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MODELING THE U.S. GRAINS PROGRAMS:

A MICROECONOMIC APPROACH

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Abstract

A framework is presented for analyzing the impact of U.S. grains programs. The model's advantages are its endogenous treatment of the participation decision, the recognition of producer heterogeneity, and consistency with microeconomic theory. The estimated model predicts that the 1986 freeze on program yields for wheat _increased_ returns to land.

MODELING THE U.S. GRAINS PROGRAMS:

A MICROECONOMIC APPROACH

Despite considerable research effort, the agricultural economics profession is still hard-pressed to assess the impact which changes in the U.S. grains programs are likely to have on variable input use and land rents in the farm sector. The fundamental difficulty in assessing these effects arises out of the conditional nature of program participation. Farmers must idle productive acreage to qualify for payments, which are computed as: (program yield) * (program base) * (deficiency payment[1]). The idea behind this program is to make payments to farmers, based roughly on their ability to produce, while simultaneously restricting acreage to prevent "overproduction".

Deficiency payments have historically had two important economic consequences. First of all, they have drawn excessive acreage into program crops. Secondly, they have created an incentive for program participants to consider the target price in deciding on variable inputs. This is because program payment yields have historically been based on previous years' proven yields. Thus higher current yields led to larger future deficiency payments. Recently there has been increasing interest in reforming the grains programs. The freeze on program payment yields established by the 1985 Food Security Act (USDA, Agricultural Outlook, March 1986) represented an attempt to address the intensification phenomenon, and the administration's proposals for base flexibility for the 1990 farm bill (USDA, Wheat: Situation and Outlook Report, Feb. 1990) are aimed at remedying the misallocation of acreage. The purpose of this paper is to outline a modeling framework which can shed additional light on the effect which some of these measures might have on factor markets.

THE MODELING PROBLEM

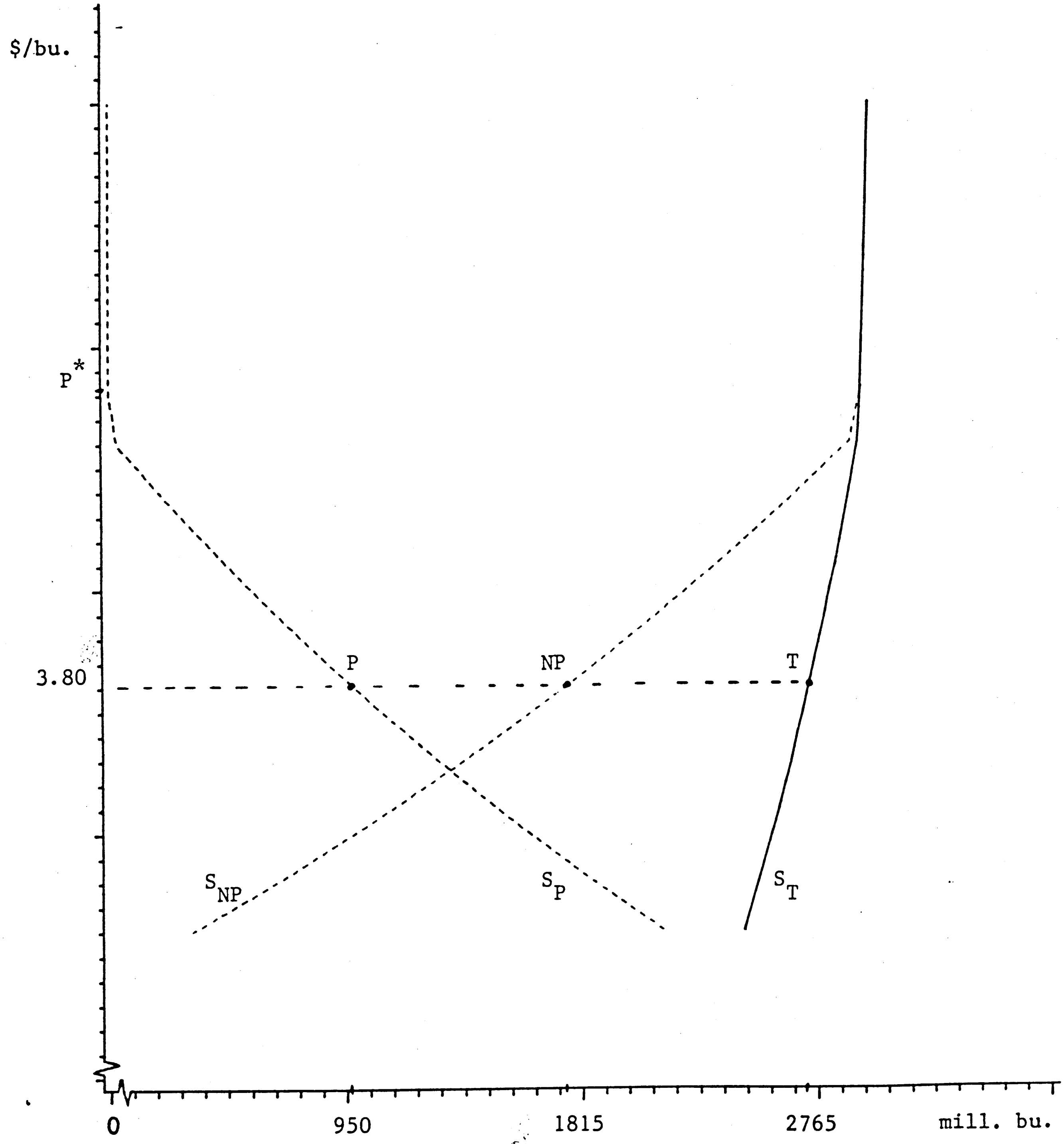
Existing models of the grains sector can be roughly divided into two groups: policy models and technology models. The policy models typically consist of reduced form equations for acreage and yield response which incorporate explicit policy variables such as the expected deficiency payment and set-aside requirement (e.g., Salathe, et al.). To the extent that the program participation decision is modeled, it is treated as a function of certain "parameters" such as average variable cost and the "slippage" coefficient [i.e., 1 - (% output reduction/% acreage reduction)] (Gardner). Herein lies the fundamental problem with these models. Some of these "parameters" are really endogenous variables. For example, average variable cost depends both on whether one is attempting to prove yields for future program participation as well as on the expected deficiency payment. Similarly, the degree of "slippage" depends on the relative productivity of the idled land and the induced change in nonland input use. The magnitude of these effects are also likely to vary with the aggregate participation rate. Since the parameter estimates of these models depend on the program regime in place when the model was estimated, they are hard-pressed to analyze changes in program regimes.

