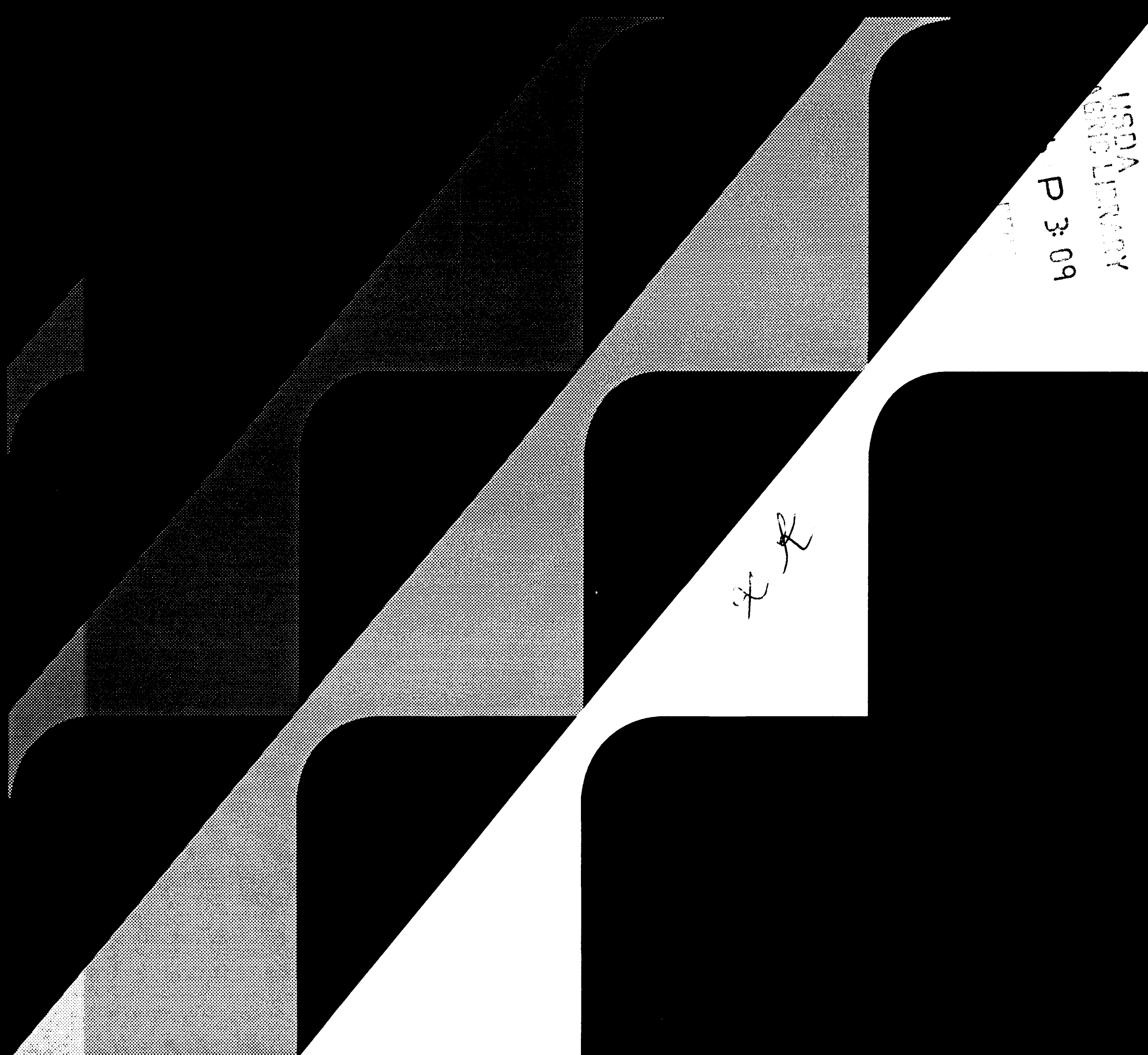
United States
Department of
Agriculture

Economic
Research
Service

Technical
Bulletin
Number 1819

A Model of Participation in U.S. Farm Programs

Robbin A. Shoemaker



A Model of Participation in U.S. Farm Programs. By Robbin A. Shoemaker. Resources and Technology Division, Economic Research Service, U.S. Department of Agriculture. Technical Bulletin No. 1819.

Abstract

Voluntary participation in U.S. farm programs significantly influences the economic consequences of these programs. The voluntary nature of these programs produces two important considerations for policy analysis. First, program provisions designed to induce participation create distortions in farm production. Second, commodity and factor market equilibriums depend crucially on the actual level of participation. U.S. farm programs are designed to provide income transfers and affect market prices through supply control. The effectiveness of supply control depends on the level of farmer participation, which, in turn, depends on the expected benefits to participants. Therefore, to estimate the effectiveness and economic consequences of farm policy options, it is important to model program participation. This report presents a general equilibrium model of the U.S. farm and nonfarm sectors. The main features of the model include the depiction of participation by farmers in the programs, explicit modeling of agricultural program instruments, and capital investment.

Keywords: Endogenous participation, U.S. farm programs, steady-state general equilibrium

Washington, DC 20005-4788 August 1993

Contents

Summary

Voluntary participation in farm programs and capital investment by farmers are choices that greatly influence the economic consequences of farm programs. This technical report presents a model of the U.S. farm and nonfarm sectors to explore such relationships. The main features of the model include a simulation of voluntary participation by farmers in the programs, explicit modeling of agricultural program instruments, and capital investment.

Participation in U.S. farm programs is voluntary. The voluntary nature of these programs produces two important considerations for policy analysis. First, program provisions designed to induce participation create distortions in farm production. The price supports for program commodities, for example, encourage or maintain production of these commodities. Second, market prices for such commodities depend crucially on the actual level of participation, since U.S. farm programs attempt to affect the market price by controlling the supply of farm produce. But, the effectiveness of supply control depends on the level of farmer participation, which, in turn, depends on the expected benefits to participants. This model estimates and analyzes the effectiveness of various farm policy options by stressing the effects on the commodity market of the voluntary nature of the farmer participation.

Policy models often simplify assumptions as to the implementation of policy. For example, most models use ad valorem subsidies instead of the actual instruments, which include target prices, set-aside requirements, and payment yields. Target prices and set-aside requirements provide opposite incentives for participation and production. With target prices, production and participation increase, but both of these decrease with set-aside requirements. Explicitly modeling actual policy instruments highlights the tradeoffs between these instruments. The effect of this tradeoff depends on the level of farmers' program participation and also on the level of capital stocks in the farm sector.

This report presents a computable general equilibrium (CGE) model that simulates the choice for participation in U.S. agricultural programs. Policy models typically assume that all farmers participate in farm programs. This assumption results in an overestimation of the effectiveness of the programs and also underestimates the economic distortions that come from the policy instruments of supply control and price support.

The three main features of this report include modeling voluntary participation in commodity programs, modeling explicit factors of program instrumentation, and modeling capital investment; this last has modifying effects on policy changes.

The model examines changes in capital stocks within and between sectors. CGE models generally examine longrun reallocations of existing capital stocks. A feature of this model is the complete adjustment of capital, which entails the reallocation of capital between sectors as well as the investment in new stocks and/or the depreciation of existing capital. The implication of modeling capital investment is that the effects of a policy change on asset revaluation can be modified by changes in capital stocks. The effects on commodity markets of the voluntary farmers' participation (as well as the other features of the model) are demonstrated with a policy scenario. The scenario examines the effects of varying target prices. A discussion of the nonfarm sector, households, Government, and the general equilibrium structure is provided in the appendix. The data, numerical simulation model, and solution algorithm will also be found in the appendix.

A Model of Participation in U.S. Farm Programs

Robbin A. Shoemaker

Introduction

Participation in U.S. farm programs is the voluntary decision of farmers. The voluntary nature of these programs produces two important considerations for policy analysis. First, program provisions designed to induce participation create distortions in farm production. Second, commodity and factor market equilibriums depend crucially on the actual level of participation. U.S. farm programs are designed to provide income transfers, but these programs also attempt to affect the market price through mechanisms that control supply of farm produce. Effectiveness of supply control depends on the level of farmer participation, and this, in turn, depends on the expected benefits to participants. Therefore, if we wish to estimate the effectiveness of various farm policy options and to analyze their equilibrium effects, we must include program participation in our proposed model.

This report presents a computable general equilibrium (CGE) model that simulates endogenous participation in U.S. agricultural programs. Policy models of U.S. agricultural programs often implicitly assume that all farm producers participate in farm programs (for example, Hertel and others, 1989, and Hrubovcak and others, 1992; exceptions are Whalley and Wigle, 1988, and Hertel and others, 1990). This assumption, that all farmers participate, results in an overestimation of the effectiveness of the programs and also underestimates the economic distortions that come from the policy instruments of supply control and price support. For example, if the commodity price increases that came from full participation actually occurred, an endogenous participation model would require greater set-aside requirements, which would lead to larger economic distortions.

Several recent policy models also make simplifying assumptions with regard to the implementation of policy (Hertel and others, 1989; Hrubovcak and others, 1992). For example, most models use ad valorem subsidies instead of the policy instruments that are actually used, which include target prices, set-aside requirements, and payment yields. Target prices and set-aside requirements provide opposite incentives for participation and production. With target prices, production and participation increase, but both of these decrease with set-aside requirements. Therefore, we will explicitly model the actual policy instruments, so that the tradeoffs between these instruments can be made clear.

This model will also examine changes in capital stocks within and between sectors. CGE models generally perform comparative statics, which represent longrun reallocations of extant capital stocks. When certain policy parameters change, capital stocks may be expected to change as well. A feature of the present model that provides an improvement over comparative static analysis is the use of comparative steady states. The use of comparative statics implies a longrun analysis in which there is full adjustment of factors within and between sectors. Complete adjustment also entails not only the reallocation of capital stocks in the sectors but also the investment in new stocks and/or the depreciation of extant capital. For sectors experiencing some policy change, endogenous capital stocks provide an additional degree of freedom, offsetting the effects of asset revaluation that occur in a fixed capital stock model. Endogenizing capital stocks is an application of the Le Chatelier principle, which states that as additional factors become variable in the long run, firms can continue to adjust in response to price or policy changes.

In the last part of the report, some general models of endogenous participation behavior are examined. This is followed by a discussion of the current model assumptions regarding participation in U.S. farm programs. Next, the equilibrium effects of endogenous participation (as well as the other features of the model) are demonstrated with a policy scenario.[1] The scenario examines the effects of varying target prices. Finally, some conclusions are presented. Further, discussion of the nonfarm sector, households, Government, and the general equilibium structure will be found in the appendix. The data, numerical simulation model, and solution algorithm will also be found in the appendix.

Endogenous Participation Models

Endogenous participation in any activity involves making a discrete choice among alternatives. Many such theoretical problems involving discrete choices have been examined in the literature of economics. Examples include the choice of tax evasion under portfolio choice models of risk aversion (Allingham and Sandmo, 1972), the effects of differential tax preferences on labor supply and occupational choice (Sandmo, 1981; Kanbur, 1981), and equilibrium wage effects between tax evading and nonevading market participation (Watson, 1985; Kesselman, 1989). The above models assume that individuals have the same utility function and/or the same gross productivity without regard to sectoral employment. The allocation of individuals across sectors or occupations is determined by differing levels of risk aversion (Kanbur, 1981) or by differential real or psychic costs (Kesselman, 1989). Other studies that examine the equilibrium effects of discrete choices include those on technology adoption (Caswell and Shoemaker, 1993) and criminal behavior (Furlong, 1987). All these studies involve discrete choices by agents whose choices affect the supply of their particular activity, thus affecting its relative return.

Endogenous participation in any activity involves weighing the benefits and costs associated with that activity. Because benefits are straightforward, choice models are usually distinguished by the source or type of costs where costs are often determined by the quality of certain factor endowments. Individuals can be distinguished by their endowments, which can be either inherent characteristics or those acquired through time. Endowments can include intrinsic skills and ability, the accumulated stock of human capital, and other attributes that distinguish individual productivity in different activities. For example, at any given time, farmers (landowners) are endowed with differing qualities of land. Variations in land quality can be interpreted as differing productive capacity or, equivalently, as the attribute that determines production costs for a given level of output. That is, for a given level of output, production costs for one who possesses high-quality (that is, productive) land are lower than costs for one who possesses low-quality land. While there are other, possibly unobservable, factors that determine program participation, the assumption made here is that participation is based on program profits and that benefits (and costs) are determined by the distribution of the quality of the farmers' land.

