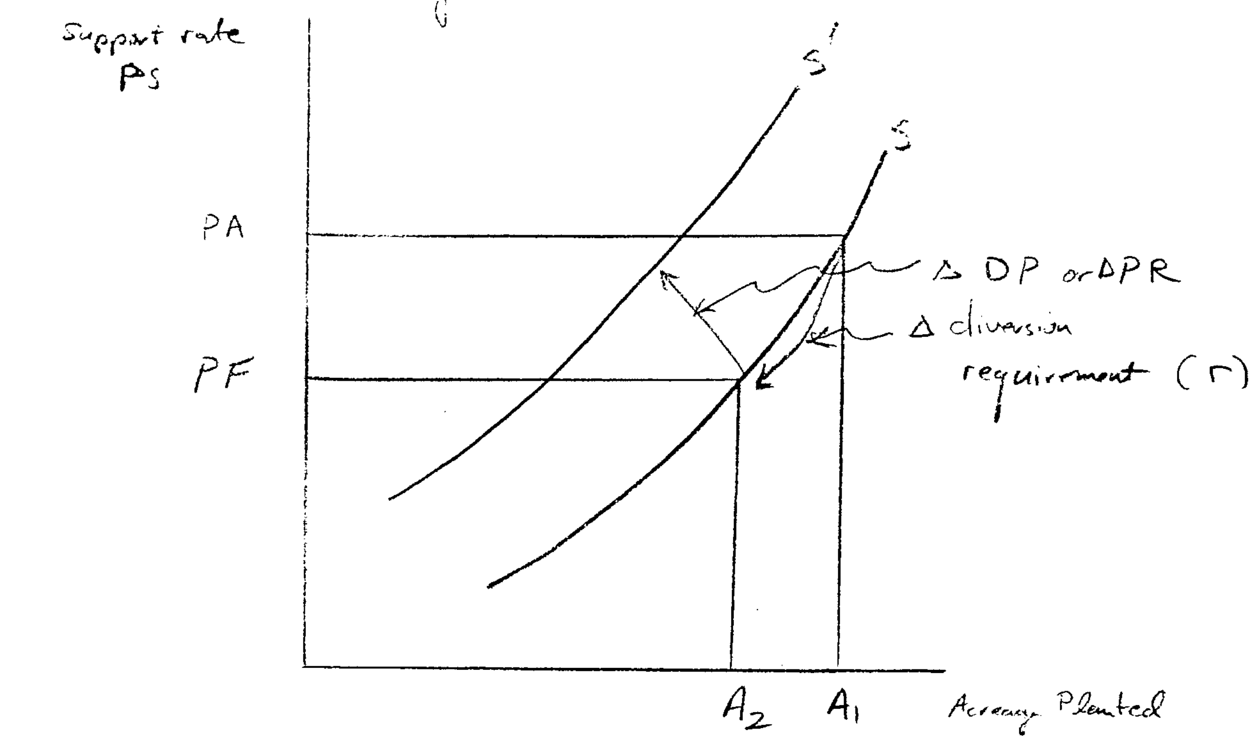
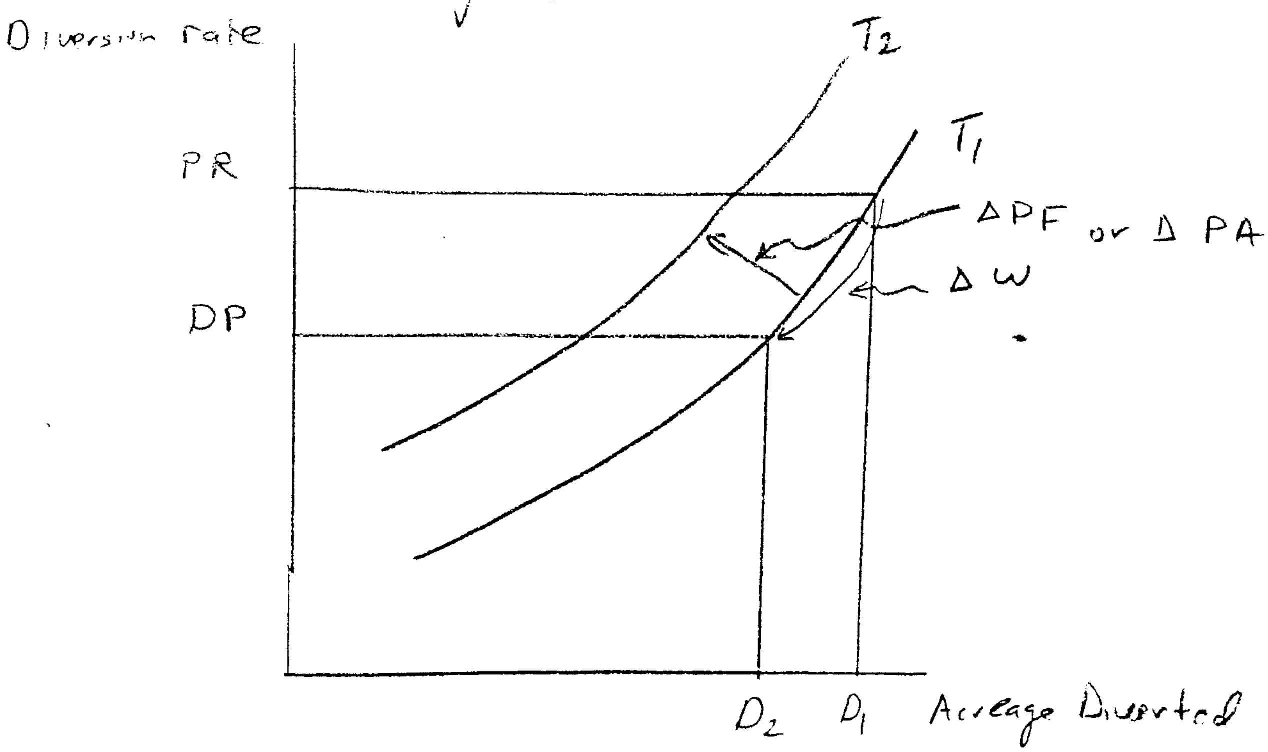


Figure 2



from PA to PF, and is represented on Figure 1 as a movement along the curve labeled S.

The effective support price can be written as PF = rPA where r is an adjustment factor which embodies the planting constraint attached to the eligibility for support price protection. Generally r will lie between 0.0 and 1.0. As the planting restriction becomes tighter, r will move closer to 0.0. Furthermore, as r moves away from 1.0, the government is offering participating farmers income protection approximated by area C in Figure 1, since farmers will be guaranteed the support price PA on their production on the A_2 acres they are allowed to plant.

Houck, et al's, precise measure for PF is formulated as:

$$PF^i = r\ PA^i = \left[\frac{1}{2}\left(\frac{A^i_{min}}{A^i_0} + \frac{A^i_{max}}{A^i_0}\right)\right] PA^i \qquad (2)$$

where

PA^i = Announced support price for feed grain i

A^i_0 = Base acreage of feed grain i

A^i_{min} = Minimum acreage of i allowable under price program

A^i_{max} = Maximum acreage of i allowable under price program

PF^i = Effective price support

Houck, et al, include a separate variable that incorporates voluntary acreage diversion programs DP. The conceptual development of the voluntary diversion DP parallels that of the effective support payment. Suppose the government wants to keep production at some level by holding acreage at A_2 as above. The government can accomplish this even when offering support payments without acreage restrictions by paying farmers to divert acreage from crop production to conservation use. If PR is the payment rate for diversion and w is the portion of the base acreage A_1 eligible for diversion, then the effective diversion payment is DP = wPR for a fixed w. Changes in PR are represented by movements along T_1 in Figure 2. Similarly, the imposition of a constraint on the maximum acreage eligible for diversion while holding PR constant can be represented as a move along T_1 from D_1 to D_2. At a fixed level of PR, w can range between 0.0 and 1.0, with no restrictions on acreage represented by 1.0.

The T curve is upward sloping since an increase in the diversion rate (diversion payment per acre) will be necessary to induce farmers to hold land out of crop production. Again, the exact slope and location of T will depend on last years prices, the support rate and other supply shifters.