In order to analyze an issue such as the freeze on program payment yields, it is necessary to develop a well-specified model of optimization at the micro level. In particular, technology and the heterogeneous resource endowments of producers must be characterized. The models which focus on technology (e.g., Antle or Ball) typically abstract from detailed policy instruments. Furthermore, they model producers as a single homogeneous aggregate. Yet heterogeneity of producers is essential to analyzing the impact of program reform. Consider once again the case of a freeze on program yields. The implication of this policy change is that participants face a lower incentive price (i.e., the target price). This will lower variable input use, which in turn lowers output and raises the market price, causing nonparticipants to raise their use of variable inputs! Thus, depending on the participation status of a producer, the freeze may induce a decline or an increase in variable input usage.

The combination of producer heterogeneity with the voluntary nature of the grains programs also confounds estimation of the agricultural technology underlying observed responses in aggregate quantities of inputs demanded by producers. This point may be illustrated with the use of figure 1, which plots the market price of wheat against the quantity of output supplied by program participants (S_P) and non-participants (S_{NP}) as well as their total ($S_T = S_P + S_{NP}$). In 1982, the expected market price was around \$3.80/bushel and total production of wheat was 2,765 million bushels, of which about 34% (950 million bushels) came from participants (see table 1 below). This locates points P, NP and T in figure 1. Now consider the effect of increasing the market price for wheat. Nonparticipants respond by increasing variable input use per acre. Also, some participants now become nonparticipants, since the deficiency payment falls. The combination of these two effects causes S_{NP} to be quite responsive to market price. By contrast, S_P is downward sloping in market price due to the fact that participants leave the program.

Assuming, for the sake of simplicity, that the total land base for wheat is fixed, then the slope of the total supply curve (S_T) reflects two effects. The first is an acreage effect caused by the endogenously determined amount of set aside land. Set aside land falls due to shrinking program participation. This continues up to P^*, at which point no one is left in the program. The second effect is due to increased yields, caused by producers responding to a higher market price for output. (The magnitude of the latter will generally differ between participants and nonparticipants -- more on this later.) This is the only component of total supply response above P^*, and it depends entirely on the elasticity of substitution between land and nonland inputs.

Figure 1. Supply Response with Heterogeneous Producers and a Voluntary Grains Program: Wheat in 1982[a].



[a] Figure 1 is based on a model which assumes that the deficiency payment is equal to: (target price) - (market price).

Table 1. Wheat Facts for Selected Crop Years.

	Units	1978	1982	1986
Program variables:				
Loan rate	$/bu.	2.35	3.55	2.40
Target price	$/bu.	3.40	4.05	4.38
Expected market price[a]	$/bu.	2.92	3.80	2.54
Set aside requirement	%	20.00	15.00	22.50
Paid land diversion (PLD)	%	0	0	6.00
PLD payment	$/bu.	0	0	1.55
Participation rate (in terms of acres)	%	63.49	42.03	73.26
Participants' planted acreage share	%	58.17	38.13	66.21
Total land in sector	mill. ac.	75.60	92.00	91.00
Planted acreage	mill. ac.	66.00	86.20	72.00
Total production	mill. bu.	1775.50	2765.00	2087.00
Production adjusted for weather[b]	mill. bu.	1846.16	2765.00	2247.07
Average yield	bu./pl. ac.	26.90	32.08	28.99
Variable cash expenses	$/pl. ac.	28.33	53.66	45.94
Variable expenses deflator		.66	1.00	.92
Expenses/deflator ratio		42.92	53.66	49.93
Total government payments	mill. $	617.00[c]	475.00[c]	3688.00[d]
Observed deficiency and diversion payment rates:	$/bu.	.52	.50	2.11
Implied participants' production (weather adj.)	mill. bu.	1233.79	950.00	1881.92
Production share	%	66.83	34.36	83.75

[a] The expected market price is defined as the average of closing prices on contracts with a September delivery date, for every Thursday in February, March, and April.

[b] Actual production adjusted for normal weather conditions, based on estimates of Ash and Lin.

[c] Deficiency payments.

[d] Deficiency payments and diversion payments.

Sources: Various issues of Wheat: Outlook and Situation Report, various issues of Agricultural Outlook, "U.S. Wheat Production Costs, 1975-82", and The Chicago Board of Trade.

One approach to estimating the elasticity of substitution between land and nonland inputs would involve observing the responsiveness of wheat supply from a given land base and inferring something about this parameter. Alternatively, if land were treated as a variable input, one might observe how the demand for nonland inputs changed as a function of changes in the output price and the land rental rate. In either case, failing to account for the endogenous participation decision will cause one to confound the set aside effect with the input substitution effect, unless we are above P^{*}.[2]

In sum, there is a need for a model which: (a) accounts for the inherent heterogeneity of producers in a tractable way, (b) specifies technology explicitly, and (c) incorporates explicit program instruments. The purpose of this paper is to develop and illustrate the use of such a model. In doing so, we build on earlier work by Whalley and Wigle, who proposed a model with five groups of producers, each of which possesses a different technology. In this paper all producers have the same technology, and we introduce differential participation incentives through a heterogenous land base.

MODELING THE GRAINS PROGRAMS

The Heterogeneous Land Base

Given the structure of the U.S. grains programs, the decision to participate is intimately related to the distribution of land on a given producing unit.[3] If the producing unit includes some relatively unproductive land (i.e., land with a low "capacity" in our terminology[4]) which can be "set aside" under program requirements, then the cost of participation will be relatively low, and the incentive to participate will be high. We assume that the distribution of land capacities on any given producing unit is uniform (i.e., the acreage base is evenly distributed over the range from minimum to maximum capacity). Thus the greater the range of capacities, the more heterogeneous is the acreage comprising a given producing unit, and hence the greater the incentive to participate.