Hertel and others (1990) also find that the distribution of land quality is a key determinant of participation in the farm programs. Further, Moore and others (1990) find that program participation depends positively on target prices and negatively on set-aside requirements. The negative result implies that the opportunity cost of idling some highly productive land may be too high to justify program participation, while, on the other hand, the program payments given for low-quality land may be higher than if the land were in production. Thus, the program essentially provides a "pure rent" for the low-quality land and can increase its value.

[1] Other policy issues have been examined in Shoemaker (1992).

The model developed in this report applies an endowments-based model in which the producer-farmers are distinguished by the quality of their land. The assumption is made that producers who incur high farming costs will participate in the program because so doing subsidizes their production costs, which will be determined by the quality of their land. Thus, program participation will be, in this model, entirely determined by the distribution of land quality. This approach has the advantage of providing a direct accounting, with an observable variable, of the source of participation decisions, and it will also provide a direct link between the source of the decisions and the equilibrium outcomes.

Modeling of Program Policy Instruments

The deficiency payment programs are the primary income transfer mechanism of U.S. farm policy.[2] The term "deficiency payments" refers to the provision of additional income to farmers when the market brings in less income than is socially or legislatively desirable. To receive these payments, farmers must reduce the amount of land in production by a certain given percentage, θ, where $0 < \theta < 1$. When those acres are set aside, the farmers receive a payment on the acres remaining in production. For the j^{th} farm, government payments, GP, are calculated as:

$$GP_j = (\bar{p}-p)(1-\theta)A_j\bar{y}_j. \quad (1)$$[3]

The payment is calculated as the difference between an established target price, $\bar{p}$, and the market price, p, times the product of the net acres in production, $(1-\theta)A$ (where A denotes land), and an established yield rate, $\bar{y}$. $\bar{y}$ can be thought of as an exogenously set average product of land. $\bar{p}$, θ, and $\bar{y}$ are the three main policy instruments used in U.S. farm income support programs. If the market price exceeds the target price, no deficiency payment will be made.

Farm Sector Production and Program Participation

The theoretical basis of the agricultural model is presented in this section, along with a description of how farm programs work. The nonagricultural sectors (that is, nonfarm production, households, and Government) are discussed in the appendix. Data development and the numerical model solution algorithm also appear in the appendix.

It is assumed in this model that the farm sector uses the full distribution of land quality, while the nonfarm sector uses only the poorest quality land. The classes of land are differentiated by the productive capacity for growing agricultural produce. Agricultural land quality is a function of such characteristics as soil fertility and water-holding capacity, and these characteristics have no bearing on the marginal productivity of land in nonagricultural uses. As a result, the nonfarm sector is assumed unwilling to pay the premium for more highly productive land.

In this model, the agricultural sector consists of T firms, each owned by a single landowning household. Each firm is endowed with a different quality of land, but all the land managed by each firm is assumed to be of homogenous quality. If a distribution of land quality is given, three

---

[2] The other aspect of U.S. commodity programs is price stabilization, in which the Government provides a minimum price for commodities. The Government maintains this price floor by purchasing commodity stocks when the market price falls below the floor price. Since the current model is confined to steady states, we abstract from price stabilization issues.

[3] In the simulation model developed below, the simplifying assumption is made that all producers face the same (average) program yield rate. This assumption results in an overestimate of the average product of low-quality land and an underestimate for good-quality land. The issue of nonuniform yield rates is examined in Shoemaker (1992).

outcomes are possible regarding participation. Either all farms participate, none participate, or some do (producers with high costs) and some do not (producers with low costs). Since there are only three possible outcomes, this model can be formed stylistically, with farms representing three land qualities: good (G), medium (M), and low (L).[4] This simple classification of land qualities implies a cumulative distribution of land quality that is the sum of three continuous, uniform land quality distributions. Assuming that the quality of land is the only distinguishing factor, the level of program participation is measured by the number of farms (distinguished by their land quality) that are in the program.

The goal of all producers, farm and nonfarm, is to maximize the discounted stream of profits, net of adjustment costs. The adjustment cost function is linear homogenous and convex in investment, I, and capital, K. Production by all producers, farm and nonfarm, is a function of capital, labor, N, and land, A. We will simplify the notation by not subscripting farms and by denoting nonfarm producers by the subscript m. Total investment costs include the cost of investment goods and the adjustment (installation) costs, J(I,K). The production technology is assumed to be separable in adjustment costs, as in Lucas (1967), so the production function can be expressed as $y = F(K,N,A) - J(I,K)$. Total investment costs are then $I + J(I,K)$. These costs represent the full opportunity cost, in terms of output, of investment.[5] Adjustment costs are defined in terms of I/K, which implies that the cost of adjusting capital is a function of the level of investment relative to the size of the capital stock. The production technology of each farm is expressed as:

$$(2) \qquad y_j = f^j(A_j,K_j,N_j) - J(K_j,I_j),$$

where j = L, M, and G, and $f^j(\cdot)$ has the properties $f' > 0$ and $f'' < 0$, where primes denote derivatives. The production function $f^j(\cdot)$ is indexed by j to indicate that factor distribution and production efficiency parameters differ because of land quality endowments. The capital adjustment cost functions, $J(I_j,K_j)$, are assumed to be identical for all farms. Equation (2) describes the total output from which nonprogram participants, given an optimal selection of inputs, receive revenues. All farmers are assumed to choose their optimal levels of demands for labor, land, and investment and to choose whether or not to enter the program so that they maximize discounted net cash flows. Firms discount their returns at the after-tax market rate of return that is paid to assets holders (households).[6] Participation is based on net benefits; for a given vector of input and output prices, if the benefits (net returns) from participation exceed the costs and are greater than the net benefits from nonparticipation, then the farm will be in the program. For the farm with poor land, A_L, the profit maximization problems are defined as:

---

[4] For all types of land, it is assumed that the productive capacity of land does not depreciate.

[5] Adjustment costs take the form $J(I,K) = 0.5b(I/K)I$, where b is the adjustment cost parameter. Total investment costs are expressed as $I + 0.5b(I/K)I$. The acquisition cost of investment goods is actually $p_k I$, where p_k is the acquisition price of new investment goods, but in this model, the nonfarm sector produces both consumer and investment goods. Since that price is used as the numeraire, $p_k = 1$.

[6] In equilibrium, the after-tax interest rate is equal to the personal rate of discount, ρ. Since firms are assumed not to pay taxes (only households pay taxes), net cash flows are discounted by ρ.

(3)
$$\pi_L = \begin{cases} \int_0^\infty e^{-\rho t}\{p[f(A,K,N) - J(K,I)] - wN - v_L A_L - I\} & out, \\ \int_0^\infty e^{-\rho t}\{p[f(A(1-\theta),K,N) - J(K,I)] + (\bar{p}-p)(1-\theta)\bar{y}A_L \\ \quad - wN - v_L A_L - I\} & in, \end{cases}$$

s.t. $$\dot{K} = I - \delta K,$$

where "out" refers to nonparticipation and "in" refers to participation, w is the wage rate for labor, v_L is the rental rate for A_L, and δ is a constant rate of depreciation. Since A_L land can be traded between the farm and nonfarm sectors, it is treated as a variable input. For both participants and nonparticipants, net returns are defined as total revenues net of labor costs, wN; land rental, $v_L A_L$; and capital investment, I. For farms with medium or good land, the optimization problem is the same as above with the exception of the fixity of land. The assumption of land specificity implies that, for these producers, there is an additional inequality constraint for land. The profit maximization problems for farms with M and G land are defined as:[7]

(4)
$$\pi_j = \begin{cases} \int_0^\infty e^{-\rho t}\{p[f(A,K,N) - J(K,I)] - wN - I\}dt & out, \\ \int_0^\infty e^{-\rho t}\{p[f(A(1-\theta),K,N) - J(K,I)] + (\bar{p}-p)(1-\theta)\bar{y}A_j - wN - I\}dt & in, \end{cases}$$

s.t. $$\dot{K}_j = I_j - \delta K_j,$$
and $$A_j \leq \bar{A}_j,$$

where j = M and G, and $\bar{A}_j$ is the fixed amount of A_j-type land. In both cases, the L farm and the M and G farms determine their maximum profits for participation and nonparticipation where they face the benefit of a subsidized price and the opportunity cost of reduced market revenues due to the acreage set-aside. Equation (3) results in the Hamiltonian for the producer that uses only poor land expressed as:

(5)
$$H_L = \begin{cases} e^{-\rho t}\{p[f(A,K,N) - J(K,I)] - wN - v_L A_L - I + q(I-\delta K)\} & out, \\ e^{-\rho t}\{p[f(A(1-\theta),K,N) - J(K,I)] + (\bar{p}-p)(1-\theta)\bar{y}A_L \\ \quad - wN - v_L A_L - I + q(I-\delta K)\} & in. \end{cases}$$

[7] In this model, the assumption that there are three farms differentiated by land quality and that all are owned by a single household is analogous to a single farmer who puts some of the land in the program (the poorer land), collecting subsidies, and farms the remaining land in nonprogram activities.

For the other j producers, the Hamiltonians are[8]

(6)
$$H_j = \begin{cases} e^{-\rho t}\{p[f(A,K,N) - J(K,I)] - wN - I + q(I-\delta K) + v_j(\bar{A}_j - A_j)\} & out, \\ e^{-\rho t}\{p[f(A(1-\theta),K,N) - J(K,I)] + (\bar{p}-p)(1-\theta)\bar{y}A_j \\ \quad - wN - I + q(I-\delta K) + v_j(\bar{A}_j - A_j)\} & in. \end{cases}$$

Assuming the A_j land constraints are always binding, the first-order conditions for the L and j firms are identical in form. The difference is in the interpretation of the marginal value product of land. For the L firms, where land is freely mobile between the farm and nonfarm sectors, v_L is the market rental value of land. For the j firms, the marginal value product of land is profit or "rent" in the Ricardian sense. That is, since land is fixed for the j producers, land is the residual claimant or the factor that is paid in revenues in excess of all other variable factor payments. Program participation is based on the maximization of rent. Although the fixed and mobile land types earn different kinds of rent, here, for the sake of simplicity, all land payments will be referred to as rent except where the distinction needs to be preserved.

Capital also receives a quasi-rent in the short run because it is a quasi-fixed factor. Since the analysis is confined to steady states in which full adjustment occurs, capital can be viewed as a variable input and the user cost of capital, as a market equilibrium rental rate.

The first-order conditions for an optimum (for either L or j firms) are different, depending on whether the farms are in or out of the programs. The first-order conditions for nonparticipating firms are

(7a) $$\frac{\partial H}{\partial N} = p\frac{\partial f(A,K,N)}{\partial N} - w = 0,$$

(7b) $$\frac{\partial H}{\partial I} = -\left[1 + p\frac{\partial J}{\partial I}(I,K)\right] + q = 0,$$

(7c) $$-\frac{\partial H}{\partial K} = q(\rho+\delta) - p\left[\frac{\partial f(A,K,N)}{\partial K} - \frac{\partial J(\cdot)}{\partial K}\right] = \dot{q}\ ,$$

(7d) $$\frac{\partial H}{\partial A} = p\frac{\partial f(A,K,N)}{\partial A} - v = 0.$$

For participating farms, the first-order conditions are[9]

(8a) $$\frac{\partial H}{\partial N} = p\frac{\partial f(A(1-\theta),K,N)}{\partial N} - w = 0,$$

(8b) $$\frac{\partial H}{\partial I} = -\left[1 + p\frac{\partial J}{\partial I}(I,K)\right] + q = 0,$$

---

[8] In this problem, we define $qe^{-\rho t}$ as the present value Lagrange multiplier for the capital accumulation constraint.

[9] These first-order conditions are subject to the transversality conditions, $K(0) = K_o$, $\lim_{t\to\infty} e^{-\rho t}q_t \geq 0$, and $\lim_{t\to\infty} e^{-\rho t}q_t K_t = 0$.

