Working Paper Series

WORKING PAPER # 457

Agricultural Policy in Economies with Uncertainty and Incomplete Markets

by

Robert D. Innes and Gordon C. Rausser

DEPARTMENT OF AGRICULTURAL AND RESOURCE ECONOMICS

BERKELEY

CALIFORNIA AGRICULTURAL EXPERIMENT STATION

University of California

DEPARTMENT OF AGRICULTURAL AND RESOURCE ECONOMICS
DIVISION OF AGRICULTURE AND NATURAL RESOURCES
UNIVERSITY OF CALIFORNIA

Working Paper No. 457

AGRICULTURAL POLICY IN ECONOMIES WITH UNCERTAINTY AND INCOMPLETE MARKETS

by

Robert D. Innes and Gordon C. Rausser

California Agricultural Experiment Station
Giannini Foundation of Agricultural Economics
December 1987

AGRICULTURAL POLICY IN ECONOMIES WITH UNCERTAINTY AND INCOMPLETE MARKETS

Robert D. Innes and Gordon C. Rausser*

*Robert D. Innes is an Assistant Professor, Department of Agricultural Economics, University of California at Davis, and Gordon C. Rausser is Robert Gordon Sproul Chair Professor, Department of Agricultural and Resource Economics, University of California at Berkeley.

AGRICULTURAL POLICY IN ECONOMIES WITH UNCERTAINTY AND INCOMPLETE MARKETS

I. Introduction

Use of geometric surplus concepts to measure social costs and distributional effects of government policy interventions has a long and rich history dating back to the pioneering work of Hicks, Marshall, Hotelling, and Harberger. In agricultural economics, these concepts have been applied to analysis of stereotypical agricultural policies by, among many others, Grilliches, Wallace, and, more recently, Gardner--work which our profession treats as core material on policy analysis. Underlying this research is the premise that the economy is characterized by certainty and complete competitive markets without distortions in other sectors. This paper shows that this conventional approach is faced with serious limitations when markets are incomplete. This is shown by evaluating target price/deficiency payment programs (the Brannan Plan), production controls (the Cochrane Proposal), and land controls under incomplete contingent claim markets.

In a perfect economy setting, the fundamental theorems of welfare economics (Debreu) apply, and any government intervention is costly to society. Further, with no uncertainty, agricultural programs such as the Brannan and Cochrane Plans benefit producers and hurt consumers (as taxpayers). These implications have become conventional wisdom in both academic circles and contemporary policy discussions. For example, Gardner writes (p. 225): deadweight losses "are the costs of obtaining various social and political objectives." Along similar lines, the 1986 Economic Report of the President states (p. 155): "Income support programs redistribute income away from consumers and toward farmers . . . [and] by inhibiting the efficient operation of agricultural markets can impose extra costs on consumers and taxpayers that exceed the amount of income transfered to farmers."