Figure 2 illustrates three hypothetical, uniform acreage densities associated with the distribution of land capacity (e) on three producing units. These units may be ordered according to their degree of land homogeneity, and each may be assigned a "homogeneity index" (r) which ranges from zero to one. The units displayed in figure 2 range from heterogeneous (unit A) to relatively homogeneous (unit C). By definition, unit A has a low value of r, while unit C has a high one. Unit A will be the first one to enter the program, since it has an opportunity to set aside rather poor land. Thus the index r may be interpreted as a measure of the propensity to stay out of the program, since a larger value of r is associated with more homogeneous land and a higher opportunity cost of participation.[5] Figure 3 displays the conditional distributions, $g(e|r)$, for units A-C, arranged according to their homogeneity index, in the context of the overall acreage distribution, $f(e,r)$. In any given year there will be some cutoff point, r^*, at which all producing units with a homogeneity index in excess of r^* will be out of the program, and all units with a value of r less than or equal to r^* will be in the program. In effect, r^* is closely related to the acreage participation rate (i.e., acreage in the program divided by total acreage devoted to a given crop).

Those producing units for which the set aside requirement is not very costly (low r) will tend to participate, even when the expected deficiency payment is relatively low. As program benefits increase, for example due to a hike in the target price, these producing units will not only remain in the program, they will reap "windfall" gains. Meanwhile, some producing units which were not previously enrolled will now find it profitable to idle acreage and enter the program. However, there comes a point where participation costs are as large as the expected benefits. We call this the "indifference point." Logically this occurs at r^*, which happens to coincide with unit B in figure

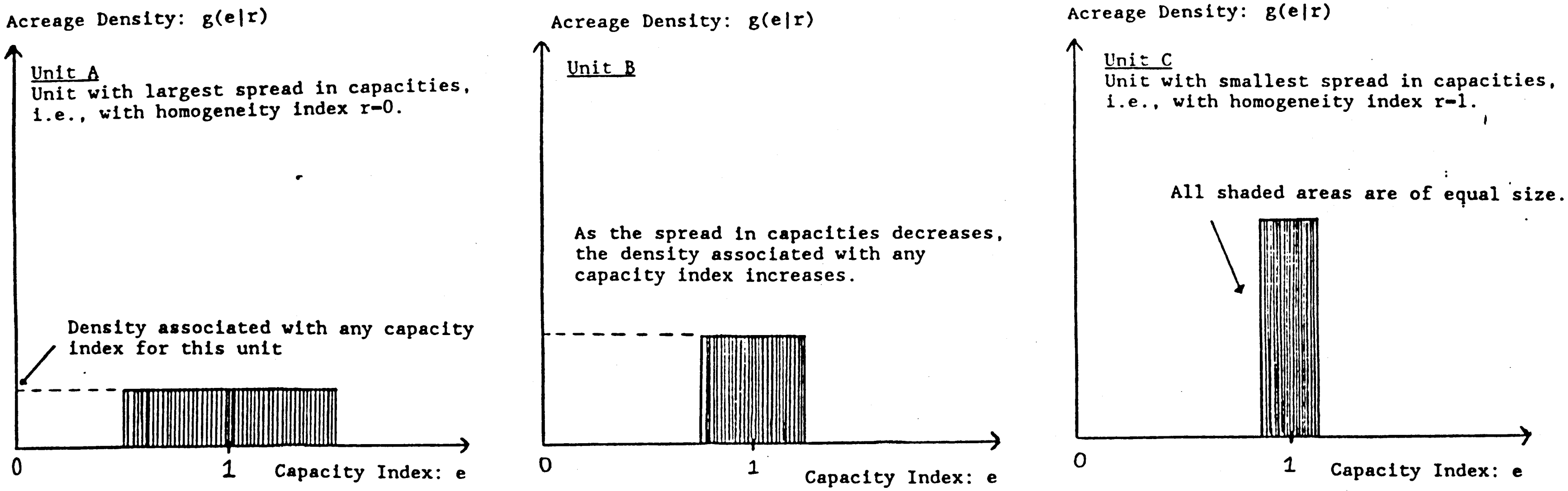


Figure 2. The Conditional Distribution of Land Capacity: g(e|r)

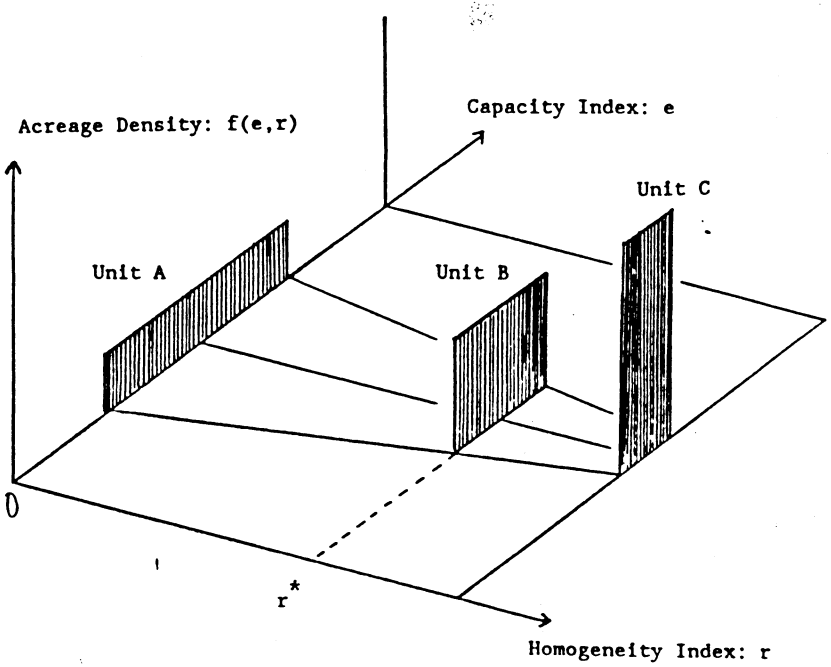


Figure 3. The Joint Distribution of Acreage: f(e,r)