(8c) $$-\frac{\partial H}{\partial K} = q(\rho + \delta) - p\left[\frac{\partial f(A(1-\theta),K,N)}{\partial K} - \frac{\partial J(\cdot)}{\partial K}\right] = \dot{q}\ ,$$

(8d) $$\frac{\partial H}{\partial A} = p\left(\frac{\partial f(A(1-\theta),K,N)}{\partial A}\theta\right) + (\bar{p}-p)(1-\theta)\bar{y} - v = 0.$$

Equations (7a) and (8a) are the usual conditions that labor will be used such that the value of its marginal product equals the wage rates in each period. Equations (7b) and (8b) imply that firms invest in capital up to the point where the shadow value of an additional unit of capital, q, equals the marginal cost of investment, where the latter includes both the acquisition price and the marginal adjustment cost. Note that the program parameters do not enter the investment function directly, which implies that the program affects investment only indirectly through the commodity price.

Rearranging equations (7b) or (8b) and noting that J(·) is a function of the investment rate, that is, (I/K), yields

(7b') $$1 + p\frac{\partial J(I/K)}{\partial I} = q,$$

which is analogous to the "q" in Tobin's "q" theory of investment. Tobin's q theory predicts that firms will continue to invest when the market value of their capital (that is, the present value of the firm as determined by expected future prices) exceeds the marginal cost of replacement (Abel, 1982). Since J(I/K) is convex, (7b) or (8b) can be inverted to yield the investment function, as:

(7b'') $$I/K = J'^{-1}\left(\frac{q-1}{p}\right) = \Phi\left(\frac{q-1}{p}\right),$$

where $\Phi'(q-1) > 0$ and $\Phi(0) = 0$.

Equations (7a)-(7d) and (8a)-(8d) also demonstrate that the major effects of the program on resource allocation are (1) the subsidization of the user cost of land due to the target price, $\bar{p}$, and (2) the effect of the set-aside, θ, on marginal products. From equation (8d), define the first part of the expression as the marginal value product, denoted as $v_j = \theta p(\partial f(A(1-\theta),K,N)/\partial A)$. The second part, $(\bar{p}-p)(1-\theta)\bar{y}$, is the subsidy. The user cost of land for participants can be defined as:

(9) $$v_j = v_j - (\bar{p}-p)(1-\theta)\bar{y}.$$

The user cost for participants is their marginal value product less the subsidy. It is the user cost of land that the participants face when making their allocation decisions. Given the reduction in the land user cost for participants relative to nonparticipants, the ratio of employed land to nonland inputs should be greater for participants.[10]

The set-aside rate, θ, has an effect on the marginal products of the nonland inputs. If all else is constant, an increase in θ decreases the actual land used and thereby decreases the marginal products

---

[10] Employed land is defined as land that is used for any purpose; that is, land used for production and, in the case of program participants, for land set-asides.

of labor and capital.[11] The effect of a change in θ on land rents is ambiguous because there are two divergent effects. An increase in θ will increase the marginal product of land but will also decrease the subsidy for the land. The net effect depends on which of the two effects dominates, although v is likely to decrease in θ.[12]

The Effect of Target Prices on Program Participation and Producer Behavior: A Model Experiment

In the following section, the properties of the model are examined by varying one of the farm policy parameters, the target price. The experiment examined here demonstrates the effect of the target price scheme on farm production and economic efficiency. The existing farm program utilizes three main policy instruments, the target price, $\bar{p}$, the set-aside rate, θ, and the established program yield rate, $\bar{y}$. This experiment involves increasing the target price while holding the set-aside rate fixed at the historical average of 15 percent. The historically based values used for the policy parameters will be referred to later as the status quo parameter values.[13] Table 1 presents the status quo values for prices, quantities, and program parameters. The values presented here are designed to be representative of a stylized economy only; they are not intended to duplicate a real situation. In the following scenario, the program yield rate is held constant and is assumed to be the same for all types of land. The assumption of a homogeneous yield turns out to be significant for efficiency and for considerations of land distribution.[14]

Changing the Target Price Given a 15-Percent Set-Aside Rate

In this experiment, the effects of increases in the target price are examined while holding the set-aside rate constant. Figures 1-3 present the results of this experiment on the production associated with each land type, the output price, and total farm production. Discrete jumps occur in all the variables as the target price is increased and firms enter the program. The apparently large size of the jumps is a result of the fairly large differences in the assumed marginal products of land in the initial benchmark data set and of the sudden reduction in land use by 15 percent that is associated with the set-aside with each program entrant. For example, when the target price increases 8.5 percent (where $\bar{p}$ = 1.12), the

---

[11] The effect of θ on the marginal products of capital and labor can be seen as follows. Define land net of the set-aside as $\tilde{A} = A(1-\theta)$ and the marginal product of the nonland input x as $z = f_x(\tilde{A},x)$, where subscripts denote partial derivatives. Then the effect of a change in θ is $\partial z/\partial\theta = (\partial z/\partial\tilde{A})(\partial\tilde{A}/\partial\theta)$, where the first term on the right-hand side is the derivative of the marginal product of x with respect to $\tilde{A}$, which is positive, assuming x and $\tilde{A}$ are substitutes. The second term is negative; therefore, an increase in θ will result in a decrease in the marginal product of x.

[12] The effect of θ on land rents can be seen by defining land rents as being made up of two components: (1) the marginal product of land, and (2) the transfer component. Rent is expressed as $v = f_{\tilde{A}}(\tilde{A},x) + (\bar{p}-p)(1-\theta)\bar{y}$, where $f_{\tilde{A}}$ is the marginal product of land, $\tilde{A}$ is defined as in footnote 11, and $(\bar{p}-p)(1-\theta)\bar{y}$ is the transfer. The partial derivative of v with respect to θ is $\partial v/\partial\theta = f_{\tilde{A}\tilde{A}}(\cdot)(\partial\tilde{A}/\partial\theta)-(\bar{p}-p)\bar{y}$. The term $f_{\tilde{A}\tilde{A}}$ is the second derivative of $f(\cdot)$ with respect to $\tilde{A}$. The product of the first two factors on the RHS is positive due to the concavity of the production and the definition of $\tilde{A}$. The second term is negative, making the net effect ambiguous. Since $f_{\tilde{A}\tilde{A}}$ is small, it is likely that the absolute value of the first term is smaller than the absolute value of the second, implying v is decreasing in θ.

[13] The historical average set-aside rate is based on the rate applied to major field crops for the period from 1979 through 1989. The target price is fixed at 1.3. This represents a 30-percent subsidy over the benchmark no-program case where the market price for agricultural goods is set at 1. A 30-percent subsidy has been estimated as the average producer subsidy equivalent (PSE) for all agricultural products from 1982 to 1987 (USDA, 1987).

[14] The issue of nonuniform program yields is examined in Shoemaker (1992).

farmer using the lowest quality land enters the program. Producers with low-quality land now receive a subsidy on the user cost of land, which results in a 1.8-percent increase in their demand for land. But, due to the 15-percent set-aside, their effective land in production is reduced by 15 percent, which results in a reduction of their output by 11 percent (fig. 1). The reduction of L land output results in an overall reduction in total farm output of 2.1 percent (fig. 2). The reduction in total farm output results in an increase in the market price (fig. 3) and a rise in the rental value of all types of land (fig. 4). The rise in land rents (fig. 4) occurs for two separate reasons. First, rents rise from the direct effect of the increase in returns from the subsidy. Second, an indirect effect on land rents is caused by higher agricultural commodity prices and the bidding-up of market rental rates for mobile land. In the steady state, the market price for farm goods is equal to the average cost of production. The rise in the market price is consistent with an increase in production costs, which came in part from the efficiency costs associated with the acreage set-aside.

The results shown in all figures present discrete jumps because of the limited number of land classes. In reality, there is a continuous distribution of quality of land. The distribution of land classes used here reflects the average quality of land within a particular land class. Each class represents the share of that class of all land. A continuous distribution of land would imply program parameters, and participation would have a continuous effect on other endogenous variables. For example, in figure 2, an interpolation of changes in the output price is estimated as a cubic function of the simulated data. This least squares estimate of price effects enables an estimate of the change in output prices that reflects a continuous distribution of land quality.

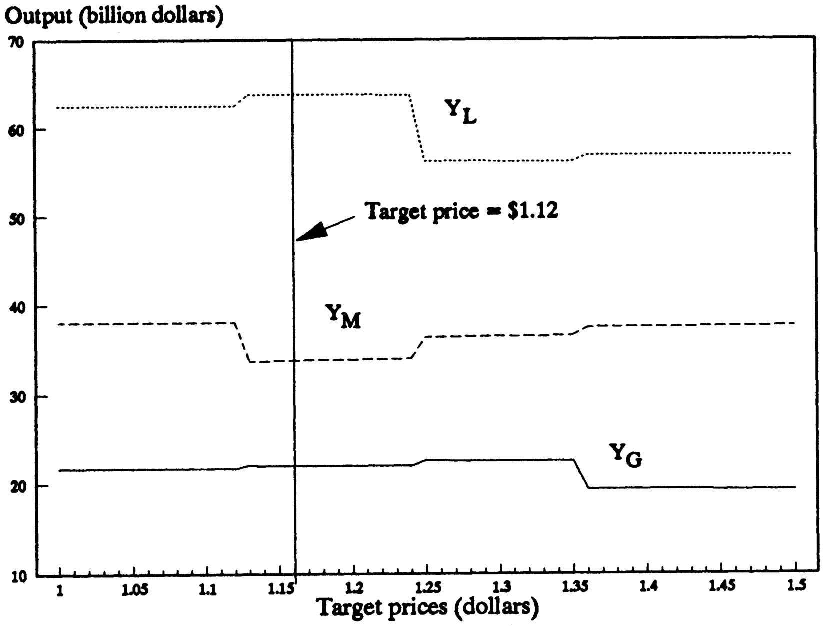
Table 1--Status quo values for prices, quantities, and policy parameters

Prices		Quantities				Policy parameters	
		Farm		Nonfarm			
Factor	Value	Factor	Value	Factor	Value	Factor	Value
---Dollars---		----------Billion dollars---------				---Dollars---	
p_A	1.05	Y_A	115.2	C	2,579.0	$\bar{p}$	1.3
r	.11	A_L	13.6	N_o	2,237.2	τ	.01
w	.99	N_G	7.7	K_o	9,036.2	$\bar{y}$[1]	1.0
v_G	1.63	N_M	7.8	A_o	.9		
v_M	1.16	N_L	5.8			---Percent---	
v_L	.80	K_G	108.5			θ	15.0
q_A	2.28	K_M	313.7				
q_o	1.33	K_L	233.8				

NOTE: Both the L and M farms participate in the status quo.
[1]Average product of land normalized to 1.0.

Yi Output	K Capital	C Consumption
p Output price	N Labor	q_A Shadow price of capital (agriculture)
v_j Land rent	A Land	r Capital rent
w Wage rate	τ Tax rate	

Figure 1
Changes in agricultural output levels for each land class due to varying the target price



Y_L = Low-quality land.
Y_M = Medium-quality land.
Y_G = Good-quality land.