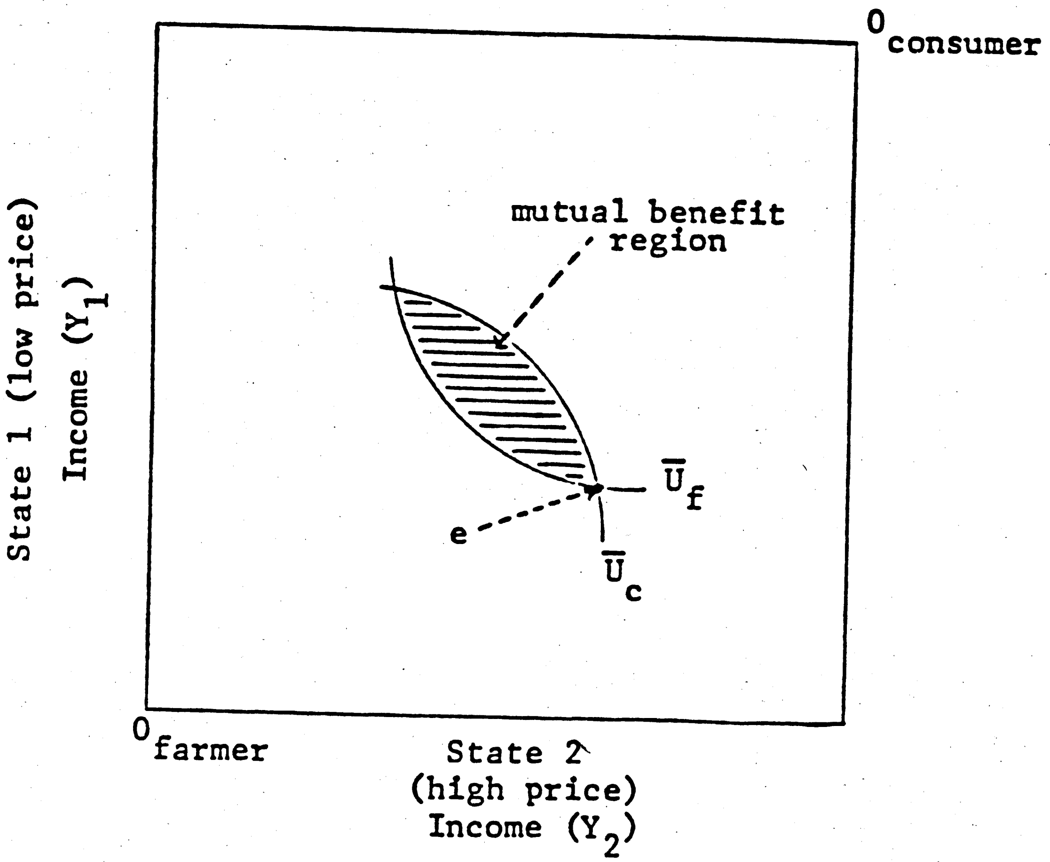
Yet, for well-established empirical reason, the importance of real world departures from a certain perfect markets framework is recognized in virtually every other branch of agricultural economic analysis.[1] In particular, whenever a farmer's decision problem is posed as an expected utility maximization, there is an implicit assumption that contingency markets are incomplete. For policy analysis, such an "imperfection" requires that we turn to "second best" conceptual frameworks (Rausser; Runge and Myers). Here, we do so by examining a simple equilibrium model with stochastic production, rational expectations, and no market for contingent trades.

It is well known that incomplete markets lead to suboptimality of competitive equilibrium (Newbery and Stiglitz; Borch). Hence, if an agricultural program induces an exchange of state-contingent income in the lens of mutual advantage, it will be Pareto-improving (figure 1). In addition, risky environments render surplus-based analysis of policy interventions' distributional effects inappropriate; with uncertainty, policy effects cannot be limited to a market for a single state-contingent commodity. Hence, it is not to be expected a priori that the distributional implications of the standard certainty model will prevail either.

In fact, in the present setting, it can be shown that the welfare and distributional effects of a Brannan Plan program can be just the opposite under uncertainty and incomplete markets as under certainty; specifically, when market parameters take on values characteristic of staple food commodities, producers are made worse off, consumers/taxpayers better off, and society better off (Innes). The welfare benefits of a Brannan Plan emanate from the

FIGURE 1

PURE EXCHANGE REPRESENTATION OF INCOMPLETE MARKETS



Legend: e = competitive (no-program) equilibrium allocation

$\overline{U}_f$ = farmer indifference curve for the utility generated by allocation e

$\overline{U}_c$ = consumer indifference curve for the utility generated by allocation e state-contingent income trades which this policy induces. Due to supply response, market prices of the supported commodity fall, increasing consumers' real income and lowering farmer profits in high-price (low-output) states of nature. In contrast, the program transfers income from consumers (as taxpayers) to producers in low-price (high-output) states in which the target price becomes the effective price received by farmers. When this exchange is in the lens of mutually beneficial trade, the Brannan Plan is Pareto-improving. In terms of figure 1, this condition is equivalent to e (the competitive equilibrium allocation) lying at the southeast end of the mutual benefit region. This graphical condition can be translated into a relationship between agents' marginal rates of substitution which will be satisfied when farmers are risk averse (with nonincreasing absolute risk aversion) and when price and income elasticities of demand are low.

Turning to the Cochrane program, we have already mentioned that its distributional and welfare implications are qualitatively similar to those of a Brannan Plan program in a world of certainty and complete competitive markets: consumers/taxpayers lose, producers gain, and society loses. Moreover, if production controls and target prices can both be used, the socially optimal redistributive policy (in terms of the compensation criterion) is to control production at the competitive equilibrium level and transfer income via allocationally neutral deficiency payments.

When we move to a world of uncertainty and incomplete markets, two questions arise: (1) Do the qualitative similarities between production controls and target price programs persist and (2) can production controls still be jointly optimal with a Brannan Plan?