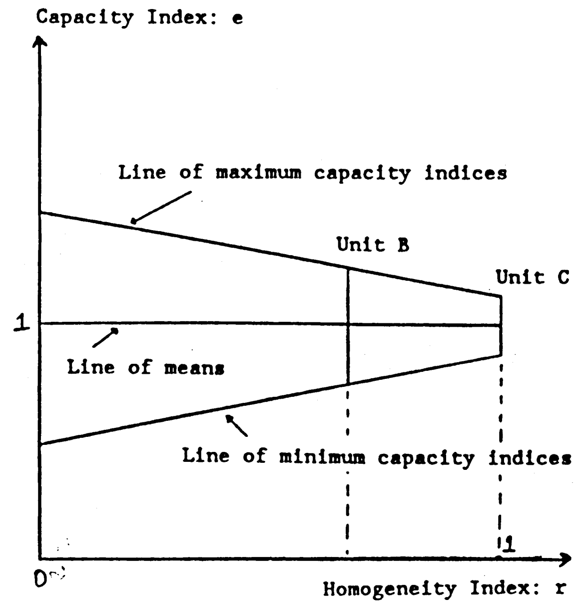


Figure 4. The Relationship between Capacity Indices and the Homogeneity Index

3, since all units with a greater incentive ($r < r^*$) participate in the program (i.e., the benefits outweigh the costs) and all units with a lesser incentive to participate ($r > r^*$) are out of the program since participation costs exceed the benefits to them.

A very important issue, which will be explored in detail below, has to do with the relationship between the homogeneity index r, and the average land capacity of a producing unit (μ_e). In particular, we would like to know whether the first units to enter the program have a higher or lower average capacity than other units, i.e., what is the sign of $\partial\mu_e/\partial r$? If they have a higher average capacity, then enrolling them in the program will have a more significant effect on output than if these heterogeneous units are also relatively unproductive. In figure 4, μ_e and r are assumed to be unrelated. In our model, μ_e is specified as a cubic function of r, with parameters to be determined by the data.

The density of producing units with respect to the homogeneity index is also important. This is the marginal distribution of the homogeneity index, h(r). We assume $h(r) = \gamma + \delta r$. Thus, if $\delta = 0$, then units are uniformly spread along r. Similarly, $\delta < 0$ would mean that the distribution is more dense near the origin where less homogeneous units are bound.

The Decision Problem

For ease of exposition, we develop the producer's decision problem utilizing a simplifying assumption. (This will later be relaxed in a series of numerical simulations designed to investigate its potential significance.) In particular, we begin by assuming that in the absence of a yield freeze, program payments are based on current production levels. Under this assumption, the target price is the supply inducing price for program participants.[6]

In this model, a manager decides whether to participate in the commodity program based on profitability. Choice variables are (a) the level of nonland inputs, $X_{i,r}$ (with price W_X) to be applied in the production function $y(\cdot)$, and (b) the discrete variable i which indicates whether the producing unit is "in" or "out" of the program. Convex transactions costs associated with participation (to be discussed below) are denoted T(r). The profit maximization problem for any particular producing unit with land base A is given by:

$$(1)\quad \max_{i,X_{i,r}} \pi, \text{ with}$$

$$\pi = \int_{v_r}^{\bar{e}_r} \{P_T e\, y(A,X_{i,r}) - W_X X_{i,r}\} f(e,r)de - T(r), \text{ for } i\text{=in, or}$$

$$\pi = \int_{\underline{e}_r}^{\bar{e}_r} \{P_M e\, y(A,X_{i,r}) - W_X X_{i,r}\} f(e,r)de, \text{ for } i\text{=out.}$$

If all land is planted (i = out), the limits of integration are the lower ($\underline{e}_r$) and upper ($\bar{e}_r$) bounds of capacity indices, and output is sold at the market price, P_M. However, if the producer participates in the program, then land of the lowest capacity is set aside and the target price, P_T, is the supply price. In this case the lower limit of integration (v_r) is determined by the condition:

$$(2)\quad \int_{\underline{e}_r}^{v_r} f(e,r)de = s \int_{\underline{e}_r}^{\bar{e}_r} f(e,r)de,$$

where $0 < s < 1$ is the set-aside requirement.

As noted above, we make some fairly weak assumptions on f(e,r). In particular, we assume that: (a) for a given r, land capacity is uniformly distributed, i.e., the conditional distribution of e, $g(e|r) = (\bar{e}_r - \underline{e}_r)^{-1}$, and (b) the marginal distribution of r, h(r) is $\gamma + \delta r$. Since, f(e,r) is equal to the product of g(e|r) and h(r), these assumptions imply that:

$$(3)\quad v_r = \underline{e}_r + s(\bar{e}_r - \underline{e}_r), \text{ and } \mu_{in,r} = \mu_{out,r} + 0.5(\bar{e}_r - \underline{e}_r)s,$$

where $\mu_{in,r}$ and $\mu_{out,r}$ denote the mean land capacity under participation and nonparticipation, respectively.

Now consider the grains production function. By definition, the capacity index, e, operates as a neutral shift on y(A,X). It accounts for differences in output which persist after land and nonland input levels are accounted for. Secondly, with two factors, substitution relationships may be reasonably described by a constant elasticity of substitution production function. To keep the problem tractable, we assume that the elasticity of substitution, σ, is invariant to e. Setting A equal to unity, we obtain the following average production function:

$$(4)\quad y(1,X_{i,r}) = \alpha[1 + \beta X_{i,r}^{(\sigma-1)/\sigma}]^{\sigma/(\sigma-1)}.$$

The Role of Transactions Costs

There are several dimensions of the participation decision which are not captured by the specification in (1). In particular, in order to participate, it is necessary to have established a crop acreage base. This acreage can only be increased when the producer is not participating in the commodity program. There is also considerable paperwork which must be executed to enroll in the programs. Continually changing program requirements add to the costs of making a decision to participate. Finally, there are many producers who dislike receiving government payments. We attempt to capture the combined impact of these deterrents to participation with the notion of transactions costs. These are assumed to be relatively invariant to farm size. Thus larger farms will have lower average (i.e., per acre) transactions costs. Since we also expect farm size to be inversely related to homogeneity, per acre transactions costs, denoted T(r), will be positively related to r. More formally, we specify the convex transactions cost function as:

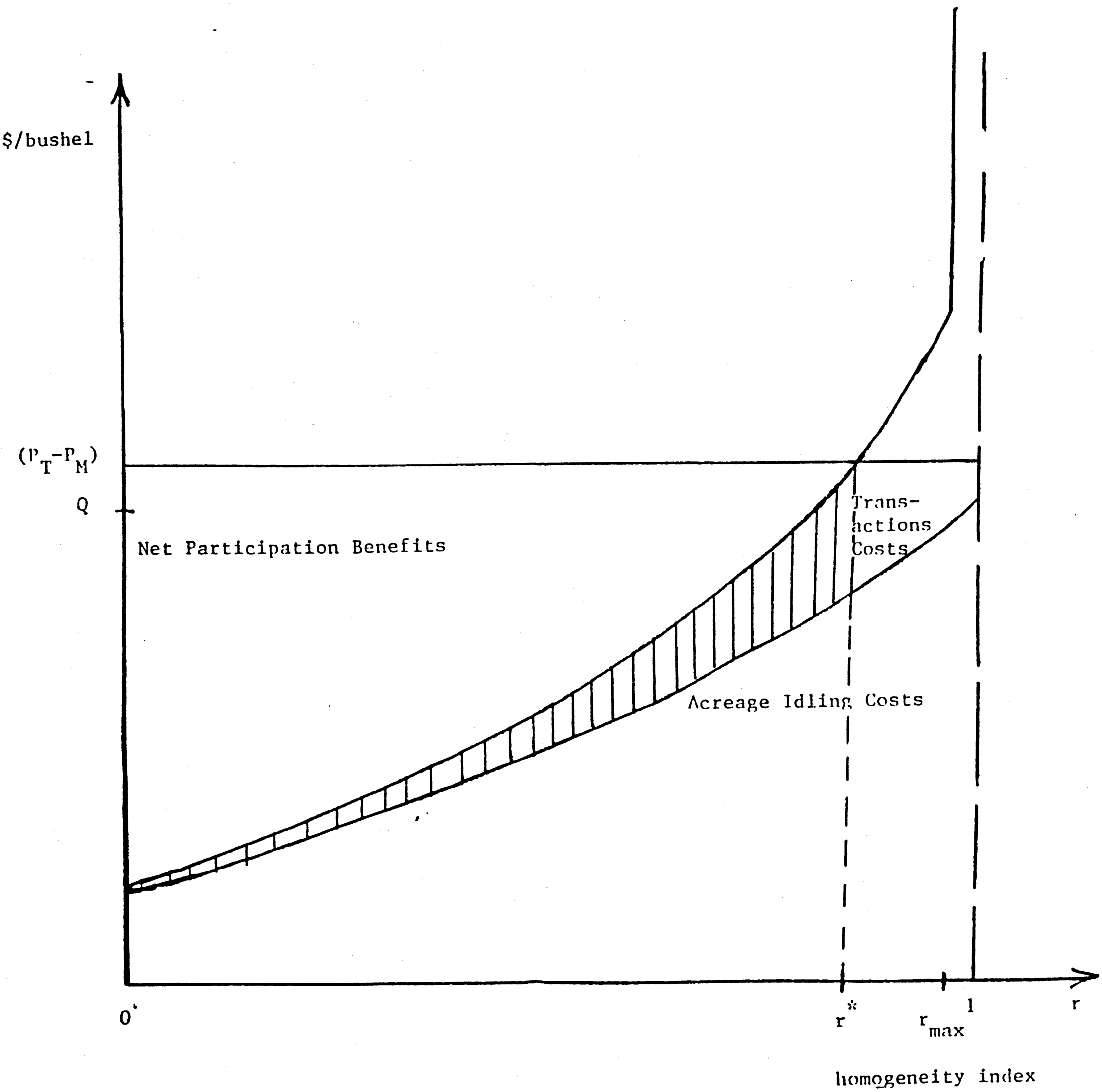
$$(5)\quad T(r) = \theta * [r/(1 - r)],$$

where the value of $\theta > 0$ will be determined from the data.

Producing units will participate in the commodity program as long as profits "in the program," minus transactions costs, exceed profits "out of the program". In equilibrium, there will be some unit which is indifferent to being in or out of the program. Recall that we label the associated homogeneity index r^* and that all units with a value of $r \leq r^*$ are expected to be in the program. Conversely, all of those with $r > r^*$ are expected to be out of the program. This critical value which we use for distinguishing participants and nonparticipants varies as a function of program parameters (i.e., the target price and the set aside requirement). With a generous program, r^* approaches one. By contrast, as the expected deficiency payment shrinks, r^* approaches zero.

The decision problem is summarized graphically for a hypothetical case in figure 5, where the expected participation costs and benefits are shown. These are expressed on a per bushel basis, and they are plotted against the homogeneity index (r). On extremely heterogeneous producing units, the opportunity cost of idling the poorest land is relatively low. This increases with r (the lower cost curve in figure 5) and reaches Q \$/bushel when r = 1. Since the expected deficiency payment ($P_T - P_M$) exceeds Q, we expect 100% participation in the absence of transactions costs. This was essentially the case immediately following passage of the 1985 Food Security Act, at which point extension specialists were counseling all eligible farms to participate in the grains programs. Yet some producers chose not to do so, presumably due to transactions costs. (These are captured by the shaded area in figure 5.) Of

Figure 5. Hypothetical Costs and Benefits from Program Participation.



course, at some point (r_{max} in figure 5) all eligible acreage will be enrolled in the program and the transactions cost function becomes vertical. The indifference point (r^* in figure 5) is found by equating the benefits from participation with the sum of idling and transactions costs. This will never lie to the right of r_{max}.

Aggregation to the Sector Level

Thus far, the decision problem has been couched in terms of an individual manager. However, since we are ultimately interested in the behavior of variables at the sector level, we must account for the entire land base (L) which may be obtained by integrating as follows:

$$(6)\quad L = \int_0^1 \int_{\underline{e}_r}^{\bar{e}_r} f(e,r)de\ dr.$$

In performing this aggregation, recall that there is a critical point, r*, at which the producing unit is indifferent to the participation decision. As a consequence, the sector-wide profit maximization problem reduces to a problem of finding r* and computing the distribution of optimal nonland input use: $X^*_{i,r}$. This is summarized in (7):

$$(7)\quad R = \max_{r^*, X_{i,r}} \int_0^{r^*} \int_{v_r}^{\bar{e}_r} \{P_T e\ y(1,X_{in,r}) - W_X X_{in,r}\} f(e,r)de\ dr$$
$$- \int_0^{r^*} T(r)dr + \int_{r^*}^1 \int_{\underline{e}_r}^{\bar{e}_r} \{P_M e\ y(1,X_{out,r}) - W_X X_{out,r}\} f(e,r)de\ dr.$$