Figure 2
Simulated and interpolated agricultural changes due to varying the target price

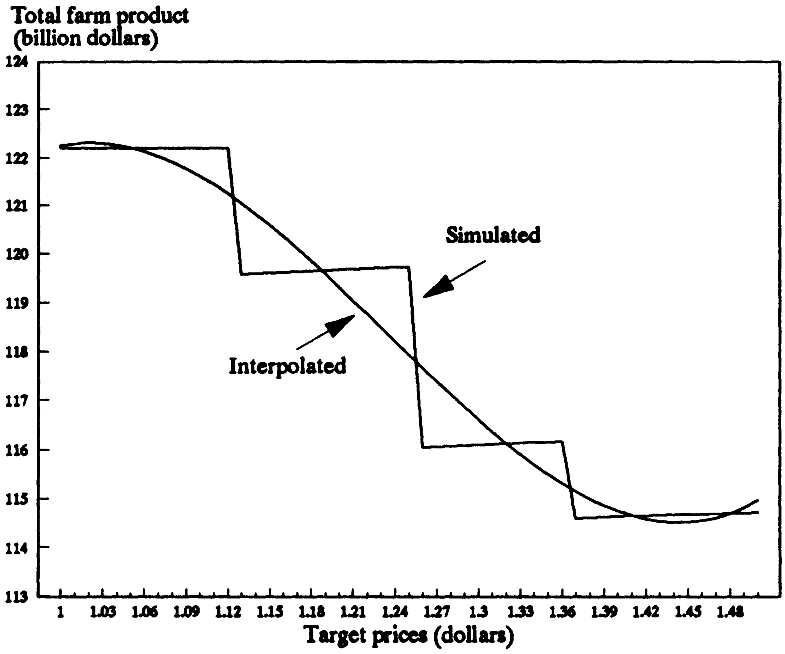


Figure 3

Change in agricultural output price due to varying the target price

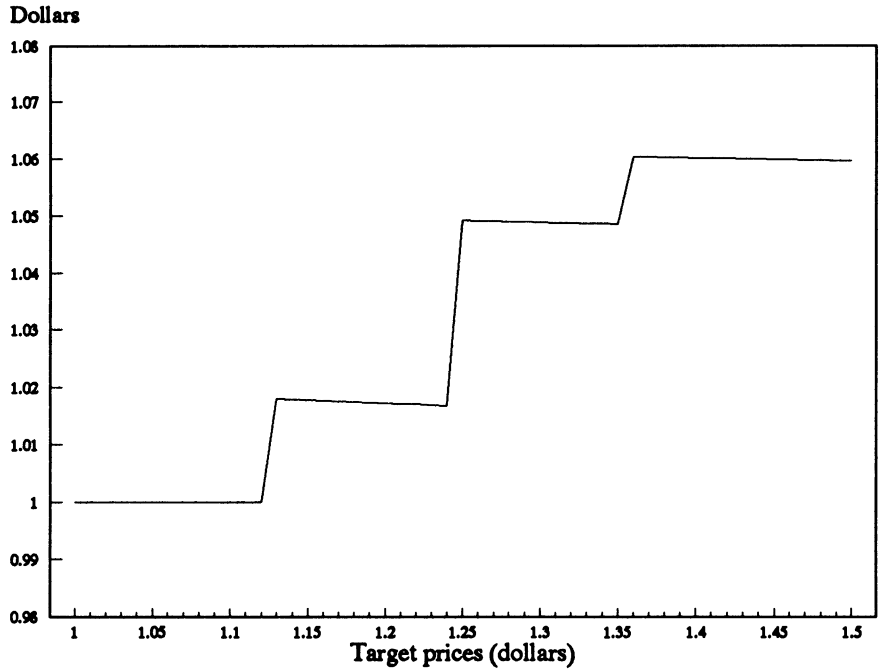
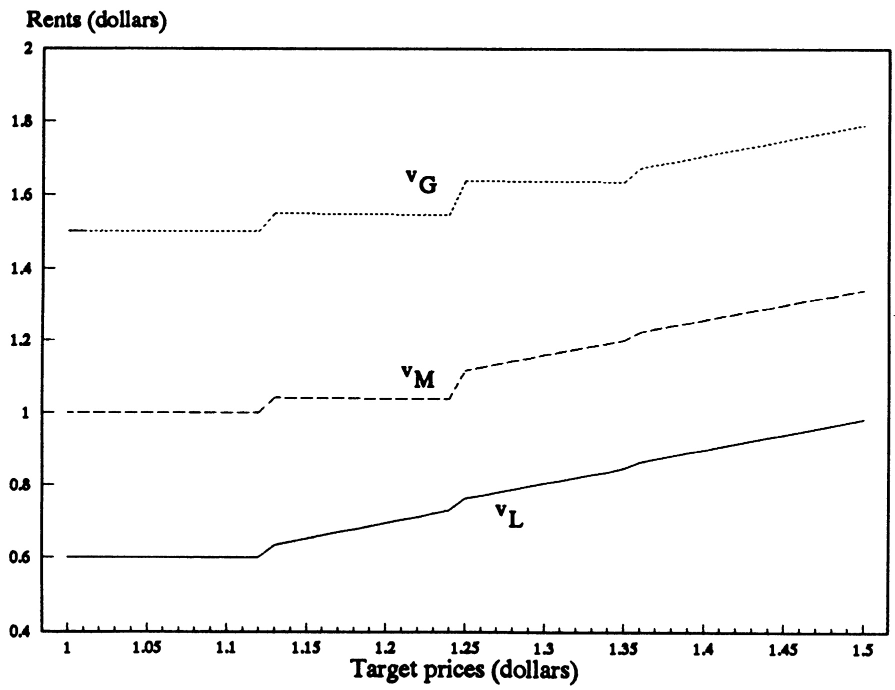


Figure 4

Change in land rents and shadow prices for each land class due to varying the target price



v_L = Land rents for low-quality land.

v_M = Land rents (shadow price) for medium-quality land.

v_G = Land rents (shadow price) for good-quailty land.

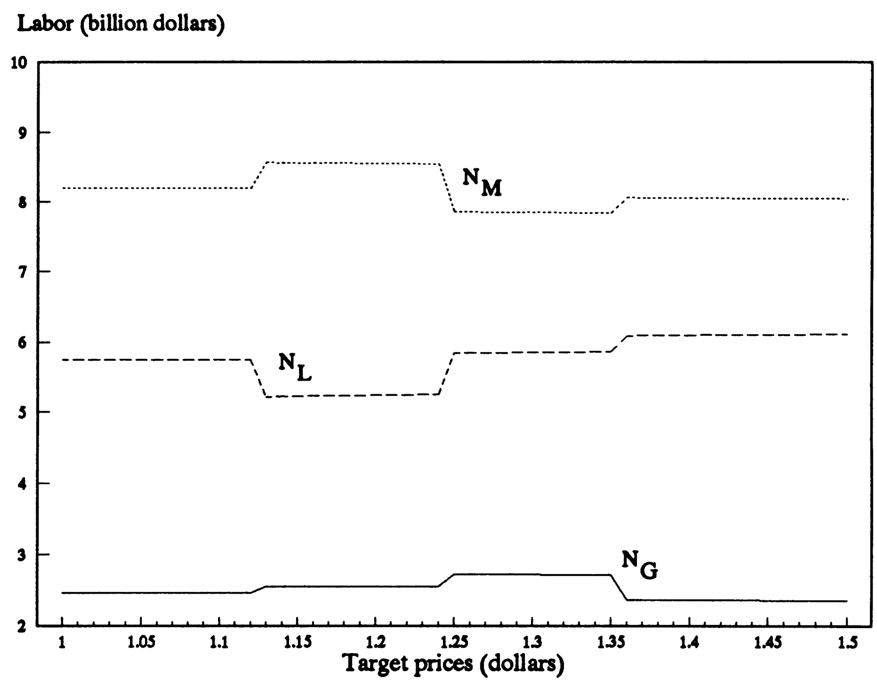
This kind of modeling also shows the net effects of both the substitution and output (or expansion) effects. For example, when the low-quality land enters the program, wage rates decline. For nonparticipants, labor demand increases the substitution effect, but for participants, the demand for labor decreases, since some of the land is now set aside (fig. 5). For all land types and every level of participation, the output effect seems to dominate the substitution effect. As a new land type enters the program, production decreases, and derived demand for inputs (such as labor and capital, figs. 5 and 6) also declines. On the other hand, for those farms that were either already in the program or have not entered at all, the output and the derived demands increase.

The effects of set-asides on output and derived demands can be seen more clearly following the results presented in figures 1, 5, and 6. The first program entrant is L, which results in declines in Y_L (fig. 1) and therefore in K_L (fig. 6) and N_L (fig. 5), while Y_j and K_j and N_j increase. As the target price continues to increase, L stays in the program, but at $\bar{p}$ = 1.24, M also enters the program. At that point, Y_M, K_M, and N_M decline, while Y_L, K_L, N_L, Y_G, K_G, and N_G increase. Next, when $\bar{p}$ reaches 1.35, G enters the program, Y_G, K_G, and N_G decline, while Y_L, K_L, N_L, Y_M, K_M, and N_M increase.

Despite the increase in individual production (fig. 1), total output declines with the new program entrants (fig. 2) because of the additional loss of land in production from the acreage set-aside. Also, the effect of the program on commodity prices and total output is not monotonic. For example, in figure 2, as firms enter the program, total output declines in a ratchet-like fashion. But, between ratchet points, total output actually increases very slightly (fig. 3). Similarly, between ratchet points, the agricultural market price declines very slightly. The implication is that, in this model, it is only the relatively large set-aside requirements that have any effect on total agricultural production and prices.

Figure 5

Change in agricultural labor demands for each land class due to varying the target price



N_L = Labor demands for low-quality land.

N_M = Labor demands for medium-quality land.

N_G = Labor demands for good-quality land.

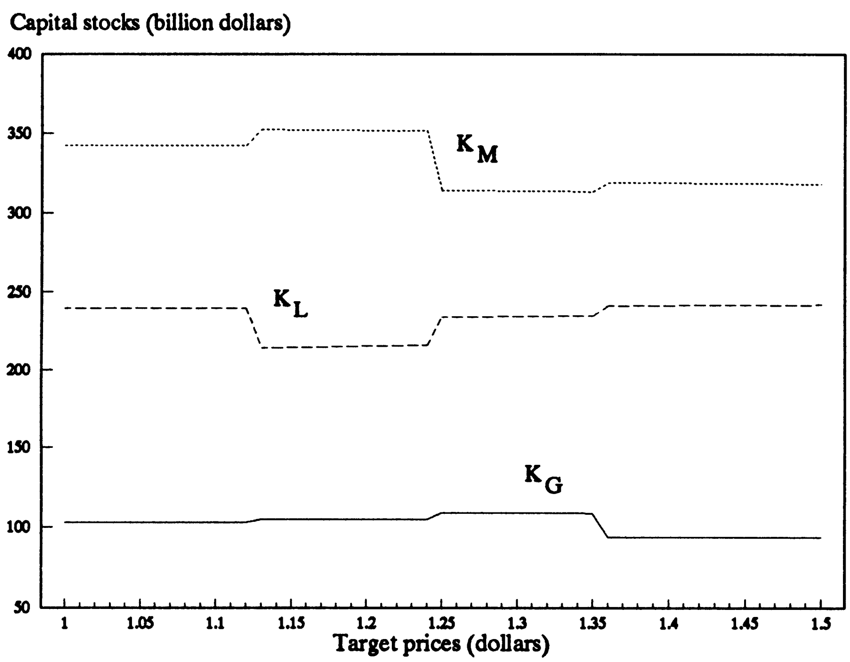
The behavior of the different agricultural firms also differs during the intervals between ratchet points. For example, output from the M and G producers declines; only output from L increases (fig 1). Capital stocks and labor demands decline for M and G, and they increase for L. The differences in these outcomes between the L and M and the G producers result from the mobility of land for L producers and the immobility of land for the M and G producers.

A continual increase in the demand for land exists for the L producer. Here, the difference between the market rental price of land and the shadow rent for fixed land is paramount. For the L producer, where land is treated as a variable input, the target price has the effect of reducing the user cost of land and thereby encourages this producer to employ more land. Since the program is designed to pay producers on the basis of their employed land, the program thus encourages producers to increase their payment basis on hired land holdings. This is exactly what L does. The increases in employed land result in greater output and in the derived demand for capital and labor.

For the M and G producers, the program payment scheme has only the effect of increasing the shadow value of land, which is interpreted here as program rents or the capitalization of commodity programs into land values (fig. 4). Since land is fixed for these producers, land demand does not increase with an associated increase in production. The percentage of change in these variables over an interval between ratchet points is quite small. For example, during the interval when only L and M are in the program, land demand increases only 0.63 percent, K_L increases 0.35 percent (fig. 6), and Y_L increases 0.4 percent (fig. 1). That small increase in Y_L results in the net increase in total farm output over the interval of only 0.05 percent (fig. 2). Total farm output increases despite the declines in Y_M and Y_G of 0.12 percent and 0.04 percent, respectively.

Figure 6

Change in agricultural capital stocks for each land class due to varying the target price



K_L = Capital stocks for low-quality land.
K_M = Capital stocks for medium-quality land.
K_G = Capital stocks for good-quality land.

The demand side is also an important driver of these results. Since nonfarm sector production is the numeraire good, the increase in the farm price is relative to the nonfarm price. Therefore, households decrease their consumption of farm goods and increase their demand for nonfarm goods. Between no participation and full participation, the price of farm goods relative to nonfarm goods rises 6 percent. Due to that relative price increase, the consumption of farm goods declines roughly 6 percent, while consumption of nonfarm goods rises by 0.65 percent.