Houck's exact construction for effective diversion payments DP is:

$$DP^i = \frac{1}{2}\left(\frac{D^i_{min}}{A^i_0}\right) PR^i_1 + \frac{1}{2}\left(\frac{D^i_{max}}{A^i_0}\right) PR^i_2 \qquad (3)$$

where

PR_1^i = Diversion payment rate for levels of diversion near the minimum requirement

PR_2^i = Diversion payment rate for levels of diverison near the maximum allowable

D_{min}^i = Minimum acreage diversion requirement

D_{max}^i = Maximum acreage diversion allowable

A_0^i = Base acreage

The interaction between the two government variables is characterized by shifts in the S and T schedules. An increase in the effective support payment PF and/or and increase in the support rate PA will shift the T_1 schedule in Figure 2 to T_2. An increase in the effective diversion payment DP or the diversion rate PR will shift the S_1 schedule to S_2.

Houck, et al, specify the typical acreage equation as:

$$AX_t = a_0 + a_1PX_{t-1} + a_2PFX_t + a_3DPX_t + a_4PFY_t + a_5DPY_t + a_6K_t + U_t \quad (4)$$

where

AX_t = Acreage planted of X in year t

PX_{t-1} = Previous year's market price of X

PFX_t = The value of DP for crop X in year t (reflecting both payment rates and the proportion of base acreage eligible for diversion)

PFY_t = The value of PF for crop Y in year t

DPY_t = The value of DP for crop Y in year t

K_t = All other relevant supply shifters in year t

U_t = A mean-zero, serially independent random variable with finite variance.

Using the above model specification, Houck, et al, estimated separate equations (using OLS) for corn, soybeans, wheat, cotton, oats and barley acreages. Their results exemplify the use of the effective support rate and effective diversion payment concepts as a way to incorporate government program variables into the aggregate acreage response equation.

However, Houck, et al's, model fails in several important ways. One, the model implies that an increase in the diversion requirement (planting constraint attached to the availability of the support price PA) always results in a decrease in the acreage planted. This may not happen if the market price is high enough to make program participation an unprofitable alternative when compared to not participating in the program. Furthermore, with everything else constant, increasing the diversion requirement may well result in increased acreage planted since the increase in the diversion requirement may push farmers out of the program by making profits from compliance less than profits from non-compliance. This will become more clear in the model section of this paper.

Two, the model as outlined depends critically on the market price residing below the effective support rate PF. If market price is higher than the effective support rate, no farmers would be willing to participate in any post-1961 voluntary diversion program. Therefore, small changes in the support rate and/or the diversion requirement would not have any effect on the acreage planted.

Three, the model as outlined fails to include many other benefits associated with program compliance in the post-1961 years. Among these are 1) cost savings from not planting and 2) interest rate subsidies offered from the Commodity Credit Corporation to farmers in compliance with the program.

Four, the model is estimated using OLS and, assuming that the sample can be considered large, efficiency can be gained by using Zellner's seemingly unrelated regression (SUR) method of estimation since the error terms in each equation are subject to the same kinds of unknown influences.

Five, the model that is actually estimated fails to include any variable for variable input cost (fertilizer, labor, machinery, etc.) even though this is discussed in the theoretical section. If these variables are part of the "true" model, then the coefficients of the estimated model will be biased and inconsistent.

Six, the model uses price to measure farmers' price expectations. This is a very naive approach. Several authors have crticized this and estimated various other models using alternative approaches.

Seven, the model fails to take farmers' yield per acre responses into account. Clearly, government programs may at the same time give farmers an incentive to reduce acreage and increase the yield per acre. These effects may offset each other to the degree that government programs have no impact on total agricultural production. This has obvious and important policy implications.

Eight, the empirical models are estimated over the interval extending from 1948-1969. This estimation interval includes two different policy regimes. As discussed in the historical section above, prior to 1959 there were penalties for non-compliance, while government programs after 1960 were voluntary. Thus, it seems likely that there should be structural breaks in the model between the 1948-1958 period, the free market period of 1959-1960, and the 1961-1969 period. However, Houck, et al, restrict the estimated coefficients to be the same throughout the period of estimation.

Studies of acreage response subsequent to Houck and Ryan's [1] initial work have tended to incorporate most of Houck, et al's, [2] variables with little or no modification. Instead most of this research has focused on a) refining the definitions of farmers' price expectations used in acreage response models as in Gardner, 1976 [3], Gallagher, 1978 [4], Morzuch, Weaver and Helmberger, 1980 [5] and Chavas, Pope and Kao, 1983 [6];

b) exploring the stability over various time periods of the coefficients estimated by Houck, et al, as in Moe, Whittaker and Oliveira, 1979 [7] and Morzuch, et al, [5]; and c) analyzing the effect of risk and uncertainty on farmers' acreage decisions as in Gallagher [4] and Kramer and Pope, 1981 [8].

Gardner [3] estimated acreage response equations for soybeans and cotton. The essential distinction of this model is that Gardner uses futures prices as a proxy for expected crop prices arguing that, under rational expectations, futures market prices represent farmers' price expectations. After including futures prices in the model, Gardner found that Houck, et al's, policy variables were no longer statistically significant for explaining cotton or soybean acreage. Gardner's empirical results also indicate that the futures prices explain the historic variation in soybean acreage as well as an adaptive expectations model with lagged market price and the lagged dependent variable.

Morzuch, Weaver and Helmberger [5] incorporate the work of both Houck, et al, and Gardner. They estimate regional acreage response equations for wheat and find that government policy variables, closely akin to those developed by Houck, et al, are useful in explaining acreage response. However, they find that there is a structural difference between the pre- and post-1961 years. Like Gardner, Morzuch, et al, use futures price data for the price expectations component in their model. They find that futures prices are a good alternative to distributed lag models.

Moe, Whittaker and Oliveira [7] update the work of Houck, et al, on wheat by including additional observations from 1971 to 1976. They use Houck's specification and find that adding these new observations to the model results in a large decrease in the elasticity of the wheat acreage response with respect to the market price of wheat lagged one year.

Chavas, Pope and Kao [6] extend Houck, et al's, model by considering cash prices, support prices and the role of futures prices in the acreage response equations for corn and soybeans. They use the policy variables developed by Houck, et al, in their model and they estimate their equations using 1957-1977 data. Their results indicate 1) the policy variables defined by Houck, et al, play a major role in determining the aggregate corn and soybean acreage decisions, 2) futures prices are good substitutes for cash prices lagged one year in supply analysis, and 3) that it is unclear whether futures prices are informationally efficient for the formulation of price expectations in the absence of government intervention.

Starting with the Houck, et al, model, Gallagher [4] adds to the previous work by assessing producers' reactions to price risks and developing a price expectations variable that is a function of lagged market prices and a support price.

Gallagher hypothesizes that when prices are low, farmers' price expectations will be dominated by considerations of the level of the support price and when prices are high, farmers' price expectations will be dominated by the market price. However, price supports affect producers' decisions even when prices are moderately high. His empirical model supports both of these hypotheses.

Kramer and Pope [8] use a different approach. They establish an objective function in which a farmer evaluates the benefits and costs of participating in the Food and Agriculture Act of 1977. Kramer and Pope then use a normative risk model based on stochastic dominance theory to evaluate the impact on farmers' decisions of changes in various program features. Their results indicate that small changes in program parameters and farm size can significantly affect a farmer's decision to participate in the program.

It is possible to draw several inferences from the literature subsequent to the Houck, et al, study on acreage response. First, futures prices provide good measures of farmers' price expectations. Second, empirical models should be estimated using data prior to 1961 or after 1961, but not both periods unless the model takes into account the fundamental change in model structure between the two periods. Third, very little work has been done since the Houck, et al, model that explores a better way to incorporate government variables into acreage response equations. Fourth, no empirical research has yet been reported that incorporates government policy variables into yield response equations. Fifth, the elasticities of acreage response with respect to the expected price are smaller in the post-1961 period than in the pre 1961-period.

THE THEORETICAL AND EMPIRICAL MODEL

Many of the problems with Houck, et al's and subsequent models may be uncovered by exploring in detail the choices each individual farmer must make when deciding how much of what crops to produce. At planting time, a farmer must decide, given his resource constraints, 1) whether to participate in any government programs that are offered, 2) the number of acres of each crop to plant, and 3) what level of variable inputs to use on each acre of land planted. Furthermore, the decision to participate in government programs imposes additional constraints on the farmer's actions. In making this set of decisions, a farmer must first determine the optimal input decisions for land and variable inputs for both compliance and non-compliance with government programs, and then he must evaluate which of these options is most profitable.

When a farmer decides not to participate in any program, he is free to plant whatever crops he likes. His only constraints are 1) his available land and resources, 2) his production function, and 3) his market price expectations. His choice variables are the the acreage of each crop a_i and the amount of variable input applied to each acre of each crop x_i. This choice is represented by Equation 5. Expected price is specified as a function of the observed cash market price, the support price and the anticipated rate of farmer compliance in any government programs that are being offered.