We assume that $X^*_{in,r}$ and $X^*_{out,r}$ do not depend on the distribution of e_r. That is, for a given r, managers do not vary the optimum quantity of nonland inputs as e varies between its lower and upper limits. Nonland input use depends only on relative prices and the mean capacity of planted acreage. From (7), integrating over e and substituting in $X^*_{in,r}$ and $X^*_{out,r}$, we obtain:

$$(8)\quad R = \max_{r^*} (1-s)\int_0^{r^*} \{P_T y(1,X^*_{in,r})\mu_{in,r} - W_X X^*_{in,r}\}(\gamma+\delta r)dr$$
$$- \int_0^{r^*} T(r)dr + \int_{r^*}^1 \{P_M y(1,X^*_{out,r})\mu_{out,r} - W_X X^*_{out,r}\}(\gamma+\delta r)dr.$$

Notice that r* is a continuous variable, $0 \leq r^* \leq 1$. The value r* is determined by the following conditions:

$$(9)\quad \partial R/\partial r^* = 0 \text{ if } r^* > 0, \text{ and}$$
$$\partial R/\partial r^* \leq 0 \text{ if } r^* = 0.$$

In the case that $r^* > 0$ the indifference condition may be written as follows:

$$(10)\quad (1-s)\{P_T y(1, X^*_{in,r^*})\mu_{in,r^*} - W_X X^*_{in,r^*}\} - T(r^*) =$$
$$P_M y(1,X^*_{out,r^*})\mu_{out,r^*} - W_X X^*_{out,r^*}.$$

Farm level demand for output is assumed to be of constant price elasticity form with an elasticity of -0.53[7], while the aggregate supply of wheat (Y^S) is given by (11):

$$(11)\quad Y^S = \int_0^{r^*}\int_{v_r}^{\bar{e}_r} e\, y(1,X^*_{in,r})f(e,r)de\, dr$$
$$+ \int_{r^*}^1\int_{\underline{e}_r}^{\bar{e}_r} e\, y(1,X^*_{out,r})f(e,r)de\, dr,$$

The aggregate demand for variable inputs is derived in an analogous manner.

MODEL ESTIMATION

Obtaining Nonland Input Data

Estimation of the model outlined in the previous section is complicated by many factors. First of all, the distribution of land capacities, f(e,r), is unobservable. Typically we only observe yields for a given producing unit. Once one knows the level of nonland inputs applied, land capacity may be inferred from yields. Unfortunately, nationally representative data on both nonland input use and yields is not available. Furthermore, it is very difficult to obtain input data for a specific commodity, such as wheat. In fact, many farms grow several crops and their fixed inputs must be arbitrarily "allocated" in order to obtain commodity-specific data. This is what is done in the USDA cost of production surveys, which are performed for specific commodities every four years (USDA, Cost of Producing Selected Crops in the United States). (This is the only source of national, commodity-specific input data of which we are aware.)

Because of the input allocation problem, it is attractive to focus on variable input use, which is more readily assigned to specific crops. Also, these inputs are more likely to be the appropriate decision variables within the annual timeframe implicit in our model. This means that the estimated elasticity of substitution (σ) is conditional on the level of fixed factors available to the sector. We assume this constraint is not binding so that one can simply replace the term "nonland inputs" with variable inputs in the theoretical model. Thus the elasticity of substitution in question is that which describes the substitutability of variable inputs for land.

Implications for the Distribution of Land Capacities

Given these data constraints, we choose to estimate the model using data from 1978, 1982, and 1986 crop years. These data are presented in table 1. They include information on the U.S. wheat program, expected market price, aggregate production, variable input use, participation rate, and the distribution of production between participants and nonparticipants. The latter data suggest a positive correlation between mean productive capacity and the homogeneity index (i.e., $\partial\mu_e/\partial r > 0$) over the observed range of participation rates. For example, in 1982, participants accounted for a disproportionately small share of production, while in 1986 this was reversed: participants controlled only 66.21% of planted acreage but accounted for 83.75% of total output. In 1978 the participation rate (63.49%) was between that of 1982 and 1986, and participants produced slightly more than their "share" of output. (They controlled 58.17% of planted acreage, but accounted for 66.83% of output.) This suggests that $\partial\mu_e/\partial r > 0$, over the approximate range $0.42 \leq r \leq 0.73$.

Of course, since nonparticipants in 1986 accounted for a disproportionately small share of output, we may conclude that μ_e must drop as r approaches one. This makes intuitive sense, since the most homogeneous units are also likely to be the smallest ones, which are likely to suffer from an excessively small scale of production. Because we have postulated the same constant returns to scale production function for all producing units, we have forced scale economy effects to be absorbed in the distribution of land capacities. This is not problematic for our purposes, since we are primarily interested in obtaining the distribution of output between participants and nonparticipants. However, it does point out the potential value of adding another dimension -- namely farm size -- to future refinements of this model. Thus we may infer that μ_e must drop at high levels of r. This presumably reflects the inefficiency of very small, homogeneous units.

Estimation Procedure

The specific estimation procedure employed is motivated by estimation strategies employed in most of the real business cycle literature (e.g., Kydland and Prescott). We choose values for the free parameters in the model to obtain, as close as possible, a correspondence between model predictions and observed values. Due to the limited data, our estimated parameters will not have standard errors attached to them. Rather, we are engaged in a "calibration" exercise, whereby we use the model as a "lens" for interpreting the available data. We minimize the weighted sum of squared errors:

$$(12) \quad \sum_j \sum_t (\hat{Y}_{j,t} - Y_{j,t})^2 / S_j,$$

where the weights, $S_j = \sum_t (Y^o_{j,t} - Y_{j,t})^2$, are particular to each of the variables being fitted. To clarify notation, $\hat{Y}_{j,t}$ is the fitted value for variable j in year t, $Y_{j,t}$ is the observed value and $Y^o_{j,t}$ is the model prediction, based on the starting values of the parameters to be estimated. Subscripts t = 1978, 1982, and 1986, and j = sectoral output, variable cash expenses, and participants' share in total output. Note that the generalized sum of squares in (12) is obtained by applying Zellner's method for estimating seemingly unrelated regressions. However, we are assuming that the matrix of the covariances of the errors across equations is diagonal.