The Efficiency Effects of the Farm Programs

The aggregate effects of farm programs are summarized by the welfare measures associated with each household. Given that we have direct measures of utility, we can make ordinal comparisons of utility for each individual to provide direct evidence of the efficiency effects of the program (Varian, 1984). Figures 7, 8, and 9 portray what happens to overall economic efficiency. Figure 7 shows the ever-increasing government payment associated with the rise in the target price. Once the first firm enters the program, payment rises over each interval and is ratcheted up with each new entrant. Since it is assumed in this model that income taxes exist only to finance the program, increased program payments result in increased income tax rates. Despite the ever-increasing tax rates, only the nonlandowning household faces a decline in after-tax income (fig. 8). After-tax income for the landowning household continually increases because of the continual rise in land rental values.[15] For nonlandowners, after-tax income declines because of reductions in capital stocks and very small decreases in wage rates. Although capital rental rates increased, they are not sufficient to offset the effect on income of the declines in capital stocks.

For nonlandowners, the fall in after-tax income contributes to a welfare loss, and that loss increases with each new program entrant (fig. 9). The welfare loss stems from two sources, a production distortion from agricultural programs and a distortionary income tax that is a direct result of the program. An experiment performed elsewhere (Shoemaker, 1992) showed that the welfare losses attributed directly to the program exceed those stemming from the nature of the tax scheme used to finance the program.

At the same time, however, the landowning household receives a welfare gain from the program (fig. 9). The program increases land rents, thus increasing after-tax income for landowners. Figures 8 and 9 indicate an initial drop in income and welfare with the first program entrant. This drop appears because the rise in the agricultural commodity market price was greater in relative terms than the rise in income. As a result, the price effect dominates the income effect, which results in a decline in consumption and, therefore, utility.

Conclusions

The model presented in this report demonstrates that equilibrium outcomes that stem from policy changes in the farm program depend crucially on the level of farmer participation. Further, when we explicitly model policy instruments (land set-asides and target prices), the tradeoffs between these two instruments become clear. Set-asides are designed to control supplies and increase market prices, but price supports induce farmers to increase supply, and by so doing, to depress market prices. This study shows that the extent to which this tradeoff occurs depends most critically on the level of farmers' participation in the program and also on the level of capital stocks in the farm sector. Finally, the model shows how the assumption of full participation results in an overestimation of the

[15] Landowners are intended here to represent farmers.

Figure 7

The effect on government payments from varying the target price

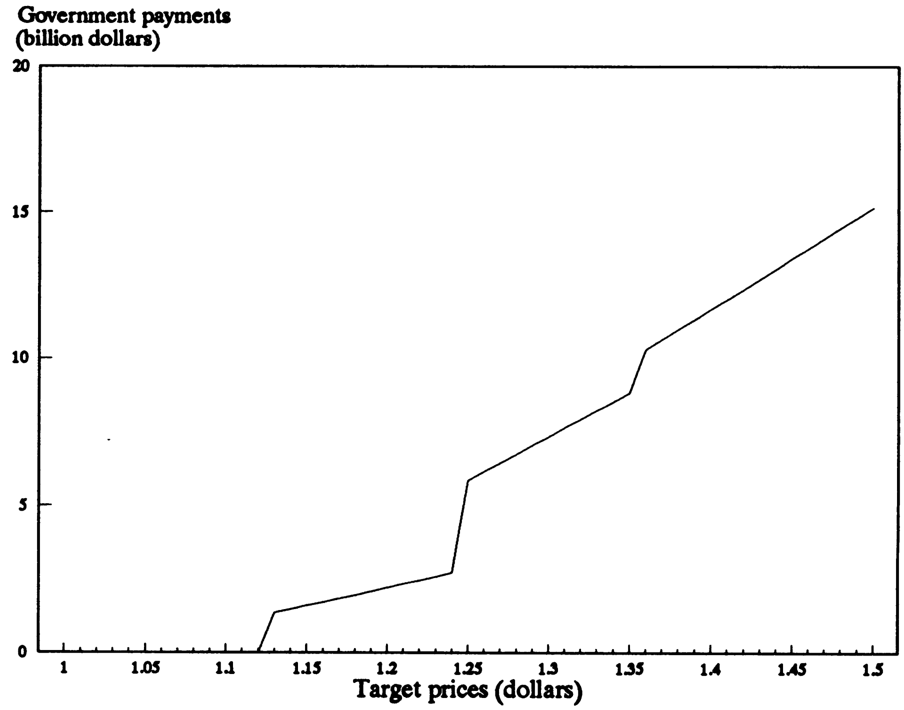
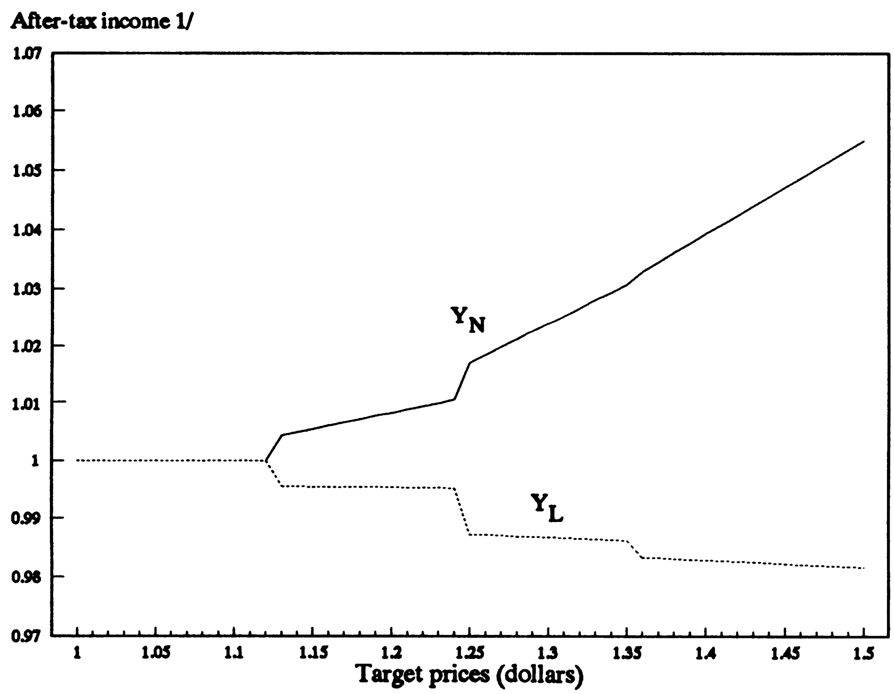


Figure 8

Change in after-tax incomes for landowning and nonlandowning households due to varying the target price

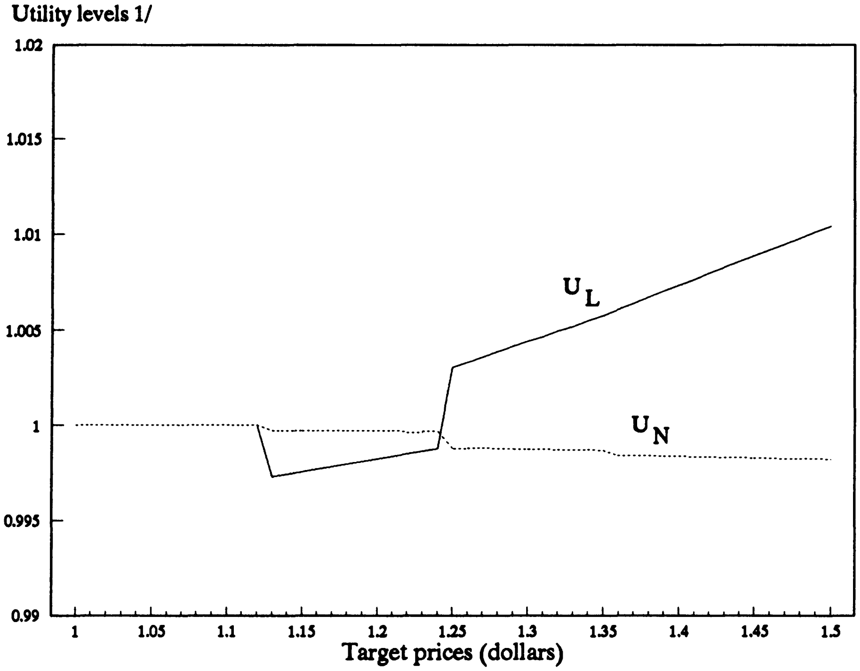


1/ Normalized to 1.0 when target price equals 1.0.

Y_L = Landowning household.

Y_N = Nonlandowning household.

Figure 9
Relative utility levels for landowning and nonlandowning household due to varying the target price



1/ Normalized to 1.0 when target price equals 1.0.
U_L = Landowning household.
U_N = Nonlandowning household.

effectiveness of commodity programs and leads to an underestimation of the economic distortions caused by the supply control and price support policy instruments.

Four main conclusions can be drawn from this report. First, when we estimate the equilibrium effects of commodity programs, we find that the participation effect is of first importance. For example, modeling program participation leads to different conclusions regarding the capitalization of farm programs. Differential participation permits the distinction between marginal and inframarginal producers; inframarginal participants have the most to gain from the program.

Second, explicit modeling of the deficiency payment programs reveals the relative effectiveness of the specific policy instruments. The limited ability of the set-aside requirement to control agricultural supplies is demonstrated in this model. The goal of the set-aside is to increase the market price for farm goods by reducing agricultural output. In this model, the set-aside is only 40 percent effective, since, with a set-aside rate of 15 percent, total production is reduced only by 6 percent. This 6-percent reduction in output results only in a 5-percent increase in the market price. The effectiveness of the set-aside requirement in reducing production is mitigated by the substitution of nonland inputs for land.

Third, explicitly modeling policy instruments highlights the tradeoff between set-aside rates and target prices. This tradeoff becomes even more striking when combined with the participation effect. Models without endogenous participation understate the tradeoff effects. The nature of the tradeoff is that the set-aside and the target price have exactly opposite results. The target price provides an inducement for program participation, while the set-aside presents an opportunity cost, thus discouraging participation. A policy goal of supporting income could easily be accomplished by using only a target price. Using the target price alone would significantly increase profits. However, the target price is not designed to be the marginal price: it is used solely to calculate the deficiency payment. The set-aside rate is designed to increase the market price by reducing agricultural supply. If policymakers seek to achieve increased farm income, they should determine an optimal target price/set-aside rate combination that is conditioned on the production and behavioral parameters in the system.

Finally, endogenous capital stocks matter when estimating sectoral policy effects. The effect of reforming policy may be overstated with fixed stocks. The ability of capital stocks to shrink or expand in response to policy changes can result in offsetting price effects. The analysis in this study shows that the primary effect of endogenous capital stocks has been a mitigating effect on agricultural returns, given changes in policy variables. For example, in the extreme case of a partial equilibrium with a fixed capital stock, a reduction in the target price would result in the reduction in the return to capital. That is, if capital is fixed, it must fully absorb the reduction in program support.[16] In the longer run, when stocks are variable, simple application of the Le Chatelier principle suggests adjustments can be made that will offset some of the losses that might be sustained with the reduction in support. The model in this study expands that theme to two sectors, one with three firms, which results in four sectors with demand for capital investment. The market equilibrium effects on capital returns between the two sectors and the sometimes opposing demands by the different commodity program participants in the farm sector produce some interesting price and output effects. Overall, the primary effect of endogenous capital stocks is to soften or offset the direct effects of policy changes.

[16] The actual extent of the loss depends on the elasticity of substitution between capital and other inputs.

References

Abel, Andrew B. "Dynamic Effects of Permanent and Temporary Tax Policies in a q Model of Investment," Journal of Monetary Economics 9(May 1982)3: 353-373.

Allingham, M.G., and A. Sandmo. "Income Tax Evasion: A Theoretical Analysis," Journal of Public Economics 1(Nov. 1972): 323-338.

Antle, J.M. "The Structure of U.S. Agricultural Technology, 1910-78," American Journal of Agricultural Economics 66(Nov. 1984): 414-421.

Auerbach, Alan J., and Laurence J. Kotlikoff. Dynamic Fiscal Policy. Cambridge, England: Cambridge Univ. Press, 1987.

Ball, V.E. Estimating Supply Response of Multiproduct Farms. TB-1750. U.S. Dept. Agr., Econ. Res. Serv., Jan. 1989.

Ballard, C.L., D. Fullerton, J.B. Shoven, and J. Whalley. A General Equilibrium Model for Tax Policy Evaluation. National Bureau of Economic Research Monograph. Chicago: Univ. of Chicago Press, 1986.

Berkovec, J., and D. Fullerton. A General Equilibrium Model of Housing, Taxes and Portfolio Choice. National Bureau of Economic Research Working Paper No. 3505. Cambridge, MA, Nov. 1990.