When a farmer decides to participate in a government program offered for any particular crop, this restricts his entire crop choice because of cross-compliance requirements. The decision to comply involves giving up acreage that could otherwise be planted. In return, the farmer recieves a guaranteed minimum income (deficiency payments plus support price protection), reduced costs of production, interest rate subsidy, and, for some programs, additional cash payments. The choice of program compliance is represented by Equation 6. If the farmer complies, he is constrained 1) to reduce his acreage by an amount at least equal to the diversion requirement, 2) by his production function, 3) by his market price expectations, and 4) by his available land. His choice variables are 1) the amount of land he plants (as long as it is below the maximum allowable), 2) the amount of variable inputs he applies to each acre planted, and 3) in some years, he is also able to divert additional acreage (beyond the amount required for basic program participation) for an additional per acre diversion payment.

Ignoring fixed costs and assuming risk neutrality, a farmer's objective function can be written as:

$$\max_{a,x,\delta,d} \quad \delta(E(\pi_N)) + (1-\delta)(E(\pi_G)) \tag{5}$$

since, for the risk neutral farmer, $\max E(U(\pi)) = \max E(\pi)$, where profits earned from not participating in any program are:

$$\pi_N = a'Py - a'\,C(w,y) \tag{6}$$

$$\text{s.t.} \quad L \geq a'i$$

$$y = f(x,a) + \varepsilon$$

$$P = g(P^m, P^s, \gamma) + v$$

and where

- a is a vector of acreage planted
- P is a diagonal matrix of expected prices
- P^m is a diagonal matrix of market prices
- P^s is a diagonal matrix of support prices
- γ is a diagonal matrix of expected rates of program participation for each crop
- y is a vector of per acre yields
- x is a vector of optimal inputs for each
- L is a constant for the farmer's total acreage
- C is a cost function
- w is a vector of input prices for the optimal bundle of inputs for each crop
- ε and v are vectors of random error terms
- i is the summation vector
- δ is a 0,1 variable that represents the decision of whether of not to participate in the government program

Profit earned from participating in the program is:

$$\pi_c = a' \max(P, P^t)\, y^p + a' \max(P, P^s)(y - y^p) + (r - r_{ccc})\, a' P^s y - a' C(w, y) + p^{d\prime} \Delta b + p^{vd\prime} d \quad (7)$$

$$\text{s.t.} \quad (I - \Delta)\, b \geq a$$

$$b \geq a + \Delta b + d$$

$$y = f(x, a) + \varepsilon$$

$$P = g(P^m, P^s, \gamma) + v$$

$$d^m \geq d$$

where

Δ is a diagonal matrix of voluntary diversion requirements for each crop

b is a vector of base acreages for each crop

d is a vector for voluntary additional acreage diverted

d^m is a vector of maximum allowable acreage that can be voluntarily diverted

p^d is a vector of per acre diversion payments

p^{vd} is a vector of per acre additional voluntary payments

r is the market interest rate

r_{ccc} is the subsidized interest rate offered to farmers by the Commodity Credit Corp.

y^p is per acre program yields

P^t is a diagonal matrix of target prices

Thus Equation 5 can be rewritten as:

$$\max_{a, x, \delta, d, \lambda, \zeta, \phi, \theta} \delta(a'Py - a'C(w, y) + \lambda(L - a'i)) \qquad (8)$$

$$+ (I - \delta)\,[a' \max(P, P^{t})y^{p} + a' \max(P, P^{s})(y - y^{p})$$

$$+ (r - r_{ccc})\, a'P^{s}y - a'C(w, y) + p^{d\prime}\Lambda b$$

$$+ p^{vd\prime}d + \zeta(b - a - \Lambda b - d) + \phi(d^{m} - d)$$

$$+ \theta((I - \Lambda)b - a)]$$

where

λ, ζ, ϕ and θ are Lagrange multipliers

Assuming the constraints are binding, the first order conditions are:

for π_N non-participation ($\delta = 1$)

$$\mathcal{L} = a'P\, f(x, a) - a'\, C(w, y) + \lambda(L - a'i) \qquad (9)$$

$$\frac{\partial \mathcal{L}}{\partial a} = f(x, a)'\, P + a'P \frac{\partial f}{\partial a} - C(w, y)' - a' \frac{\partial C}{\partial y}\frac{\partial y}{\partial a} - \lambda i' = 0 \qquad (10)$$

$$\frac{\partial \mathcal{L}}{\partial x} = a'P \frac{\partial f}{\partial x} - a' \frac{\partial C}{\partial y}\frac{\partial y}{\partial x} = 0 \qquad (11)$$

$$\frac{\partial \mathcal{L}}{\partial \lambda} = L - a'i = 0 \qquad (12)$$

for π_C participation (compliance) ($\delta = 0$)

$$\mathcal{L} = a' \max(P, P^{t})y^{p} + a' \max(P, P^{s})(y - y^{p}) \qquad (13)$$

$$+ (r - r_{ccc})\, a'P^{s}y - a'\, C(w, y)$$

$$+ p^{d\prime}\Lambda b + p^{vd\prime}d + \zeta'(b - a - \Lambda b - d)$$

$$+ \phi'(d^{m} - d) + \theta((I - \Lambda)b - a)$$

$$\frac{\partial \mathcal{L}}{\partial a} = y^{p\prime} \max(P^t, P^s) + (y - y^p)' \max(P, P^s)$$
$$+ a' \max(P, P^s) \frac{\partial f}{\partial a} + (r - r_{ccc})\, y' P^s \qquad (14)$$
$$+ (r - r_{ccc})\, a' P^s \frac{\partial f}{\partial a} - C(w, y)'$$
$$- a' \frac{\partial C}{\partial y} \frac{\partial y}{\partial a} - \zeta' - \theta' = 0$$

$$\frac{\partial \mathcal{L}}{\partial x} = a' \max(P, P^s) \frac{\partial f}{\partial x} + (r - r_{ccc})\, a' P^s \frac{\partial f}{\partial x}$$
$$- a' \frac{\partial C}{\partial f} \frac{\partial f}{\partial x} = 0 \qquad (15)$$

$$\frac{\partial \mathcal{L}}{\partial \zeta} = b' - a' - \Lambda b' - d' = 0 \qquad (16)$$

$$\frac{\partial \mathcal{L}}{\partial d} = p^{vd\prime} - \zeta' - \phi' = 0 \qquad (17)$$

$$\frac{\partial \mathcal{L}}{\partial \phi} = d^{m\prime} - d' = 0 \qquad (18)$$

$$\frac{\partial \mathcal{L}}{\partial \theta} = ((I - \Lambda)b - a)' = 0 \qquad (19)$$

The first order conditions for non-participation can be solved to give:

the optimal choice for acreage

$$a_N^* = a_N(P, w, \eta) \qquad (20)$$

where η is the rental rate for land, and

the optimal choice for variable inputs

$$x_N^* = x_N(P, w, \eta). \qquad (21)$$

The first order conditions for participation can be solved to give:

the optimal choice for acreage

$$a_C^* = a_C(P, P^s, P^t, w, \zeta, b, \phi, d, d^m, r, r_{ccc}, y^p, \Lambda, \theta) \qquad (22)$$

and

the optimal choice for the variable input bundle

$$x_C^* = x_C \, (P, P^S, P^C, w, \bar{y}, b, \phi, d, i^a, r, r_{ccc}, y^p, \Delta, \bar{\pi}) \qquad (23)$$