There are also a set of constraints associated with this problem. Most of these restrict parameters to have reasonable signs. For example, distributive shares and the elasticity of substitution in production must be positive. However some of the constraints add important economic content. In particular, we require that the marginal participant ($r = r^*$) be indifferent between being in or out of the program in each of the three years [i.e., condition (10) holds exactly in every year]. Also, in line with the preceding discussion of land capacities, we constrain μ_e to be decreasing over the range: $0.75 \le r \le 1.00$. Finally, we require predicted and observed land use to be equal. The parameter estimates resulting from minimization of (12) are provided in table 2, as are the discrepancies between actual and fitted values in percentage form [i.e., $(\hat{Y}_{j,t} - Y_{j,t})/Y_{j,t}$].[8] The parameter estimates in

Table 2. The Fitted Model.

A. Parameter Estimates

$\sigma = 0.591$; $\alpha = 54.7$; $\beta = 0.394$; $'\theta = 12.8$;

$\epsilon = 3.4$; $W_X = 64.5$;

$\delta_{1978} = -40.6$; $\delta_{1982,\ 1986} = 4.43$;

$\bar{e}_r = 1.90 - .947r + 4.06r^2 - 4.01r^3$; and

$\underline{e}_r = .0227 - .349r + 1.41r^2 - .0857r^3$.

B. Model Predictions (percentage deviations from observed values in parentheses)

	1972	1982	1986
Weather-adjusted output in millions of bushels	2185 (18.4)	2830 (2.34)	1825 (-18.8)
Variable cash expenses in 1982 dollars per planted acre	50.70 (18.8)	43.57 (-18.8)	55.21 (9.94)
Participants' production share	.6022 (-9.89)	.3813 (11.0)	.7869 (-6.04)

table 2A produce model predictions which fit the data well. The predicted value for 1982 sector production in table 2B is 2.34% above the observed value (table 1), and the 1986 value of participants' production share is 6.04% below the observed value (table 1).

AN ILLUSTRATION: FREEZING PROGRAM PAYMENT YIELDS

In order to illustrate the potential of this model for analyzing a change in program regimes, we have simulated the impact of a permanent, unanticipated freeze on program payment yields prior to the 1986 crop year for wheat. These results overstate the impact of the actual freeze for several reasons. First, the 1985 farm bill imposed a freeze on payment yields for 1986 and 1987, with the Secretary of Agriculture having the discretion to continue the freeze in 1988-90. Subsequently, the Secretary chose to leave it in place. However, legislation was passed in 1989 which required the Agricultural Stabilization and Conservation Service to once again begin recording yields. Farmers were definitely getting mixed signals on the relevance of current yields for future payments. Thus it is unlikely that we would observe the kind of sharp break in the data that might follow a permanent, unanticipated freeze.

A second reason for our results to overstate what has actually occurred is that we compare simulated changes to observed 1986 values. However, the 1985 farm bill was implemented partway through the 1986 crop year for wheat. Even though it was not well understood at the time, the freeze may have had some effect on farmer decisions in that year. Thus the observed values for 1986 may already include some effects of the freeze. Finally, we overstate the effects of the freeze due to the simplifying assumption that program payment yields and actual yields are identical. This will be relaxed below (Case II).

Case I: Program Yields Equal Actual Yields

Table 3 presents the estimated impact of a permanent freeze on three groups of wheat producers. Group I consists of producers who did not participate in the program prior to the change, and they remain nonparticipants after the change. For them, the market price is all that changes. Since it rises, their net returns rise, as do their variable input use and yields.

Members of group III also do not change their participation status as a result of the experiment. They were participants prior to the freeze and remain so afterwards. However, they no longer base their input use decision on the target price. Thus X_{in}^{*} is now a function of P_M, not P_T. This serves to lower optimal variable input use. Since they still receive $(P_T - P_M)$ on their previously established program yields, revenues fall more slowly than costs. Consequently, net returns rise for this group as well! This is somewhat surprising, since many participants argue they have been hurt by the freeze. It is true that revenues have fallen, however such arguments generally abstract from the implications of the input use decision for variable costs. Yet the latter change dominates the former.[9]

The last group in table 3 consists of producers who were participants prior to the change, but they exit the program after the change because the market price rises and the deficiency payment falls. Returns to land for these producers increase, since their costs fall more rapidly than revenues. Thus, even though sectoral receipts fall, all three producer groups gain from the freeze in program payment yields due to the cost reductions.

Column one of table 4 (Case I) reports the change in selected variables at the sector level as a result of the permanent, unanticipated freeze on program payment yields. While nonparticipants raise variable input use slightly in response to the higher market price, this change is dominated by the large reduction in variable input use by participants. Average variable input use falls by 23%, and total use falls by almost that much. (Planted

Table 3. Distributional Consequences of an Unanticipated Permanent Freeze in Program Payment Yields for U.S. Wheat, Prior to the 1986 Crop Year.

	Producer Groups					
	Group I		Group II		Group III	
	Nonparticipants		Part.	Nonpart.	Participants	
	Before	After	Before	After	Before	After
Receipts (million $):						
Market receipts	987	1,477	231	250	3,415	3,410
Deficiency payments	--	--	180	--	2,650	1,833
Total	987	1,477	411	250	6,065	5,243
Less costs (million $):						
Variable inputs	615	843	187	141	2,834	1,846
Transactions	--	--	142	--	650	650
Equal Net Returns (million $):	372	634	82	109	2,581	2,747
Acres (million acres):						
Total	24.33	24.33	3.85	3.85	62.82	62.82
Planted	24.33	24.33	2.75	3.85	44.92	44.92
Returns/acre ($/acre):	15.29	26.06	21.30	28.31	41.06	43.73

Table 4. Implications of an Unanticipated, Permanent Freeze in Program Yields for U.S. Wheat (percentage change in selected variables).

Variable	Case I (Z = 1)	Case II (Z = 2/3 and nonprovers)
	Percent change	
Variable inputs:		
Average use (per planted acre)	-23	-11
Total use	-22	-10
Output (quantity)	-11	- 5
Exports (quantity)	-16	- 7
Participating acres	- 6	- 4
Average annual return to land	+15	+ 6

acreage increases as the participation rate falls.) Output falls by 11% and, due to its relatively larger price elasticity, this comes disproportionately out of exports, which fall by 16%. Finally, net returns to land rise by 15%!