Berndt, E.R., C.J. Morrison, and C.G. Watkins. "Dynamic Models of Energy Demand: An Assessment and Comparison," Modeling and Measuring Natural Resource Substitution. Ed. E.R. Berndt and J. Fields. Cambridge, MA: MIT Press, 1981.

Boyd, Roy. An Economic Model of Direct and Indirect Effects of Tax Reform on Agriculture. TB-1743. U.S. Dept. Agr., Econ. Res. Serv., July 1988.

Burmeister, Edwin, and A. Rodney Dobell. Mathematical Theories of Economic Growth. New York: Macmillian Co., 1970.

Caswell, M.F., and R. Shoemaker. "Equilibrium Effects of Adoption: The Case of Induced Output Price Changes," Journal of Technological Forecasting and Social Change May 1993.

Chambers, R.G., and W.E. Foster. "Participation in the Farmer-Owned Reserve Program: A Discrete Choice Model," American Journal of Agricultural Economics 65(1983): 120-124.

Cochrane, W.W. Farm Prices: Myth and Reality. Minneapolis: Univ. of Minnesota Press, 1958.

Daugherty, A.B. Major Uses of Land in the United States, 1987. AER-643. U.S. Dept. Agr., Econ. Res. Serv., Jan. 1991.

Domencich, T., and D. McFadden. Urban Travel Demand: Behavioral Analysis. Amsterdam: North-Holland, 1975.

Epstein, L.G., and M. Denny. "The Multivariate Flexible Accelerator Model: Its Empirical Restrictions and an Application to U.S. Manufacturing," Econometrica 51(May 1983)3: 647-764.

Furlong, W.J. "A General Equilibrium Model of Crime Commission and Prevention," Journal of Public Economics 34(1987): 87-103.

Gardner, B.L. The Decline and Fall of Agricultural Economists' Models of the Farm Problem. Univ. of Maryland Working Paper. Nov. 1983.

Goulder, Lawrence H., and Lawrence H. Summers. Tax Policy, Asset Prices, and Growth: A General Equilibrium Analysis. National Bureau of Economic Research Working Paper No. 2128. Cambridge, MA, Jan. 1987.

Hendershott, P.H., and Y. Won. Introducing Risky Housing and Endogenous Tenure Choice Into Portfolio-Based General Equilibrium Models. National Bureau of Economic Research Working Paper No. 3114. Cambridge, MA, Sept. 1989.

Hertel, Thomas W., M.E. Tsigas, and P.V. Preckel. An Economic Assessment of the Freeze on Program Yields. Staff Report No. AGES-9066. U.S. Dept. Agr., Econ. Res. Serv., Dec. 1990.

_______________, Robert L. Thompson, and M.E. Tsigas. "Economywide Effects of Unilateral Trade and Policy Liberalization in U.S. Agriculture," Macroeconomic Consequences of Farm Support Policies. Ed. R. Stoeckel and J. Vincent. Durham, NC: Duke Univ. Press, 1989.

Hrubovcak, J., R. Shoemaker, and M. Anderson. A General Equilibrium Analysis of U.S. Agricultural Policy Reform. Paper presented at the Western Economics Association meetings, San Diego, June 1990.

Johnson, D.G. "Food Production and Marketing: A Review of Economic Developments in Agriculture," Food and Agricultural Policy. Washington, D.C: American Enterprise Institute, 1977.

Kanbur, S.M. "Risk Taking and Taxation: An Alternative Perspective," Journal of Public Economics 15(1981): 163-184.

Kesselman, J.R. "Income Tax Evasion: An Intersectoral Analysis," Journal of Public Economics 38(1989): 137-182.

LeBlanc, Michael, and J. Hrubovcak. "The Effects of Tax Policy on Aggregate Agricultural Investment," American Journal of Agricultural Economics 68(1986): 767-777.

Lucas, R.E. "Adjustment Costs and the Theory of Supply," Journal of Political Economy 75(Aug. 1967): 321-334.

Mansur, A., and J. Whalley. "Numerical Specification of Applied General Equilibrium Models: Estimation, Calibration and Data," Applied General Equilibrium Analysis. Ed. H.E. Scarf and J.B. Shoven. Cambridge, England: Cambridge Univ. Press, 1984.

Moore, M., D. Negri, and J.A. Miranowski. "Determinants of Cropland Allocation Decisions in California Agriculture: The Role of Agricultural Commodity Programs and the Reclamation Water Program," Economics and Management of Water and Drainage in Agriculture. Ed. A. Dinar and D. Zilberman. Amsterdam: Kluwer Pub. Co., 1990.

Sandmo, A. "Income Tax Evasion, Labor Supply, and the Equity-Efficiency Trade-off," Journal of Public Economics 16(1981): 265-288.

Schultz, T.W. Agriculture in an Unstable Economy. New York: McGraw-Hill, 1945.

Shoemaker, R. "The Incentive Effects of Agricultural Support Programs: A Dynamic Analysis of U.S. Agricultural Policy." Ph.D. thesis. George Washington Univ., 1992.

U.S. Department of Agriculture, Economic Research Service. Agricultural Resources, Agricultural Land Values and Markets. AR-14. June 1989.

U.S. Department of Agriculture, Economic Research Service. Economic Indicators of the Farm Sector, National Financial Summary, 1989. Jan. 1991.

U.S. Department of Agriculture, Economic Research Service. Government Intervention in Agriculture: Measurement, Evaluation, and Implications for Trade Negotiations. FAER-229. Apr. 1987.

U.S. Department of Commerce, Bureau of Economic Analysis. Fixed Reproducible Tangible Wealth in the United States, 1925-85. June 1987.

U.S. Department of Commerce, Bureau of Economic Analysis. "U.S. National Income and Product Accounts," Survey of Current Business 72(July, 1988)7: 5-45.

Varian, H. Microeconomic Analysis. 2nd ed. New York: W.W. Norton & Co., 1984.

Vasavada, U., and R.G. Chambers. "Investment in U.S. Agriculture," American Journal of Agricultural Economics 68(Nov. 1986)4: 905-960.

Watson, H. "Tax Evasion and Labor Markets," Journal of Public Economics 27(July 1985)2: 231-246.

Whalley, John, and Randall M. Wigle. Endogenous Participation in Agricultural Support and Ad Valorem Equivalent Modelling. National Bureau of Economic Research Working Paper No. 2583. Cambridge, MA, May 1988.

Appendix

The nonagricultural sectors of the model are presented in this appendix. Here, the theoretical models of the nonfarm producing sector, households, and Goverment are presented. A discussion follows of data development and the numerical model solution algorithm.

Nonfarm Production

The nonfarm sector produces both consumer and investment goods, while farm production involves only consumer goods. The assumption that the nonfarm sector produces a single good which can be either consumed or invested implies that substitution in production between these goods is infinitely elastic. The basic structure of the nonfarm sector production problem is almost identical to that of farm sector production. However, nonfarm producers are assumed to make use of only low-quality land.

The nonfarm problem of optimizing returns on captial investment is as follows:

$$(10) \quad Max\ \pi = \int_0^\infty \{F_m(A_m,K_m,N_m) - J_m(I_m,K_m) - I_m - wN_m - v_L A_L^m\} e^{-\rho t},$$

$$(11) \quad s.t.\ \dot{K}_m = I_m - \delta_m K_m.$$

The Hamiltonian for nonfarm producers (omitting the m subscripts) is[17]

$$(12) \quad H = \left\{[F(A,K,N) - J(I,K)] - I - wN - v_L A_L^m + q(I - \delta K)\right\} e^{-\rho t}.$$

The first-order conditions are

$$(13a) \quad \frac{\partial H}{\partial N} = \frac{\partial F}{\partial N} - w = 0,$$

$$(13b) \quad \frac{\partial H}{\partial I} = -\left[1 + \frac{\partial J}{\partial I}\right] + q = 0,$$

$$(13c) \quad -\frac{\partial H}{\partial K} = q(\rho+\delta) - \left[\frac{\partial F}{\partial K} - \frac{\partial J}{\partial K}\right] = \dot{q}\ ,$$

$$(13d) \quad \frac{\partial H}{\partial A_L^m} = \frac{\partial F}{\partial A_L^m} - v_L = 0.$$

The first-order conditions have the same interpretations as those given for the farm sector. One of the important differences between the structure of farm and nonfarm production is in the costs of adjustment. It is here assumed that the farm sector adjusts more slowly than the nonfarm sector, following evidence from several econometric studies of capital investment.[18] Higher adjustment costs

---

[17] This problem is subject to the same transversality conditions as the farm sector's dynamic goal of optimizing returns on capital.

[18] For farm sector investment, see Vasavada and Chambers (1986) and LeBlanc and Hrubovcak (1986). For nonfarm aggregate investment, see Epstein and Denny (1983) and Berndt, Morrison, and Watkins (1981).

in agriculture are assumed in the literature that explores the persistence of the low relative returns to agricultural assets (Johnson, 1977; Cochrane, 1958; Schultz, 1945). While the difference in returns between the farm and nonfarm sectors has diminished in recent years (Gardner, 1983), the hypothesis for the existence of persistently low relative returns is based on slow factor adjustments. Such slow adjustments in factors (like capital) appear in high relative adjustment costs.

Households

Households are assumed to consume two goods in each period, agricultural products, C_a, and nonagricultural products, C_m. Income for purchases is derived from their inelastically supplied fixed endowments of labor, denoted as $\bar{N}$, land, denoted as $\Sigma_i \bar{A}_i$, and capital holdings to the producing sectors.[19] In this model, the labor-leisure decision is not treated explicitly. Households are distinguished by their endowments. This distinction is made to provide two income classes, one that could be thought of as farmers and the other as nonfarmers. Landowning households own all the land in the economy and a small fraction of both the total capital and labor endowments. Both the capital and labor endowments are 5 percent of the total, which represents the approximate durable capital holdings and population of the U.S. farm sector (USDC, 1987). To control for differences in tastes and preferences, each household is assumed to have the same utility function and utility function parameters. The household problem is one of choosing a sequence of consumption which maximizes the present value of utility, as follows:

$$(14) \qquad \underset{C_t}{Max} \int_0^{\infty} u(C_a, C_m) e^{-\rho t} dt,$$

where ρ is the personal discount rate. The utility function is assumed to be additively separable in consumption, as well as separable in time. Separability in time implies that the utility maximization problem for each period can be solved independently. This assumption, although restrictive, is immaterial in a steady-state problem because optimal steady-state levels of consumption are constant. Assuming the utility function takes a logarithmic form, the maximization problem for the h^{th} household, expressed in discrete form, is

$$(15) \qquad \mathcal{L} = \sum_{t=0}^{\infty} \frac{1}{(1+\rho)^t} \Sigma_i \omega_i \ln C_{it}^h + \lambda \left\{ \sum_{t=0}^{\infty} \frac{1}{(1+\iota(1-\tau))^t} \left[Y_t^h - \Sigma p_{it} C_{it}^h \right] \right\},$$

where Y^h is total factor income for the h^{th} household, ι is the before-tax interest rate, τ is proportional income tax rate, and ω_k are the consumption share parameters for the i = a and m goods. The first-order conditions for two periods are

$$(16a) \qquad \frac{\partial \mathcal{L}}{\partial C_{it}^h} = \frac{\omega_i}{(1+\rho) C_{it}^h} - \lambda \frac{p_{it}}{(1+\iota_t(1-\tau))} = 0,$$

$$(16b) \qquad \frac{\partial \mathcal{L}}{\partial C_{i_{t+1}}^h} = \frac{\omega_i}{(1+\rho)^t C_{it+1}^h} - \lambda \frac{p_{it+1}}{(1+\iota_{t+1}(1-\tau))^t} = 0.$$

[19] By assuming the labor supply is fixed, we are abstracting from the notion of a growing economy. In the current model, production and investment must merely grow at the sectoral capital depreciation rates. This simplifying assumption does not affect the overall results of the model.

Solving the first-order conditions in terms of $p_{a0}C_{a0}$ for all t and substituting back into the constraint yields

$$(17)\qquad \sum_{t=0}^{\infty}\frac{Y_t^h}{(1+\iota_t(1-\tau))^t} = (1/\omega_a)\sum_{t=0}^{\infty}\frac{p_{a0}C_{a0}^h}{(1+\rho)^t}.$$

In a steady state, Y^h, p_{a0}, C_{a0}^h, and ι are constant, and equations (16a) and (16b) indicate that $\rho=\iota(1-\tau)$. Therefore, the steady-state solution for C_i^h is

$$(18)\qquad p_{i_{ss}}^h C_{i_{ss}}^h = \omega_i Y_{ss}^h,$$

where ss indicates the steady state. Equation (18) implies that steady-state consumption is a constant proportion of steady-state income.