Thus, each farmer's optimal decision rules for acreage and yield can be written as:

$$a^* = a \, (a_N^*, a_C^*) \qquad (24)$$

$$y^* = f \, (x_N^*, x_C^*, a_N^*, a_C^*) + \mathcal{E} \qquad (25)$$

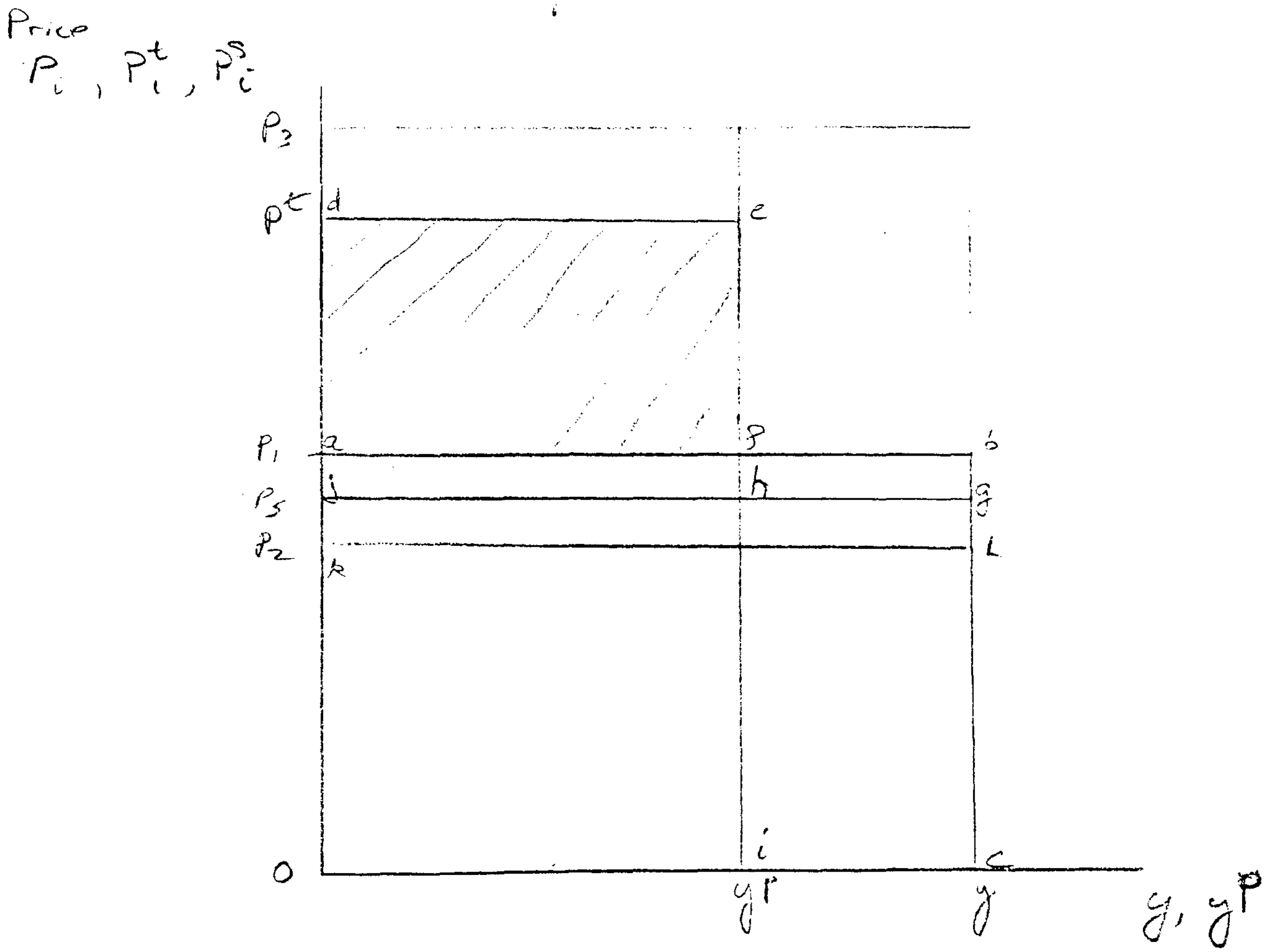
where $\mathcal{E}$ is a random variable.

A simplified model of the optimal acreage choice for each farmer is presented in Figure 3. Assuming there are no costs of production, no diversion payments or interest subsidies from program compliance, and the expected price is P_1, the expected revenue from non-compliance is $\square$ oabc while the expected per acre revenue from compliance is $\square$ oabc plus $\square$ adef, where $\square$ oabc is revenue earned from grain sales and $\square$ adef is deficiency payments. If $\square$ oabc $>$ $(1 - \Lambda)$ [$\square$ oabc + $\square$ adef], where Λ is the percentage diversion requirement for participation, then the farmer will not comply with the program. Similarly, an = in the above relationship implies program indifference and a $<$ implies a compliance decision.

Under the same assumptions as above but with an expected market price of P_2 (below the support rate), it is clear that the farmer will be {better off by / worse off by / indifferent to} complying if

oklc {$<$ / $>$ / $=$} $(1 - \Lambda)$ [$\square$ oabc + $\square$ adef]. However, when the

Figure 3



expected market price is above P^{S} (like P_3) (assuming as above, zero production costs and no diversion payments or interest rate subsidies from program compliance), it will never be more profitable to comply with the program if a farmer must divert land from production in order to qualify for the program.

Aggregate acreage and yield response equations can be easily derived from the individual farmer model.

$$A^* = \sum_{i=1}^{T} a\,(a_N^*, a_C^*)_i$$

$$= A\,(a_N^*, a_C^*) + \rho \qquad (26)$$

where ϕ is a random error term and T is the total number of farmers, and

$$Y^* = \sum_{i=1}^{T} \left[f(x_N^*, x_C^*, a_N^*, a_C^*) + \varepsilon\right]_i$$

$$= F(x_N^*, x_C^*, a_N^*, a_C^*) + \theta \qquad (27)$$

where θ is a random error term and $\theta = \sum_{i=1}^{T} \varepsilon_i + v$, where v is a random vector independent of ε and assuming that the ε s are distributed identically and independently. These equations only indicate the variables that should be in each equation and give an idea of the structure of the error terms.

Before specifying a functional form, it is useful to consider some desirable properties of the model. For the acreage equations, these properties are:

1) An increase in the target price, all else constant, should result in a decrease in acreage since an increase in the target price makes program compliance a more profitable alternative.

2) An increase in the expected price, all else constant, should result in increased acreage planted, since this would make the non-compliance option more profitable.

3) An increase in the diversion requirement, all else constant, should have an ambiguous sign. If farmers are just indifferent or slightly inclined toward participation in the program, an increase in the diversion requirement will cause them to leave the program, in which case they will increase the acreage they plant. If farmers are really inclined to participate in the program, then an increase in the diversion requirement will lead then to divert more acreage in order to stay in the program.

4) An increase in the support price, all else constant, should result in an increase in the acreage planted, since an increase in the support price will lead to a higher expected market price.

5) An increase in the additional voluntary diversion payment, all else constant, should result in decreased acreage planted.

6) An increase in the interest rate subsidy $r - r_{ccc}$, all

else constant, whould result in a decrease acreage planted.

7) An increase in the maximum allowable additional voluntary diversion d^m, should result in a decrease in the acreage planted.

8) An increase in the land rental rate, all else constant, should result in a decrease in the acreage planted.

9) An increase in costs for crop i, all else constant, should result in decreased acreage planted for crop i.

10) An increase in the price of crop j, all else constant, should result in a decrease in the acreage of crop i.

11) An increase in the cost for crop i, all else constant, should increase the acreage of crop j.

12) Prices and costs should be expressed in real terms in order to maintain homogeneity of degree zero.

The two step maximization process that each farmer faces provides a good starting point for finding the best functional form which captures the above desirable characteristics and contains all the relavent variables. Consider first a farmer who makes the decision not to participate in a any government program. In this case, the acreage allocation will depend on the profitability of each competing crop. For example, with no program participation, the acreage equation for feed grains (corn and grain sorghum) could be written as:

$$A_i = B_{0i} + B_{1i}((p_{fg}y_{fg} - c_{fg})/LR) + B_{2i}((p_w y_w - c_w)/LR) + B_{3i}((p_s y_s - c_s)/LR) + \mu_i \quad (28)$$

i = feed grains fg, wheat w, soybeans s

where

p_i is the expected price of crop i

y_i is the expected yield of crop i

c_i is the variable per acre cost of producing crop i

A_i is the acreage planted of crop i

LR is the land rental

μ_i is an error term for each crop i

The non-compliance acreage decision for a crop is then based on the net per acre profitability for each crop deflated by the land rental rate. The net profit is calculated using variable costs since cost of production data that include returns to management and land are of questionable quality and difficult to interpret. Net profits are deflated by the land rental rate to reflect the notion that the decision to plant is an investment decision, and what is important to the farmer is the return on investment.

Now consider the farmer who decides to participate in the government programs. The farmer made the decision to participate in the program in order to guarantee a minimum level of income, one provided by the program. To get this guarantee, however, the farmer must restrict his planted acreage to the base acreage less the amount he must divert to non-productive use. In addition, once he is in compliance with the basic program, the farmer may choose to divert even more land from production by participating in the additional voluntary program.