Intuition suggests that the answer to the first question will be "no." Although consumers can be better off with a target price plan due to free benefits of supply response in high price states of nature, they are worse off in every state of nature with production controls. Furthermore, the welfare effects of the Brannan Plan are attributable to the interstate income transfers which it generates, from consumers to producers in one state and from producers to consumers in the other; in contrast, production controls transfer income from consumers to producers in both states of nature.

Though production controls may be dominated by a Brannan Plan approach when both policies are considered in isolation, their joint employment may prove optimal. Intuitively, you may expect this outcome for the following reasons: Under certain circumstances, a target price program yields welfare benefits by way of the interstate income transfers it producers but at a cost of giving producers a wrong incentive price in at least one state of nature. Suppose, for example, that a Brannan Plan program is used to achieve full equality between consumers' and producers' marginal rates of substitution for state-contingent incomes in a two-state setting--that is, an optimal no-supply-response target price is chosen. In this case, the farmer has the "right" marginal utilities in his first-order condition but the wrong price; in fact, the wrong price is too high and, hence, so too will be the output choice. Consequently, a production control will be optimal.

So far, this discussion has assumed a particular form for the design of production controls--namely, control of ex ante output. There are at least two reasons why somewhat altered forms deserve attention. First, legal or other constraints may prevent the government from mandating a given production level. In this case, voluntary participation must be elicited, for example, via a link to deficiency payments. Second, the government may not be able to observe ex ante output but be able to monitor land utilization. In this case, production controls must take the form of land controls.

A voluntary participation requirement imposes an additional constraint on the policy choice problem. Though this constraint may be costly, the analysis below will show that it does not alter the qualitative implications of the above discussion, namely, that the constrained optimal policy under circumstances plausible for the agricultural setting will include both Brannan Plan program and an associated production control. Not surprisingly, the constraint implies less control, not no control.

However, ignoring soil conservation arguments, land controls impose an allocational inefficiency not present with direct production targets. Hence, the desirability of having such controls in conjunction with a Brannan Plan program hinges on the size of this allocational inefficiency. Particularly when "slippage" is significant, this cost will be large and will outweigh any gains associated with the resulting output reduction.

The balance of this paper elaborates and formalizes the above discussion. Following a brief description of the conventional certainty/perfect markets analysis of agricultural policy, the incomplete markets model will be specified. Given the basic model, each of the programs--Brannen Plan production controls, combined Brannan Plan/production controls with and without voluntary participiption, and land controls--is analyzed.

II. Agricultural Policy in a Certain Economy with Perfect Markets

At the outset, consider the surplus-based analysis of stereotypical agricultural policies in an economy with no uncertainty and complete competitive markets. Following Wallace, three programs to support farmer income levels can be examined. The first program, the Brannan Plan, sets a target price above the free-market equilibrium and pays farmers the difference between this target price and the market-clearing price in the form of so-called "deficiency payments." Note that with this program, farmers freely choose output levels. In contrast, the second program is a Cochrane-type production control which sets farmer output levels below free-market levels, thereby giving farmers a higher price for their commodity. The final program, acreage controls, also aims to reduce farmer output levels but by controlling an input, land, rather than by controlling production directly. Both the second and third program types can be either combined with a Brannan Plan target price/ deficiency payment policy or imposed separately.

The Brannan Plan

In the certain perfect economy framework, the Brannan Plan can be depicted graphically as in figure 2. This program sets a target price, P^*, which induces farmers to produce Q, yielding a market-clearing price of P. Farmers thus receive a deficiency payment of $(P^* - P)$ for each unit of their output for a total taxpayer cost of $(P^* - P)\,Q$ = Area ABCE. Ignoring tax costs, both consumers and producers are better off under the program. With S being the general equilibrium supply curve, farmer profits have risen by the area ABGF. With D being the compensated general equilibrium demand curve, consumers would be willing to pay area FGCE for the price drop from P^{ce} to P. Summing up the welfare costs of the program gives:

$$(1) \qquad W \equiv \text{Welfare Change} = -BGC = ABGF + FGCE - ABCE.$$

Cochrane Production Controls

Using exactly the same surplus analysis, the effects of production controls are shown in figure 3. Here, farmers enjoy additional profits from the