Government and Tax Revenues

The role of Government is greatly simplified for this model. It is assumed here that the cost of the farm programs is fully financed. Since the model excludes other government spending, this assumption is tantamount to assuming that the budget is always in balance. Government outlays are treated here simply as the total program costs. To simplify the analysis, taxes are assumed to be proportional to current income.[20] This income tax is the sole source of government revenues. Tax revenues are calculated as:

$$(19)\qquad GP = \tau\left\{w\bar{N} + \Sigma_j v_j\bar{A}_j + \frac{\rho}{(1-\tau)}\Sigma_i q_i K_i^h\right\}.$$

Closing the model and maintaining a balanced budget implies that the tax rate is endogenous. That is, since farm program parameters are exogenous, the necessary condition for a fully determined system is that the tax rate be endogenous to accommodate endogenous participation decisions and a balanced budget.

Model Implementation

In this section, all the sectoral components of the model are brought together to form the general equilibrium system. The numerical model is presented for specific functional forms, followed by a discussion of the data as well as the parameters of the model and the solution algorithm for the discrete choice equilibrium problem.

General Equilibrium

The equilibrium of the full system is the steady-state solution to all the above first-order conditions, the factor market equilibriums, and the maintenance of the government budget constraint. The general equilibrium conditions require that the goods and labor market clear, as well as satisfy, steady-state growth conditions. The above sectors are combined to produce an equilibrium in the goods market, where real values of output equal real spending. The goods market equilibrium is expressed as:

---

[20] Alternative taxing schemes are explored with this model elsewhere (Shoemaker, 1992). For example, a consumption tax scheme is used to distinguish between the distortionary effects associated with the farm program and the distortionary effects of the income tax.

$$(20) \quad \Sigma_i F_i(.) - \Sigma_i J_i(K_i, I_i) = \Sigma_i p_i C_i + \Sigma_i I_i + GP,.$$

That is, total real output net of total adjustment costs, denoted J(·), must equal consumption, investment, and government spending, GP. This condition is the familiar IS curve in macroeconomics for a closed economy.

In the standard neoclassical growth models, a steady state is characterized by the condition that the net investment rate in each sector equals the exogenous growth rate of the economy (for example, the rate of growth of the labor supply) plus the sectoral depreciation rates. This is a standard result of multisector neoclassical growth models (Burmeister and Dobell, 1970). In this model, the growth rate of the economy is set to zero. Thus, in the steady state, the level of investment is $\delta_i K_i$.

Numerical Model Structure. For the numerical model of the steady-state equilibrium, it is assumed that producers use a Cobb-Douglas technology with constant returns to scale and quadratic adjustment costs. Households are assumed to have a logarithmic utility function. These functional forms were chosen primarily because of the parsimonious parameter requirements and because of their regularity or curvature properties. Appendix table 1 presents all the functions used in the numerical model.

Equations (1) and (2) are the production functions (net of capital adjustment costs) for nonparticipants and participants, respectively. Equations (3), (4), (11), and (15) represent the labor demand and market equilibrium conditions. Equations (5), (6), (12), and (16) are the land demand and market equilibrium conditions. Equations (7) and (8) represent the steady-state rental value of capital. These expressions represent the total marginal value product of capital. The first term on the right-hand side is the marginal product of capital, and the second term represents the reduction in the opportunity cost of installing capital that is made possible by the additional unit of capital.[21] Equations (9) and (14) are the investment functions that reflect the condition that the marginal benefit of investing in a unit of capital is equal to its marginal cost. Equation (16) indicates that, in the steady state, the after-tax rate of return to capital equals the personal rate of discount.

The household sector is represented with equations (18)-(21). Equation (20) and (21) define total income for each household, and equations (18) and (19) are the household demands for farm and nonfarm products. Equations (22)-(24) represent the goods market equilibrium. Equations (22) and (23) are the total levels of farm and nonfarm production. Equation (22) indicates that farm production is directly equal to farm consumables. This is a reflection of the fact that the model has no intermediate sector. Equation (23) indicates that nonfarm production includes consumer goods as well as investment goods. Finally, equation (24) is the goods market equilibrium condition. Implicit in that condition is that savings are the difference between current income and consumption and that in the steady state the personal rate of discount brings production and consumption into equilibrium. Finally, equation (25) is the government budget constraint that limits the level of program participation and endogenizes tax rates.

Data and Parameter Requirements. The data and parameter requirements for this model are reduced because of the stylistic nature of the model. Production parameters are needed for the farm and nonfarm sector. Cobb-Douglas technologies have been assumed for production, implying that the parameters needed include the factor share or distribution parameter and the scale or efficiency parameter. These parameters are determined by using a calibration technique common to CGE models.[22] This procedure can be described as a process in which, for a particular set of chosen functional forms and an assumed equilibrium data set, parameters are calculated that are consistent

---

[21] The reduction in the opportunity cost occurs because adjustment costs are decreasing in K.

[22] See Mansur and Whalley (1984) for a good discussion of calibration techniques and related issues.

Appendix table 1--Steady-state general equilibrium model

Farm sector:

(1) $Y_j = \phi_j K_j^{\alpha_j} N_j^{\beta_j} A_j^{\gamma_j} - 0.5b\delta^2 K_j, \quad 1 = \alpha_j + \beta_j + \gamma_j,$

(2) $Y_j = \phi_j K_j^{\alpha_j} N_j^{\beta_j} [A_j(1-\theta)]^{\gamma_j} - 0.5b\delta^2 K_j,$

(3) $w = p\phi_j \beta_j K_j^{\alpha_j} N_j^{(\beta_j - 1)} A_j^{\gamma_j},$

(4) $w = p\phi_j \beta_j K_j^{\alpha_j} N_j^{(\beta_j - 1)} [A_j(1-\theta)]^{\gamma_j},$

(5) $v_j = p\phi_j \gamma_j K_j^{\alpha_j} N_j^{\beta_j} A_j^{\gamma_j - 1},$

(6) $v_j = (1-\theta)\left\{p\phi_j \gamma_j K_j^{\alpha_j} N_j^{\beta_j} [A_j(1-\theta)]^{(\gamma_j - 1)} + (\bar{p}-p)\bar{y}\right\},$

(7) $q\left(\frac{\rho}{(1-\tau)} + \delta\right) = p[\phi_j \alpha_j K_j^{(\alpha_j - 1)} N_j^{\beta_j} A_j^{\gamma_j} - 0.5b\delta^2],$

(8) $q\left(\frac{\rho}{(1-\tau)} + \delta\right) = p[\phi_j \alpha_j K_j^{(\alpha_j - 1)} N_j^{\beta_j} [A_j(1-\theta)]^{\gamma_j} - 0.5b\delta^2],$

(9) $q = 1 + pb\delta.$

Nonfarm sector:[1]

(10) $Y_m = \phi_m K_m^{\alpha_m} N_m^{\beta_m} A_m^{\gamma_m} - 0.5b_m \delta_m^2 K_m, \quad 1 = \alpha_m + \beta_m + \gamma_m,$

(11) $w = \phi_m \beta_m K_m^{\alpha_m} N_m^{(\beta_m - 1)} A_m^{\gamma_m},$

(12) $v = \phi_m \gamma_m K_m^{\alpha_m} N_m^{\beta_m} A_m^{(\gamma_m - 1)},$

(13) $q_m\left(\frac{\rho}{(1-\tau)} + \delta_m\right) = \phi_m \alpha_m K_m^{(\alpha_m - 1)} N_m^{\beta_m} A_m^{\gamma_m} - 0.5b_m \delta_m^2,$

(14) $q_m = 1 + b_m \delta_m.$

Factor market equilibriums:

(15) $\bar{N} = N_m + \sum_{j=1}^{3} N_j,$

(16) $\bar{A}_L = A_L^m + A_L^a,$

(17) $\frac{\rho}{(1-\tau)} = \frac{p_i\left\{\phi_i \alpha_i K_i^{(\alpha_i - 1)} N_i^{\beta_i} A_i^{\gamma_i} - 0.5b_i \delta_i^2\right\}}{q_i} - \delta_i, \quad \forall_i, \text{ and } K_a = \sum_{j=1}^{3} K_j.$

Households:

(18) $C_m^h = \omega_m TY^h,$ where h = nonlandowners (N) and landowners (L),

(19) $pC_a^h = \omega_a TY^h,$

See footnote at end of table. Continued--

(20) $$TY^N = \sum_{i=1}^{2}\{q_i(\rho+\delta_i)K_i^N + wN^N(1-\tau)\},$$

(21) $$TY^L = \sum_{i=1}^{2}\left\{q_i(\rho+\delta_i)K_i^L + [\sum_{j=1}^{3} v_j\bar{A}_j + wN^L](1-\tau)\right\}.$$

Goods market equilibriums:

(22) $$\sum_{h=1}^{2} C_a^h = \sum_{j=1}^{3} Y_j,$$

(23) $$\sum_{h=1}^{2} C_m^h + \sum_{i=1}^{2}\delta_i K_i = Y_m,$$

(24) $$\sum_{h=1}^{2}\sum_{i=1}^{2} p_i C_i^h + \sum_{i=1}^{2}\delta_i K_i + (\bar{p}-p)\bar{y}(1-\theta)\sum_{j=1}^{3} A_j = \sum_{i=1}^{2} q_i(\rho+\delta_i)K_i + \sum_{j=1}^{3} v_j\bar{A}_j + w\bar{N}.$$

Government budget constraint:

(25) $$(\bar{p}-p)\bar{y}(1-\theta)\sum_{j=1}^{3} A_j = \tau\left\{w\bar{N} + \sum_{j=1}^{3} v_j\bar{A}_j + \frac{\rho}{(1-\tau)}\sum_{i=2}^{2} q_i K_i\right\}.$$

Variable definitions:

Parameters:

α_{ij}	Capital production coefficient
β_{ij}	Labor production coefficient
γ_{ij}	Land production coefficient
ϕ_{ij}	Production efficiency parameter
δ_i	Geometric rate of capital depreciation
ρ	Personal rate of time preference
b_i	Capital adjustment cost parameter
$\underline{\omega}_i$	Consumption distribution parameter
$\underline{N}$	Fixed labor supply
$\bar{A}_j$	Fixed supply of j land, where j = L, M, and G

Government program parameters:

$\bar{p}$	Target price
θ	Acreage reduction set-aside rate
$\bar{y}$	Established average yield rate

Variables:

w	Wage rate
v	Land rental rate
q_i	Shadow price of capital
p	Agricultural commodity price
K_i	Capital stock
A_j	Land employment
Y_i	Output
N_{ij}	Labor employment
TY	Total after-tax income
C_i^h	Consumption
τ	Proportional tax rate

[1] Nonfarm sector output price is the numeraire. The subscript i refers to farm sectors (denoted a) and nonfarm sectors (denoted m), j refers to the three different land class-based farm types, and h indexes the landowning and nonlandowning households.

with that equilibrium. For the nonfarm sector, these parameters are derived from the National Income and Product accounts (NIPA), (USDC, 1988). The parameters for the farm sector are consistent with the data developed by Boyd (1988). Economic depreciation rates and adjustment cost parameters are consistent with Goulder and Summers (1987). Because this analysis looks at steady states, calibration to a particular time period may be dubious. Calibrating to a specific year assumes that the year is representative of a longrun equilibrium. Most static computable general equilibrium (CGE) models assume this (for example, Ballard and others, 1986). A representative year, or normal year, is a particularly dubious notion for agriculture, in which the effects of weather greatly affect commodity supplies. Using a multiyear average somewhat avoids this problem, although this use leaves unclear how many years represent a "long run." Also, constructing averages is an extremely data-intensive exercise. In this study, for farm program parameters, averaging is deemed appropriate, and the relevant horizon is based on the period between major farm legislation (that is, between 1985 and 1990). The data used for calibration is presented in appendix tables 2-4. For example, the average

Appendix table 2--Benchmark factor endowments and prices

Factor	Stocks values	Prices
	Billion dollars	Dollars
Capital	10,057	0.1
Labor	22,253	1.0
Land classes:		
Good	14	1.5
Medium	20	1.0
Low	7	.6

Appendix table 3--Benchmark factor demands

Factor	Farm			Nonfarm
	Low	Medium	Good	
	Billion dollars			
Capital	239.40	342.10	102.60	9,373.70
Labor	5.74	8.20	2.46	2,237.30
Land	13.99	19.99	5.99	1.27

Appendix table 4--Benchmark commodity supplies and demands

Sector	Production	Consumption	Investment
	Billion dollars		
Farm	122.22	122.22	20.52
Nonfarm	3,154.90	2,592.50	562.40
Total	3,297.60	2,714.70	582.90

set-aside rate for major program crops was chosen for the parameter θ. The target price was based on the average producer subsidy equivalent (PSE) for major field crops over this period.[23]

Utility function parameters include the share parameter between food and nonfood consumption goods. This parameter is derived from aggregate consumption data from the NIPA and from Boyd (1988). The personal discount rate used is the same as that used by Goulder and Summers (1987). Finally, stock values are needed for labor and land. Since these two are the only stocks and both are assumed fixed, only relative levels between sectors matter.