So, the acreage equation for the farmer complying with the program is:

$$
\begin{aligned}
& BA_i\ (1 - DR_i) - ((1/2)\ d_i^m)(BA_i) \qquad (29) \\
& = \alpha_{1i} + \alpha_{2i}\ [[(1 - DR_{fg})(p_{fg}^t y_{fg}^p + p_{fg}^s (y_{fg} - y_{fg}^p) \\
& \quad + (r - r_{ccc}) p_{fg}^s y_{fg} - c_{fg}) + p_{fg}^d\ DR_{fg}]/\ LR] \\
& \quad + \alpha_{3i}[[(1 - DR_w)\ (p_w^t y_w^p + p_w^s\ (y_w - y_w^p) \\
& \quad + (r - r_{ccc}) p_w^s\ y_w - c_w) + p_w^d\ DR_w]/\ LR] \\
& \quad + \;_{4i}\ (p_i^{vd}/\ LR) + e_i \qquad\qquad i = fg,\ w
\end{aligned}
$$

where

BA_i = base acreage for crop i

DR_i = diversion requirement for crop i

y_i^p = per acre program yield for crop i

p_i^t = target price for crop i

p_i^{vd} = per acre additional voluntary diversion payment

p_i^d = per acre diversion payment

d_i^m = maximum allowable additional voluntary paid diversion

p_i^s = support price for crop i

e_i = error term for crop i

Soybeans are not included in Equation 29 since no acreage programs are offered by the government.

An acreage response equation that captures the desirable properties listed above can be obtained for each crop by subtracting Equation 29 from Equation 28. The hypothesized functional form for the aggregate acreage equations is:

$$\begin{aligned} A_i = {} & \alpha_{0i} + \alpha_{1i} \left[(1 - DR_i)\ BA_i - (1/2) d_i^m\ BA_i\right] \qquad (30) \\ & + \alpha_{2i} \left[\left[p_{fg} y_{fg} - c_{fg} - \left[(1 - DR_{fg})(p_{fg}^t y_{fg}^p + p_{fg}^s (y_{fg} - y_{fg}^p) \right.\right.\right. \\ & \left.\left.\left. + (r - r_{ccc})\ p_{fg}^s y_{fg} - c_{fg}\right] + p_{fg}^d DR_{fg}\right] /LR\right] \\ & + \alpha_{3i} \left[\left[p_w\ y_w - c_w - \left[(1 - DR_w)\ (p_w^t\ y_w^p + p_w^s\ (y_w - y_w^p) \right.\right.\right. \\ & \left.\left.\left. + (r - r_{ccc})\ p_w^s\ y_w - c_w\right] + p_w^d\ DR_w\right] /LR\right] \\ & + \alpha_{4i}\left[(p_s y_s - c_s)/\ LR\right] + \alpha_{5i}\ (p_i^{vd}/LR) + v_i \end{aligned}$$

where i = feed grains fg, wheat w, soybeans s and v_i is a vector of random error terms.

Equation 30 captures the desirable theoretical properties described above.

The desirable properties of the functional form for the yield response equations are:

1) Assuming farmers are operating in stage II of their production functions, an increase in profitability should result in an increase in the use of variable inputs and thus an increase in yield per acre.
2) An increase in acreage diverted from production production should increase yields per acre since farmers will remove their least productive land from production when they paritcipate in a reduction program.

These characteristics can be captured in an equation by including separate variables for 1) expected net profits from not complying with any program, 2) the minimum net profit from participating in the program, and 3) the acreage diversion requirement. The hypothesized functional form for the aggregate yield response equation is:

$$\begin{aligned} Y_i &= B_{0i} + B_{1i}\, T + B_{2i}\, (p_i y_i - c_i) \\ &+ B_{3i}\, [(1 - DR_i)[\, p_i^t y_i^p + p_i^s\, (y_i - y_i^p) \\ &+ (r - r_{ccc})\, p_i^s y_i - c_i] + p_i^d\, DR_i] \\ &+ B_{4i}\, DR_i + e_i \end{aligned} \tag{31}$$

where

i = feed grains fg, wheat w, soybeans s

T = a time trend variable representing technology

B_{3s} = 0 (since there are no soybean acreage programs)

e_i = a random error term

The model, then, consists of six equations: three acreage equations and three yield response equations. These six equations represent subcomponents of the same decision that farmers must make at planting time. Therefore, there may be correlation between the random error terms (v_i, e_i), (v_i, v_j), (e_i, e_j) in the different equations. This contemporaneous error reflects common omitted factors like weather, the state of the general economy and the export outlook for agricultural commodities. Furthermore, with the assumptions of 1) no correlation through time, 2) the estimated contemporaneous disturbances of the different equations are not linearly dependent so that the covariance matrix Σ and $\hat{\Sigma}$ are positive definite, 3) the independent variables in each equation are measured non-stochastically, 4) X'X is full rank where X is a block diagonal matrix of explanatory variables for each equation and the variables in each equation are different, and 5) $E(X'u) = 0$ or $E(u_i) = 0$ and $E(u) = 0$, where $u = e, v,$ and the variables in each equation are different, it is possible to gain efficiency by considering all six equations in a joint regression problem [Judge, et al, p. 321 [9]], i.e. by using Zellner's seemingly unrelated regression model.

The new model is: $y = X\beta + \varepsilon$ (32)

where

$$y = \begin{bmatrix} A_{fg} \\ A_w \\ A_s \\ Y_{fg} \\ Y_w \\ Y_s \end{bmatrix} \qquad X = \begin{bmatrix} X_{Afg} & & & & & \\ & X_{Aw} & & & 0 & \\ & & X_{As} & & & \\ & & & X_{Yfg} & & \\ & 0 & & & X_{Yw} & \\ & & & & & X_{Ys} \end{bmatrix}$$

$$\beta = \begin{bmatrix} \alpha_{fg} \\ \alpha_w \\ \alpha_s \\ B_{fg} \\ B_w \\ B_s \end{bmatrix} \qquad \varepsilon = \begin{bmatrix} v_{fg} \\ v_w \\ v_s \\ e_{fg} \\ e_w \\ e_s \end{bmatrix}$$

The estimator from the seemingly unrelated regression problem is assymptotically superior to, or at least no worse than the estimator from OLS for each individual equation.

When the covariance matrix is known, the GLS estimator for the model

$$\hat{\beta} = (X' \Phi^{-1} X)^{-1} X' \Phi^{-1}$$
$$= (X' (\Sigma^{-1} \otimes I) X)^{-1} X' (\Sigma^{-1} \otimes I) y \qquad (33)$$

where

$$= \begin{bmatrix} \sigma_{A_{fg}A_{fg}} & \sigma_{A_{fg}A_w} & \sigma_{A_{fg}A_s} & \cdots & \sigma_{A_{fg}Y_s} \\ \sigma_{A_wA_{fg}} & \sigma_{A_wA_w} & & & \\ \vdots & & & & \vdots \\ \sigma_{Y_sA_{fg}} & \cdots & & & \sigma_{Y_sY_s} \end{bmatrix}$$

However, when Σ is not known, as in this model, it is possible to use a two step estimation procedure that starts with the estimation of Σ based on the least squares residuals for each equation $\hat{e}_i = y_i - X_i b_i$ such that $\hat{\Sigma} = [\hat{\sigma}_{ij}] = T^{-1}\hat{e}_i'\hat{e}_j$ where $i,j = 1,2,\ldots,6$. The second step is estimating the seemingly unrelated regression estimation

$$\hat{\hat{\beta}}_{SUR} = (X' (\hat{\Sigma}^{-1} \otimes I) X)^{-1} X' (\hat{\Sigma}^{-1} \otimes I) y \qquad (34)$$

With the assumptions above, the estimator $\hat{\hat{\beta}}_{SUR}$ is 1) assymptotically unbiased, 2) assymptotically efficient, and 3) consistent. These properties depend on the large sample assumptions and do not necessarily hold for small samples. Nevertheless, Monte

Carlo experiments show that even with as few as twenty observations seemingly unrelated regression estimators have smaller sampling variances than OLS estimators [9]. Furthermore, all hypothesis tests will only have large sample justification when using Zellner's SUR estimation method.

DATA

All data are for the years 1961 through 1982. All are national annual values.

Acreage, support, target and farm price data are taken directly from various issues of the Feed Grain Outlook and Situation Report [10] and the Wheat Outlook and Situation Report [11]. The yield data are calculated as yield per planted acre using data from the Situation and Outlook Reports. The expected yield data is calculated as the three-year moving average of actual yields.

Futures price data are used in the model since they take into account all of the information that are available at planting time, including the expected rate of participation in the program, the support price and other market factors. In calculating comparative statistics, an increase in the support price should increase the expected.