FIGURE 2
The Brannan Plan in a Certain Economy

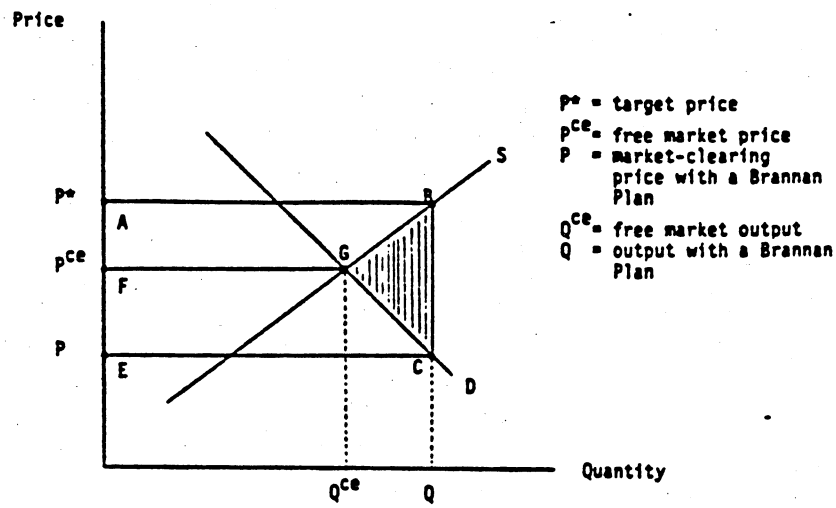


FIGURE 3
A Production Control in a Certain Economy

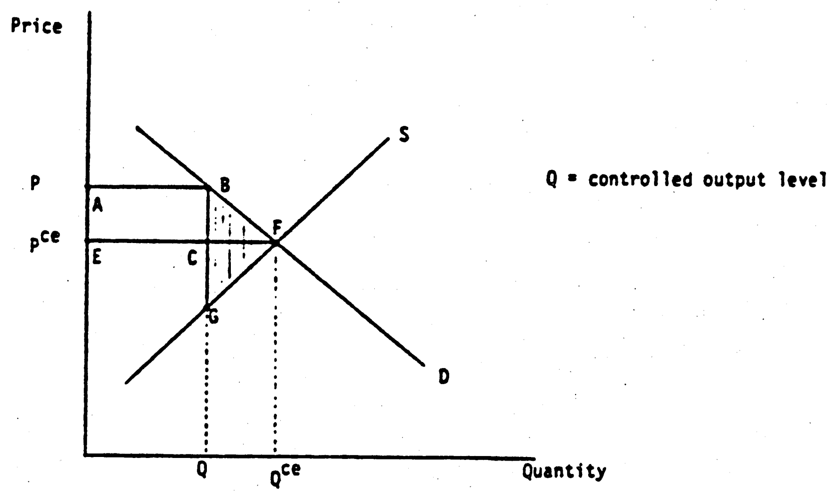


FIGURE 4
Land Controls in a Certain Economy

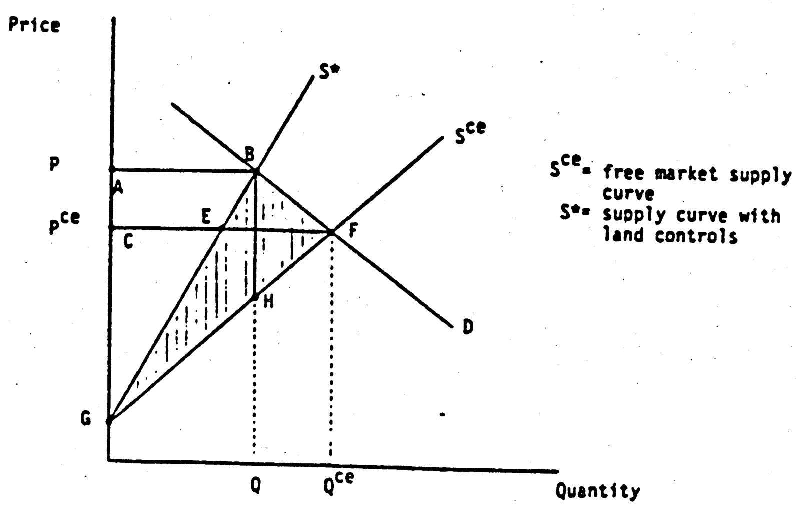
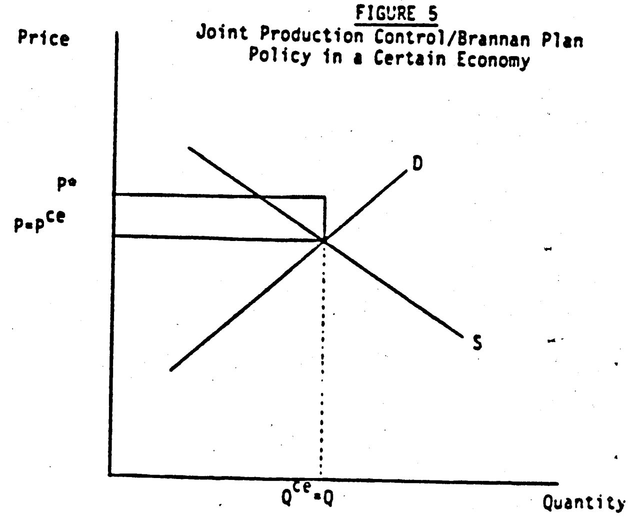