Benchmark stocks for calibration are taken from Boyd (1988). The distribution of land stocks and the benchmark rental rates between land of good, mean, and low quality and the associated land rents are based on data from Daugherty (1991), U.S. farmland values (in USDA, 1989), and unpublished sources. The calibrated parameters are presented in appendix table 5.

Solution Algorithm. The actual participation decision and model solution is based on an iterative solution technique. A schematic of the algorithm is presented in appendix figure 1. For a given set of policy parameters, a first set of guesses is made of endogenous prices. The initial price guesses (p_o) are used to calculate land rents for farm firms L, M, and G. Program participation is determined by the maximum of the rents, v, for each firm. For example, if v_M^{in} is greater than v_M^{out}, then the M firm will be in the program. This evaluation is performed for each farm firm. Next, given the determined level of participation, an initial general equilibrium (GE) is found, using a quasi-Newton method for solving the system of nonlinear simultaneous equations.[24] This GE solution yields a new set of prices, (p_1^*). If the difference between this new set of prices and the initial guess is less than a prespecified tolerance, then there is a solution. If the difference exceeds the tolerance, then the system is restarted with the new set of prices and iterates until a solution is reached.

[23] PSE's are from USDA (1987). They are calculated as the per unit transfer or subsidy applied to commodities. PSE's are designed to provide an index to measure government intervention in the agricultural sector.

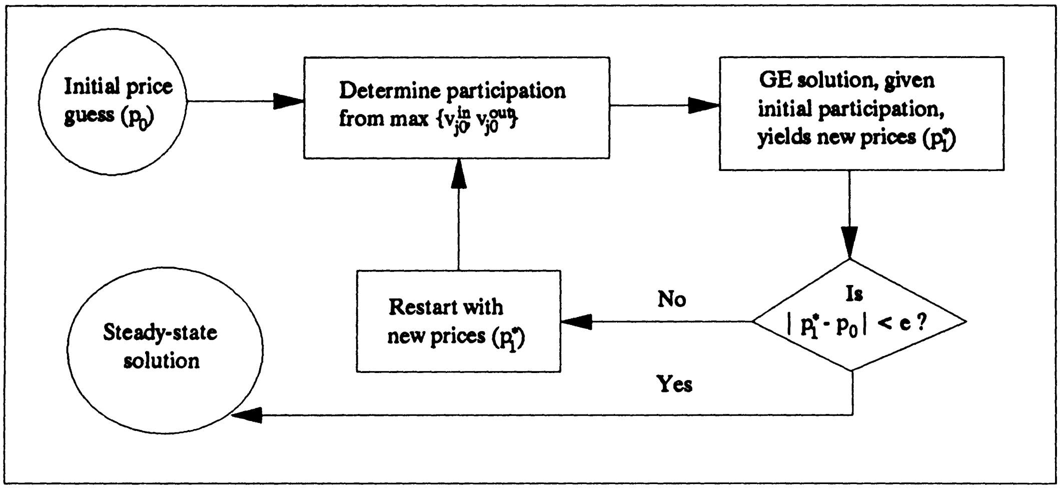
[24] The solution algorithm uses the NLSYS application module of GAUSS 2.0.

Appendix table 5--Calibrated model parameters

Parameters		Farm[1] L	Farm[1] M	Farm[1] G	Nonfarm
Production:					
Capital production share	α	0.67	0.59	0.51	0.32
Labor production share	β	.14	.12	.10	.68
Land production share[2]	γ	.19	.29	.38	.01
Efficiency parameter	ϕ	.51	.72	1.00	.93
Capital depreciation rate	δ	.03	.03	.03	.06
Capital adjustment cost	b	40.74	40.74	40.74	5.55
Utility:					
Personal rate of time preference	ρ	.015			
Consumption share of agricultural goods[3]	ω	.037			
Status quo government program:					
Target price (dollars)	$\bar{p}$	1.3			
Acreage set-aside rate (percent)	θ	15.0			
Yield rate[4]	$\bar{y}$	1.0			

[1] L denotes low-quality land. M denotes medium-quality land. G denotes good-quality land.
[2] Land production share is calculated as $\gamma = 1-\alpha-\beta$.
[3] Consumption share of nonagricultural goods is $1-\omega$. The same parameters are used for both households.
[4] $\bar{y} = 1.0$ implies an average product of land, for example, bushels per acre, normalized to 1.0 in the benchmark.

Appendix figure 1
Solution algorithm schematic 1/



1/ Where e is the prespecified tolerance.

U.S. Department of Agriculture
Economic Research Service

SUMMARY OF REPORT

Alternative Crop Insurance Plan May Cut Costs, Tailor Payouts by Crop, Area

Number 23, June 1993

Contact: Joe Glauber (202) 720-4164

The Federal crop insurance program experienced a period of excess losses (payouts exceeding premiums) in the 1980's, after achieving small surpluses for most of its history. Those cumulative excess losses ($2.5 billion) mask the wide variation in performance among crops and regions. Soybeans and wheat claimed over half of excess losses for all crops in 1981-89. Arkansas, Georgia, Louisiana, and Mississippi accounted for 72 percent ($424 million) of excess losses attributable to soybeans. Montana and North Dakota accounted for about 60 percent ($367 million) of wheat excess losses.

USDA's Federal Crop Insurance Corporation estimates that, between 1983-90, more than 40 percent of total excess soybean losses were concentrated in 1.4 percent of soybean policies. About 2 percent of wheat policies accounted for almost 20 percent of total wheat excess losses in 1983-89. Crop insurance losses tend to be concentrated geographically: wheat losses in Montana, soybean losses in the Delta States and the Southeast, and cotton and grain sorghum losses in the Texas High Plains.

A new report, *An Alternative for Reducing Federal Crop Insurance Program Losses* (AER-668), by USDA's Economic Research Service, outlines why insurance losses escalated in the 1980's, and describes how an alternative (area-based loss) program might stem those losses. Recent crop insurance reforms have aimed at charging higher premiums for policyholders with abnormal loss histories. An area-based loss program, by contrast to the current program, bases premiums and payouts not on an individual producer's yield, but on the aggregate yield of a surrounding region, the producer's county, for example. Payouts, if triggered, are based on the difference between the area yield and a predetermined yield guarantee. Each participant is charged the same premium (by amount of coverage) and receives the same payout per acre insured.

A theoretical analysis suggests that an area-based program would be most effective in providing risk protection in years of relatively high yield variability, as in the 1980's. A pilot area-based program is being tested for soybeans in 13 States that have experienced large crop insurance losses and low farmer participation.

Leading States with crop insurance excess losses, 1981-89

State	Total excess losses[1]	Soybeans	Corn	Wheat	Cotton
			$1,000		
Montana	320,827	0	992	223,855	0
Texas	290,954	27,006	27,195	40,236	121,964
North Dakota	240,848	S	17,269	143,553	0
Arkansas	155,529	127,412	355	6,701	910
Louisiana	152,456	120,409	1,502	5,381	5,363
Mississippi	140,159	123,971	1,883	5,131	2,087
Georgia	137,298	51,971	15,890	5,124	7,162
Kansas	101,245	14,958	2,061	70,435	0
Alabama	70,973	49,477	2,941	4,442	S
Missouri	56,426	37,034	5,082	7,330	S

S = surplus.
[1] Total includes crops in addition to those listed.

To Order This Report...

The information presented here is excerpted from *An Alternative for Reducing Federal Crop Insurance Program Losses*, AER-668, by Joseph W. Glauber, Joy L. Harwood, and Jerry R. Skees. The cost is $9.00.

Dial **1-800-999-6779** (toll free in the United States and Canada) and ask for the report by title.

Add 25 percent to foreign addresses (including Canada). Charge to VISA or MasterCard. Or send a check (made payable to ERS-NASS) to:

ERS-NASS
341 Victory Drive
Herndon, VA 22070.

'U.S. Department of Agriculture
Economic Research Service

SUMMARY OF REPORT

Farm Real Estate Values Resume Climb, Historical Data Show

Number 22, May 1993

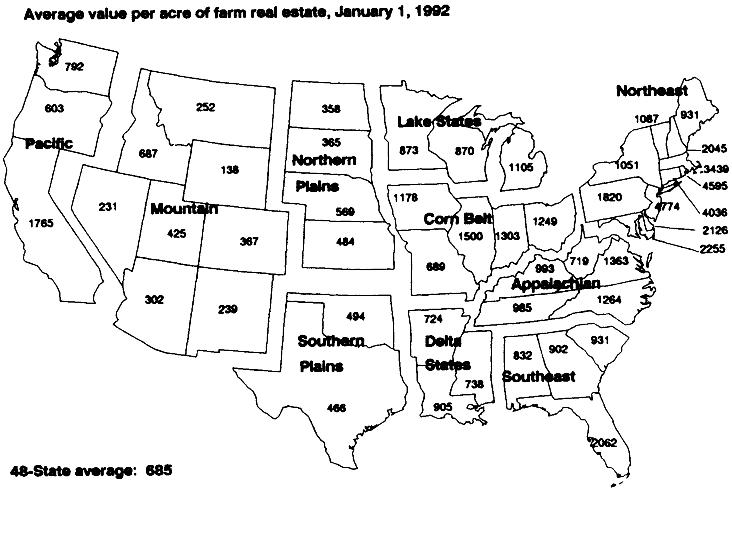
Contact: John Jones (202) 219-0428

The value of U.S. farmland rose by an average of 2.4 percent per year from 1987 to 1992, compared with a decrease of 6.6 percent per year from 1981 to 1986, according to the U.S. Department of Agriculture's *Farm Real Estate: Historical Series Data, 1950-92.*

Regional trends in the value of farmland generally mirror the national trend. From 1950 to 1982, the Southeast showed the highest rate of growth, while the Northern Plains showed the lowest. The decline in real estate value in the mid-1980's was most pronounced in the Corn Belt, while values actually increased in the Northeast. The present recovery in real estate prices has been most pronounced in the Northern Plains, while lagging in the Southern Plains.

Average farm real estate values in 1992 ranged from $138 per acre in Wyoming to $4,774 per acre in New Jersey.

Average value per acre of farm real estate, January 1, 1992



48-State average: 685

The area of land in farms has declined gradually every year since 1954, at an average rate under 1 percent per year. The number of farms has declined at an average annual rate of 2.3 percent. The average farm size, therefore, rose from 213 acres in 1950 to 467 acres in 1992.

United States: Selected statistics on farm real estate, selected years

Year	Farms	Farmland value per acre	Farmland and building value per farm	Total farmland and building value
	Thousands	*-- Dollars --*		*Million dollars*
1950	5,648	48	13,700	77,600
1960	3,955	86	34,600	136,771
1970	2,944	157	73,000	215,042
1980	2,435	636	313,495	763,285
1990	2,135	538	308,250	658,187
1991	2,100	556	317,950	667,504
1992	2,091	557	319,519	670,798

-- = Not available.
Excludes Alaska and Hawaii. Data for farms and land in farms are from "Farm Numbers," U.S. Department of Agriculture, National Agricultural Statistics Service.

To Order This Report...

Information presented here is excerpted from *Farm Real Estate: Historical Series Data, 1950-92*, SB-855, by John Jones and Patrick N. Canning. Cost is $12.00.

Dial **1-800-999-6779** (toll free in the United States and Canada) and ask for the report by title.

Please add 25 percent to foreign addresses (including Canada). Charge to VISA or MasterCard. Or send a check (made payable to ERS-NASS) to:

ERS-NASS
341 Victory Drive
Herndon, VA 22070.