Futures price data are taken from the Annual Report of the Board of Trade of the City of Chicago, [12]. The September monthly average of closing prices for the July contract is used for wheat. The March monthly average of closing prices for the September contract is used for corn and soybeans. These months were selected because they are the closest to actual planting and harvesting dates for which contracts are available. The different planting dates for much of the wheat crop and for corn and soybeans represent a potential problem in the assumption of contemporaneous covariance. However, in most areas where wheat competes with corn, wheat is also a compliment with soybeans in that wheat is often double cropped with soybeans. Thus, the decision to plant soybeans is closely associated with the decision to plant wheat in the same growing season.

Another problem with using slightly different contract dates (observed in September and March) for the expected price is that soybean and corn prices are actually unknown when the wheat acreage and yield decisions are being made. In this study however, it is assumed that the two time periods are close enough together so that only one time period is represented. With better data, this would not be a problem.

The various policy variables for wheat, corn and soybeans can be found in Cochrance and Ryan, 1976 [13], Heid, 1979 [14] and Leath, Moyer and Hill, 1982 [15]. These data were updated from various issues of the Wheat Outlook and Situation, Feed Grain Outlook and Situation and the Fats and Oil Outlook and Situation Report [16].

Prior to 1974, the variables for the target prices (p_i^t) are calculated as the total support price and includes payments for mandatory diversions on a per bushel basis. These data are from Cochrane and Ryan, Heid and Walter and Leath, Meyer and Hill.

The cost of production data come from Gallagher [17]. Cost variables include seed, chemicals, fertilizer and labor. The cost variables do not include machinery ownership, overhead, management and land costs.

Finally, the land data come from Farm Real Estate Market Developments Outlook and Situation [18]. An index was constructed from this data using a simple average of rental rates for the states of Ohio, Indiana, Illinois and Iowa. The base year for the index is 1977. Because a consistent time series was not available, the data used for the 1960 - 1966 period was for the average cash rental value for the entire farm adjusted upward by $1.77 per acre. This value was arrived at through analysis of the average differential over the time frames where the two series overlap.

THE RESULTS

Model I

The generalized least squares estimates for the acreage and yield response equations (Equations 30 and 31) are reported in Table 1. All the estimated equations are as specified in the model section except for modifications noted. The period of estimation is 1961 - 1982. A time trend variable was included in the soybean acreage response equation to account for the development of new soybean varieties that allowed wider geographical production possibilities for soybeans over the period of estimation. A dummy variable was included in the yield equation which is 1 for the years 1974 and 1980 and 0 elsewhere. This dummy variable was included to account for the effects of major droughts in the Midwest during those two years.

While all of the estimated coefficients have the expected sign, some are not statistically significant at the 5 percent level. Furthermore, the Durbin-Watson statistic for the acreage response equation for feed grains indicates that it is not possible to reject the null hypothesis $H_0: \rho = 0$ at the 5 percent level, i.e. it is not possible to reject the hypothesis of no serial correlation. Thus, the initial assumption of no serial correlation is violated and asymptotic efficiency is no longer a valid property of the model. At this point, it is possible to implement the method proposed

TABLE 1
MODEL I

Dependent Variable	AS (A_s)	AW (A_w)	AFG (A_{fg})	YLDS (Y_s)	YLDW (Y_w)	YLDFG (Y_{fg})
DW	1.7127	.9036	.5420	2.4270	1.458	1.873
RHO	.1264	.5005	.7277	-.3009	.2463	.0437
R-2	.9753	.3424	.7323	.8759	.8530	.9333
Intercept	-16.348* (3.945)	69.398* (12.366)	81.159* (6.947)	16.532* (13.109)	15.511* (16.506)	14.307* (3.145)
AFGPA			.22679* (1.797)			
AWPA		.34026* (6.495)				
FG1	-.011434 (.889)	-.055027 (1.508)	.062519* (2.156)			
S1	.078832* (4.144)	-.15282* (4.361)	-.066598* (1.947)			
W1	-.07425* (3.533)	-.23218* (4.759)	-.01781 (.324)			
DVDFG			-.057714* (2.123)			
DVDW		-.067379* (1.730)				
NPFGN						.09435* (2.406)
NPFGP						.13590* (2.877)
NPWN					.0020754 (.124)	
NPWP					.015274 (.484)	
NPSN				.029787* (2.829)		
T	2.5891* (25.863)			.31902* (3.5717)	.44938* (5.961)	1.7414* (7.081)
D7480				-4.3276* (6.673)		-16.220* (6.532)
DRFG				8.8798* (2.5645)		50.793* (4.135)
DRW					4.3022* (2.698)	

* Significant at the 5 percent level for a single tailed t test

TABLE 1 MODEL I

AS	Acres of soybeans planted
AW	Acres of wheat planted
AFG	Acres of feed grains planted
YLDS	Yield of soybeans per planted acre
YLDW	Yield of wheat per planted acre
YLDFG	Yield of feed grains per planted acre
AFGPA	$(1 - DR_{fg})\ BA_{fg} - (1/2)d^{m}_{fg}\ BA_{fg}$
AWPA	$(1 - DR_{w})\ BA_{w} - (1/2)d^{m}_{w}\ BA_{w}$
FG1	(NPFGW - NPFGP)/ LR
S1	NPSN/LR
W1	(NPWN - NPWP)/ LR
DVDFG	$p^{vd}_{fg}/\ LR$
DVDW	$p^{vd}_{w}/\ LR$
NPFGN	$p_{fg}y_{fg} - c_{fg}$
NPFGP	$(1 - DR_{fg})(p^{t}_{fg}y^{p}_{fg} + p^{s}_{fg}\ (y_{fg} - y^{p}_{fg}) + (r - r_{ccc})\ p^{s}_{fg}y_{fg} - c_{fg}) + p^{d}_{fg}\ DR_{fg}$
NPWN	$p_{w}y_{w} - c_{w}$
NPWP	$(1 - DR_{w})(p^{t}_{w}\ y^{p}_{w} + p^{s}_{w}\ (y_{w} - y^{p}_{w}) + (r - r_{ccc})\ p^{s}_{w}\ y_{w} - c_{w}) + p^{d}_{w}\ DR_{w}$
NPSN	$p_{s}y_{s} - c_{s}$
T	Time trend representing technology
D7480	Dummy variable: 1 for 1974 and 1980, 0 elsewhere
DRFG	DR_{fg}, diversion requirement for program compliance for feed grains
DRW	DR_{w}, diversion requirement for program compliance for wheat

by Parks [19] to correct for serial correlation when using a SUR (seemingly unrelated regression) model or to propose additional variables, now missing from the model, which are the cause of the serial correlation. The second option is preferable to the first since, until the true model is specified, all of the estimated coefficients will be biased and inconsistent.

One possible misspecification of the model involves the choice of variables for expected price, i.e. the futures prices observed at planting time. Perhaps farmers are unwilling to "bet the farm" on one month of futures price data. After all, futures prices are quite volital and the farmer's acreage decision is perhaps his most important in any given year.

Model II

A reasonable replacement variable which maintains the rational expectations hypothesis is to use a weighted average of futures prices and lagged cash prices where the weights are obtained from regressing the actual cash prices for the year ahead on the futures market price and the lagged cash prices. Obviously, the cash prices can only be lagged back finitely and the arbitrary period picked was two years. Again, the same random events that are effecting one equation are effecting the others, so the SUR model will gain efficiency over the OLS model for each equation estimated separately. Furthermore, it makes sense to restrict the sum of the coefficients to equal 1 and the constant term to equal 0 since if all the past prices and the futures prices are 0, the expected price would be 0, and since the sum of the weights must be equal to 1 for the expected price to be unbiased. The estimated equations for the expected prices are presented in Table 2.

The new variables for expected price are:

1) EPC = .23934 FPC + .64783 CPCL1 + .11284 CPCL2 (35)

2) EPS = .53281 FPS + .023911 CPSC1 + .44328 CPSL2 (36)

3) EPW = .11027 FPW + .88172 CPWL1 + .0080079 CPWL2 (37)

where

EPC is the expected price for corn

EPS is the expected price for soybeans

EPW is the expected price for wheat

Except in the expected price equation for soybeans, the most influential variable is the cash price lagged one period. The futures price is the second most influential. For soybeans, however, the most influential variable is the futures price and the second most influential price is the cash price lagged two years. This rather peculiar result may be attributable to multicolinearity. Furthermore, the coefficient on the cash price for soybeans lagged one year is not statistically different from the coefficient for the cash price of soybeans lagged two years.