FIGURE 5
Joint Production Control/Brannan Plan Policy in a Certain Economy



program equal to the difference between areas ABCE and CFG. Consumers, on the other hand, lose area ABFE. The net welfare loss is the shaded "Harberger triangle" BFG.

Land Controls

Acreage controls lead to an inward shift in the supply curve; since a given output must be produced with less land, more of other inputs must be employed, implying a higher cost of production. Figure 4 depicts this shift (from S^{ce} to S^*) and the associated benefits and costs. Producer profits change by the difference between areas ABEC (a gain) and EFG (a loss). Consumers lose area ABFC. The net welfare loss is the shaded triangle BFG. Note that land controls have achieved the same effects as a production control of G but at the additional allocational cost of area BHG.

Production Controls with a Brannan Plan

Putting figures 2 and 3 together gives us figure 5. This figure depicts a joint production control/Brannan Plan policy that transfers income to producers without any welfare costs. Production is controlled at the free-market level, thereby avoiding allocational costs of a support policy. Farmers are supported by deficiency payments which are equivalent to pure transfers from taxpayers.

The foregoing properties of prototypical agricultural policy regimes have constituted core material for students of agricultural economics. In what follows, we extend the certain, perfect markets framework in which these results are couched to a more realistic setting with uncertainty and incomplete markets. We show that these basic properties of agricultural policy programs must be reassessed in the presence of incomplete markets and uncertainty.

III. The Incomplete Markets Model

Consider a static two-good economy in which the two goods are a food commodity (x) and a numeraire (y).

Production

Assume that there exists a representative (aggregate) farmer who can be characterized as follows:

1. Preferences are defined on profits and satisfy the rationality axioms of Von Neumann and Morgenstern (Borch). The representative farmer's utility can then be represented by an expected utility function, $EU(\pi)$, where E denotes the expectation operator over states of nature, π (the state-dependent profit) and $U(\cdot)$, the ex post utility function, assumed state independent and twice differentiable with $U' > 0$ and $U'' \leq 0$.
2. He has a production technology defined by a twice differentiable cost function, $C(z)$ (where cost is measured in units of the numeraire), and an output function $x = \theta z$, $E(\theta) = 1$. The "expected output" choice is z which must be made before the state is revealed, and θ is a state-dependent output coefficient. Assume $C' > 0$ and $C'' > 0$. Note that the cost function, C, implicitly reflects the presence of some fixed factor of production in the agricultural sector such as land. In section VII, the role of this fixed factor is made explicit.
3. The farmer is a pricetaker and has rational expectations in the sense that the price he expects in state σ is the equilibrium price in that state.

Consumers

Assume that there exists a representative consumer whose indirect utility function is $V(P, Y)$, where P is the price of food; Y is aggregate consumer income; and $V(\cdot)$ is a twice differentiable state-independent function. Assume $V_P < 0$, $V_Y > 0$, and $V_{YY} \leq 0$. Let this consumer also obey the standard rationality axioms of choice under uncertainty, so that this utility can be represented by $EV(\tilde{P}, \tilde{Y})$. Further, suppose that, in the absence of taxes to pay for deficiency transfers, Y is constant across states. Finally, assume that consumers pay the full cost of the Brannan Plan via a lump-sum (ex post) tax.