In the next section, we explore the impact of relaxing the simplifying assumptions about program yields on the results in table 4.

Case II: Relaxing Assumptions About Program Yields

In the discussion above, we assumed that all program participants "proved" their yields and that these yields were immediately reflected in increased deficiency payments. This overstates the production incentive effect of the target price for two reasons. First, higher current yields translate into higher program yields with a lag, due to the moving average formula used to calculate the latter. If producers: (a) have a positive discount rate, (b) are uncertain about program participation in the future, or (c) place a non-zero probability on program elimination, then there is a reason to discount the target price, for purposes of determining optimal yields in the current period.

Foster shows that a producer who intends to stay in the program in perpetuity will deflate the expected deficiency payment in determining optimal yields. This deflation factor is given by $Z = B/(B + d)$, where B is the fraction of current yield reflected in next year's payment yield (0.2 for a 5 year moving average), and d is the individual's real discount rate (we assume 10% here). Thus there are now three prices which are relevant to the producer's decision problem: P_T, P_M and $P_I = Z\ P_T + (1 - Z)\ P_M = (2/3)P_T + (1/3)P_M$. The nonparticipant determines X^*_{out} based on P_M, whereas the participant uses P_I to determine X^*_{in}. However, since deficiency payments in the current year are made on the basis of the current target price (P_T), these are not to be discounted for purposes of the participation decision.

The other simplifying assumption which must be relaxed involves the behavior of participants with respect to yield-proving. Given the structure of the grains programs, prior to the 1985 Food Security Act, it was attractive for producers with relatively poor quality land to select the county-average yield as the farm's program yield. This, too, hás important implications for the price which is used to determine X_{in}^{*}. In particular, producers who choose not to prove their yields have no incentive to apply nonland inputs beyond the point justified by the expected market prices. This is because, for them, there is no link between actual yields and future deficiency payments.[10]

The introduction of nonprovers into the model generates considerable complexity. Assuming that the acreage distribution, f(e,r), represents the nationwide distribution of land capacities, the model will generate a national yield distribution. Yet it is the <u>county</u> yield distribution which is relevant to the individual producer's decision about yield-proving. We overcome this by approximating the county distribution with the national distribution. Thus a program participant decides to prove yields if it is more profitable to do so than selecting the national average yield (over all producers) as the farm's program yield, in which case X_{in}^{*} is solely based on the market price, P_M. This is best viewed as an exercise in sensitivity analysis designed to shed some light on how the introduction of nonprovers is likely to change our results.

After introducing target price discounting (with Z = 2/3) and nonprovers into our model, we solve for a new equilibrium in which nonland input use and the participation rate are somewhat lower.[11] We then implement a freeze on program yields to obtain the percentage changes reported in the second column (Case II) of table 4. Since nonproving participants are not directly affected by the freeze, and since proving participants utilize $P_I = (2/3)P_T + (1/3)P_M$ in determining X_{in}^{*}, the impact of the freeze is less dramatic. Variable input use falls by 10% and net returns rise by only 6%. This is probably a more realistic prediction of the impact of an unanticipated permanent freeze on program payment yields, prior to the 1986 crop year.

SUMMARY AND CONCLUSIONS

This paper has introduced a conceptual model of the U.S. grains sector which is well-suited to analyzing the impact of grains policies on variable input use and net returns. Producers maximize profits subject to a common technology, but a differentiated resource endowment. In particular, land capacities vary continuously within and between producing units, as do program participation transactions costs, giving rise to differential participation incentives. In equilibrium, some producers participate in the program, while others do not.

This framework is fitted to data for the U.S. wheat sector from 1978, 1982, and 1986. We then proceed to illustrate the model's flexibility for policy analysis by exploring the impact of an unanticipated, permanent freeze on program payment yields. (A temporary version of this policy was instituted under the 1985 Farm Bill.) We find that this measure substantially lowers variable input use and raises net returns, for participants and nonparticipants alike! This is a striking result, given recent proposals by some farm groups to reverse this policy and unfreeze yields.

Footnotes

[1] The deficiency payment is calculated as the minimum of the differences: (target price - average farm price) and (target price - loan rate).

[2] This point has been made by Lee and Helmberger, who show that the presence of the corn program leads to biased estimates of supply response for both corn and substitute crops (soybeans).

[3] Since participation decisions are made on the basis of ASCS farm records, not economic farming enterprises, we choose to use the term "producing unit" to describe the parcel of land in question.

[4] Land capacity is a measure of potential yield given nonland input levels.

[5] Since producers may take the county average yield as their program yield, there is another source of incentive to participate in the case where the producing unit has an average yield which is lower than the county average yield. We explore the role of participants who do not prove their yields later in this paper.

[6] In practice, program payment yields are computed as the average of actual yields for the last five crops, disregarding the high and low years. Furthermore, a producer may select the county-average yield as the farm's program yield. Both of these considerations will be taken into account below.

[7] We calculate the aggregate farm level demand elasticity for wheat (e) as a share-weighted function of the domestic and export demand elasticities:

$$\eta = (1 - \alpha)\ \eta^{d} + (\alpha)\eta^{x}.$$

Values for the first two parameters are taken from Gardner (1988): $\eta^d = -0.2$ and $\alpha = 0.55$. The short-run export demand elasticity is based on Seeley: $\eta^x = -0.80$. So that $\eta = -0.53$.

[8] The estimate of the real price W_X for 1978 and 1982 is 64.5. The 1986 value of W_X is computed as ϵ times 64.5, where ϵ is estimated as all other parameters. We make this distinction to account for some of the effects of the financial stress of the mid-1980s.

[9] It can be shown graphically, using a simple supply-demand framework, that costs always fall more than revenues in this case, even when our simplifying assumptions are relaxed.

[10] Some producers may choose not to prove their yields <u>after</u> realizing unexpectedly low yields in a particular year. However, these producers may still consider the target price in determining variable input use. Here, we are interested in those producers who have no expectation of proving yields.

[11] Comparison of this new equilibrium with the initial 1986 equilibrium shows that total nonland input use declines by 13%, and the participation rate drops by 4% to 70.4% of total acreage. Nonproving participants account for 20% of participating acreage (i.e., 14% of total acreage).

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