Dependent Variable	CPW	CPS	CPC
FPC			.23934 (1.078)
CPCL1			.64783 (2.313)
CPCL2			.11284 (.691)
FPS		.53281 (1.438)	
CPSL1		.023911 (.055)	
CPSL2		.44328 (2.707)	
FPW	.11027 (.477)		
CPWL1	.88172 (3.129)		
CPWL2	.0080079 (.046)		
DW	1.3867	1.4172	1.5369
RHO	.3051	.2578	.2312
R-2	.6671	.8262	.7390

TABLE 2

CPC	Cash price of corn
CPCL1	Cash price of corn lagged one year
CPCL2	Cash price of corn lagged two years
CPS	Cash price of soybeans
CPSL1	Cash price of soybeans lagged one year
CPSL2	Cash price of soybeans lagged two years
CPW	Cash price of wheat
CPWL1	Cash price of wheat lagged one year
CPWL2	Cash price of wheat lagged two years
FPC	p_{fg}
FPS	p_s
FPW	p_w

The results using the new expected price variables (EPi where i is G, W, S) as replacements for the futures price variables (FPi where i is FG, W, S) in Model I are presented in Table 3. The results from Model II indicate the presence of serial correlation in the acreage response equation for the feed grains. Additionally, using the new definitions for expected prices introduces serial correlation in the acreage response equation for soybeans. On these grounds alone, the new definition appears to be inferior to the old futures price definition.

The new definition of expected price also reverses the signs on the variables for net profits for wheat from compliance and for net profit from wheat from non-compliance. In Model I, the signs are theoretically correct, but with the new model specification, they become theoretically incorrect. So, not only does the new definition for expected prices fail to remedy the serial correlation problem, it also leads to undesirable results elsewhere in the model. There must be some other error in the model specification.

Model III

The original theoretical model for farmers' aggregate acreage response equation (Equation 30) can be viewed as the "ideal" or desired acreage response of farmers. In a world with no other constraints than those specifically incorporated into the theoretical model, farmers would plant A_{fg}, A_w and A_s and would

DW	1.9168	.3320	.5829	2.5569	1.4436	1.9465	TABLE 3
RHO	.0288	.5796	.7014	-.3469	.2347	.0050	MODEL II
R-2	.9715	.8692	.7605	.8519	.8602	.9325	

Dependent Variable	AS (A_s)	AW (A_w)	AFG (A_{fg})	YLDS (Y_s)	YLDW (Y_w)	YLDFG (Y_{fg})
Intercept	-22.536* (3.341)	85.189* (13.867)	76.681* (6.106)	16.898* (12.653)	16.191* (17.319)	12.459* (2.627)
AFGPA			.22434* (2.171)			
AWPA		.37135* (7.921)				
FG1	-.027047* (1.909)	-.016616 (.513)	.078663* (2.855)			
S1	.12039* (3.327)	-.30973* (6.596)	-.015919 (.247)			
W1	-.056523* (2.251)	.23616* (4.834)	-.082189 (1.380)			
DVDFG			-.090268* (2.974)			
DVDW		.0087709 (.275)				
NPFGN						.096669* (1.892)
NPFGP						.15611* (2.983)
NPWN					-.022289 (1.156)	
NPWP					-.022992 (.683)	
NPSN				.006322 (.402)		
T	2.6302* (21.090)			.40702* (5.154)	.52211* (7.433)	1.8030* (7.112)
D7480				-4.1838* (6.169)		-13.732* (5.734)
DRFG				5.6412 (1.586)		54.846 (3.965)
DRW					2.4811 (1.501)	

* Significant at the 5 percent level for a single tailed t test

apply variable inputs in sufficient quantities to achieve Y_{fg}, Y_w and Y_s. However, farmers live in a world where there are many other constraints that restrict their optimal acreage choices. For example, farmers' acreage decisions are restricted by 1) crop rotation decisions, 2) their livestock enterprises such as dairy cows that require corn silage which cannot be purchased on the market, and 3) the need for specialized machinery. As a result of these constraints, farmers can only make partial adjustments in any time period.

In the partial adjustment model, current values of the independent variables determined the desired acreage as in Equation 30, but only some fraction ϕ of the desired adjustment is accomplished in one period. So, the new acreage response equation can be written:

$$A^A_{i,t} - A^A_{i,t-1} = \phi (A_{i,t} - A^A_{i,t-1}) \qquad (38)$$

where

A_{it} = desired acreage of crop i (as in Equation 30) in year t

A^A_{it} = actual acreage planted of crop i in year t

i = feed grains fg, wheat w, soybeans s

ϕ = fraction of desired adjustment achieved $0 < \phi < 1$

Combining Equations 30 and 38, and rewriting gives:

$$
\begin{aligned}
A^{A}_{i,t} = {} & \phi\alpha_{0i} + \phi\alpha_{1i}\,[(1 - DR_i)\,BA_i - (1/2)d^{m}_{i}\,BA_i] \\
& + \phi\alpha_{2i}\,[[p_{fg}y_{fg} - c_{fg} - [(1 - DR_{fg}) \\
& (p^{t}_{fg}y^{p}_{fg} + p^{s}_{fg}(y_{fg} - y^{p}_{fg}) + (r - r_{ccc})\,p^{s}_{fg}y_{fg} \\
& - c_{fg}] + p^{d}_{fg}\,DR_{fg}]\,/LR] \qquad (39) \\
& + \phi\alpha_{3i}\,[[p_{w}\,y_{w} - c_{w} - [(1 - DR_{w}) \\
& (p^{t}_{w}\,y^{p}_{w} + p^{s}_{w}\,(y_{w} - y^{p}_{w}) + (r - r_{ccc})\,p^{s}_{w}\,y_{w} \\
& - c_{w}] + p^{d}_{w}\,DR_{w}]\,/LR] \\
& + \phi\alpha_{4i}\,[(p_{s}y_{s} - c_{s})/\,LR] + \phi\alpha_{5i}(p^{vd}_{i}/LR) \\
& + (1 - \phi)\,A^{A}_{i,t-1} + \phi\,v_{it}
\end{aligned}
$$

where i = feed grains fg, wheat w, soybeans s and t = time period.

Now, assuming that the v_{it}'s are 1) distributed independently and indentically so that the dependent variable is serially uncorrelated with residual error terms, 2) zero mean and constant variance, and 3) the other original assumptions for Model I hold, the estimated coefficients using SUR are 1) consistent, 2) asymptotically unbiased and 3) asymptotically efficient. However, if the model is incorrect and v_{it} is autocorrelated, then the estimator $\hat{\hat{\beta}}_{SUR}$ will be inconsistent because of the presense of the dependent variable. These new assumptions seem plausible since, once the lagged dependent variable is added to the model, the error term represents effects like weather and the state of the general economy.

Variable input decisions are not as restricted as acreage decisions. Therefore, it seems plausible to maintain the original model specification for the yield response equations (Equation 31), which assumes that farmers adjust to their optimal input decision in one period.

The results for the partial adjustment model, Model III, estimated from Equations 31 and 39, are presented in Table 4. Model III uses the futures price data for expected price, as in the original model. All of the coefficients have the expected signs. Furthermore, the t-ratios generally indicate that the coefficients are highly statistically significant.

Notable exceptions are found in the acreage response equation for feed grains where the calculated t-ratio for the soybean profitability variable S1 is 1.346 and the calculated t-ratio for the wheat profitability variable W1 is 0.954. This same problem occurs in the yield response equation for wheat where the calculated t-ratios for net profit for complying with the program NPWP and not complying with the program NPWN are 0.184 and 0.063 respectively. These low t-ratios indicate that it is not possible to reject the null hypothesis $H_0: \beta_{S1, W1, NPWN, NPWP} = 0$ at the 5 percent level, versus $H_1: \beta_{S1, W1} < 0$ and $H_1: \beta_{NPWN, NPWP} > 0$.

The low t statistics in the acreage equation for the feed grains may be related to the aggregation of corn and grain sorghum. Corn and soybeans are easily substitutable crops since they are largely produced in the same geographic

TABLE 4
MODEL III

Dependent Variable	AS	AW	AFG
Intercept	-13.000* (3.650)	31.164* (3.795)	42.426* (2.924)
FG1	-.023892* (2.165)	-.044698* (1.746)	.05275* (2.266)
S1	.066068* (4.049)	-.051973* (1.733)	-.036931 (1.346)
W1	-.049812* (2.746)	.16773* (4.751)	-.042466 (.954)
AFGL			.34731* (3.801)
ASL	.39358* (3.236)		
AWL		.49857* (5.005)	
AFGPA			.27212* (2.576)
AWPA		.20569* (4.452)	
T	1.6658* (6.124)		
DVDFG			-.05473* (2.357)
DVDW		-.069296* (2.599)	
D h	-1.1375	1.737	1.8216
RHO	-.1992	.3274	.3509
R-2	.9830	.9194	.8321

* Significant at the 5 percent level in a single tailed t test

AFGL Acreage of feed grains lagged one year
ASL Acreage of soybeans lagged one year
AWL Acreage of wheat lagged one year

TABLE 4
MODEL III

Dependent Variable	YLDS	YLDW	YLDFG
Intercept	16.213* (13.308)	15.953* (16.652)	15.458* (3.458)
T	.32235* (5.705)	.44744* (5.927)	1.6900* (6.787)
NPFGN			.094974* (2.437)
NPFGP			.14094* (2.975)
DRFG	9.6021* (2.913)		48.240* (3.868)
NPWN		.0010523 (.063)	
NPWP		.0057948 (.184)	
DRW		3.8190* (2.391)	
NPSN	.031291* (3.115)		
D7480	-3.8841* (6.041)		-15.630* (6.109)
DW	2.4682	1.4774	1.9397
RHO	-.3231	.2365	.0205
R-2	.8698	.8522	.9342

* Significant at the 5 percent level in a single tailed t test

regions. Grain sorghum and soybeans are not good substitute crops since grain sorghum is largely produced in Nebraska and the Southwest, areas that do not produce large amounts of soybeans. However, because in most years, when government programs are offered for feed grains as a single crop unit (corn and grain sorghum together and sometimes, corn, grain sorghum, and barley together), other data difficulties are encountered by disaggregating corn and grain sorghum. Thus, the problem in the feed grain equation should be noted, but is not deemed serious enough to warrant respecifying the model.

The problem in the yield response equation for wheat may be related to the dominant influence of weather and the relatively small importance of variable inputs in wheat production. What is needed is a variable to account for weather variations. However, such a variable was not sought for the present study.

The Durbin-Watson statistic is not an appropriate test statistic for the presence of serial correlation with a lagged dependent variable included in the model. Under these circumstances the D-W statistic has reduced power and is biased toward 2.0. However, Durbin's h statistic is an asymptotic test for serial correlation when a model contains a lagged dependent variable. Durbin's h statistic is

$$h = \hat{\rho}\sqrt{\frac{T}{1 - TV(b_1)}}$$

and, under the null hypothesis of no serial correlation $H_0: \rho = 0$, h is asymptotically normal with zero mean and unit variance [9, p. 456]. The calculated Durbin's h statistics for the partial adjustment model are presented in Table 4 and indicated that the null hypothesis should not be rejected at the 5 percent level, i.e. there is no serial correlation at the 5 percent level. Thus, the assumptions of the model hold.

CONCLUSIONS, IMPLICATIONS AND AREAS FOR ADDITIONAL RESEARCH

The two step maximation process developed for the individual farmer provides a good perspective for analyzing the various farm programs offered to grain producers. Moreover, the model that is adopted from this analysis remedies many of the problems that appear in the Houck, et al specification. Furthermore, the estimated empirical model maintains enough structure so that analysis can be conducted to determine the aggregate response to various changes in market and government parameters.

Various short-run response elasticities from Model III are presented in Table 5. The elasticities indicate that while government programs can be used to reduce acreage, they are relatively ineffective and even less effective in reducing total output. For example, the calculated elasticity of wheat acreage response with respect to the minimum diversion requirement for wheat is -.01, while the corresponding elasticity for feed grain production is -.04. This indicates that , as a group, farmers are not very willing to forego planting their land without some additional incentive. At the group level, an increase in the diversion requirement, all else constant, forces those farmers who were just willing to comply with the program before the increase (because they were at the break-even

TABLE 5
ESTIMATED SHORT-RUN ELASTICITIES
(Calculated at Mean Values)

Variable	Wheat			Feed Grains			Soybeans		
	Acre-age	Yield	Total	Acre-age	Yield	Total	Acre-age	Yield	Total
FPC	-.14		-.14	.12	.17	.31	-.10		-.10
FPW	.28	.00	.29	-.05		-.05	-.11		-.11
FPS	-.15		-.15	-.07		-.08	.25	.13	.38
TPC	.10		.10	-.08	.18	.11	.07		.07
TPW	-.21	.01	-.12	.04		.04	.08		.08
DRFG				-.04	.08	.05	.00	.05	.05
DRW	-.01	.03	.02						
VDPC				-.01		-.01			
VDFG				-.02		-.02			
VDPW	-.02		-.02						
VDW	-.01		-.00						

point between compliance and non-compliance with the program) out of the program. These farmers wil likely increase their acreage planted once they are out of the program. Only those farmers who were most willing to be in the program in the first place remain in the program by diverting the additional land. In all probability, this latter group has the most variance in land quality, making their non-compliance profits lower thatn their compliance profits. Thus, as the government raises the diversion requirement, all else constant, it forces the lowest quality land out of production while leaving the total acreage planted nearly unchanged.

The estimated coefficients for diversion requirements in the yield equations indicate that as the diversion requirement is increased, yields also rise. The estimated elasticities of the aggregate yield response with respect to a change in the diversion requirement are .03 for wheat, .08 for the feed grains and .05 for soybeans. The diversion requirement for feed grain is included in the soybean yield equation since many farmers produce both corn and soybeans, and when they decide to divert low quality land from production, this increases the expected yields for both the feed grains and soybeans. Once again, a good explanation of these positive elasticities is that increases in the diversion requirement push the lowest quality land out of production, thus raising the national average yield per acre.

The estimated coefficient on the net profitability variables indicate that the yield response is greater due to an increase in net profits from compliance in programs than from an increase in net profits from non-compliance in programs. There is one major reason for this result. An increase in the net profit from compliance indicates that more farmers will be participating in the program. These farmers will remove their lowest quality of land from production and aggregate per acre yields will rise.

At the individual farm level, the impact of changing the profits from compliance and non-compliance should be approximately the same since, at the margin, small increases in net profits will be calculated at the same price for both compliance and non-compliance. Net profit from program compliance must be calculated as the change in yield multiplied by the maximum of the support or expected cash price, since deficiency payments are only made on the government-determined program yield. The marginal contribution of a small increase in yield to net profit from not complying with the program must be calculated as the change in yield multiplied by the cash price. As long as the cash price is higher than or near the support price, these marginal conditions will be the same. Throughout the period of estimation, the expected cash price was higher than or close to the support price.

It is difficult to say anything about the marginal productivity of inputs under compliance and non-compliance. On the one hand, farmers most likely to comply have low quality land with a lot of variation in quality. On the other hand, they can take their least productive land out of production by complying with the program.

The elasticities reported in Table 5 for target price indicate that the government must offer very large prices (deficiency payments) to farmers to induce them to reduce acreage just a little. The calculated elasticity of acreage response with respect to target price are -.21 for wheat and -.08 for feed grains. Both are very inelastic. Furthermore, even though the higher target price may not induce individual farmers to increase variable input use, since they only get deficiency payments on the government-determined yield, it does result in an increase in the aggreagate yield response by allowing farmers to take their lowest quality land out of production. Thus, the total supply response may go in a direction opposite to that desired by the government. This is indeed the case for feed grains. The estimated elasticity of the supply of feed grains with respect to the target price for feed grains is .11, indicating that the yield effect overwhelms the acreage effect for changes in the target price. It must be kept in mind, however, that these elasticities are calculated values and in general this adverse supply response need not be true.

The elasticities calculated for acreage response with respect to expected price are within the range of those of other studies. They indicate that, at least in the short run, the supply curve is rather inelastic.

Of course, there are many criticisms which can be made of these models. Two are most obvious. First, estimating the model with aggregate data obscures the analysis to the point where it is not possible to describe the response of the individual farmer.

Second, nearly all of the empirical results reported in this paper depend on the large sample assumption. This assumption is difficult to justify, even though Monte Carlo results indicate that it may be valid. For this reason, identical models were estimated using OLS. The OLS results differ only slightly when compared to the SUR results. The most notable difference, as expected, it that the estimated standard errors are larger for the OLS results. The OLS results are not reported, but are available from the author upon request.

Most of the effects in the model appear to be the result of redistributing planted acreages from one farm to another in such a way that the lowest quality land goes out of production. One way to remedy this problem would be to work with the theoretical model developed for the individual farmer and with data on individual farms. The data should be separated into two regions, one for compliance and one for non-compliance, to estimate the model. A third equation could be estimated using the Probit or Logit framework to get an equation for the compliance, non-compliance decision.

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