General

Suppose that there is perfectly symmetric information and that equilibrium is stable in a Walrasian sense. Further, for analytical tractability, it will be assumed generally that there are two equi-probable states of nature with $\theta_1 > \theta_2$; when practicable, the more general case will be examined--namely, that of states, indexed by σ, continuous on an interval $[a, b]$ with the production coefficient, $\theta(\sigma)$, decreasing in σ.

With this construction, farmer profits in state σ are:

(2) $$\pi_\sigma = \max(P_\sigma, P^*)\, \theta(\sigma)\, z - C(z) - s_f$$

where P_σ is the market price of food prevailing in state σ, P^* is the target price, and S_f is a fixed (nonstate-contingent) government tax. When the farmer is choosing "expected output," his utility maximization problem can be written:

(3) $$\max_z EU[\max(P^*, P)\ \theta z - C(z) - s_f]$$

with first-order condition (assuming an interior solution):

(4) $$E\{U'[\max(P^*, P)\ \theta - C']\} = 0.$$

Clearly, the farmer's optimal z, z*, is a function of received prices in all states, $[\max(P_\sigma, P^*)]$; the tax, s_f; and parameters of cost utility functions. Given rational farmer expectations, market prices are determined by the equilibrium conditions (using Roy's identity and subsuming relevant parameters in the z* function):

(5) $$x^d(P_\sigma, Y_\sigma) \equiv - \frac{V_P(P_\sigma, Y_\sigma)}{V_Y(P_\sigma, Y_\sigma)} = \theta(\sigma)\ z^*\{[\max(P_\sigma, P^*)], s_f\}$$

where $x_d(\ )$ denotes consumer demand, assumed downward sloping in price,

$$Y_\sigma = Y - [P^* - \min(P_\sigma, P^*)]\ \theta(\sigma)\ z^*\{[\max(P_\sigma, P^*)], s_f\} - s_c$$

and s_c is a fixed (nonstate-contingent) government tax on consumers. Letting $[P_\sigma(P^*, s)]$, $s \equiv (s_f, s_c)$ denote the solutions to (5), the equilibrium producer input choice can be represented as a function of P* and s alone:[2]

(6) $$z^{**}(P^*, s) \equiv z^*(\{\max[P_\sigma(P^*, s), P^*]\}, s).$$

Notably, structural parameters are also subsumed in the z** function; when one of these parameters is of interest, as it will be in the examination of land controls, the dependence can be made explicit with the addition of an argument.

IV. The Brannan Plan in a Policy Vacuum

Define welfare in a conventional way as the sum of producer and consumer compensating variations (PS and CS, respectively). Essentially, government taxes s_f (c.f., PS) and s_c(c.f., CS) are selected to preserve agents' pre-program utilities and the following welfare question is posed: Given P* and the associated utility-preserving taxes, is there a surplus in the government budget? To answer this question for the two-state setting, PS and CS are expressed implicitly by the following equations:

$$\text{(7a)} \qquad \sum_{\sigma=1}^{2} .5\left\{V\left[P_\sigma(P^*),\ Y - \{P^* - \min[P^*,\ P_\sigma(P^*)]\}\ \theta_\sigma\ z^{**}(P^*) - CS\right]\right\} = \bar{V}^{ce}$$

$$\text{(7b)} \qquad \sum_{\sigma=1}^{2} .5\left(U\{\max[P^*,\ P_\sigma(P^*)]\ \theta_\sigma\ z^{**}(P^*) - C[z^{**}(P^*)] - PS\}\right) = \bar{U}^{ce}$$

where $\bar{V}^{ce}$ and $\bar{U}^{ce}$ denote no-program competitive equilibrium utilities of the two agents and where prices and outputs represent compensated equilibrium outcomes. Differenting and summing for the case of $P^* < P_2$:

$$\text{(8)} \qquad \frac{dW}{dP^*} = \frac{dCS}{dP^*} + \frac{dPS}{dP^*} = .5\left\{\theta_1\ z^{**}\ (P^*)\left[\frac{U_1'}{E(U')} - \frac{V_{1Y}}{E(V_Y)}\right] + \theta_2\ z^{**}(P^*)\left[\frac{U_2'}{E(U')} - \frac{V_{2Y}}{E(V_Y)}\right]\left[\frac{dP_2}{dP^*}\right] - \left[\frac{V_{1Y}}{E(V_Y)}(P^* - P_1)\ \theta_1\right]\left[\frac{dz^{**}}{dP^*}\right]\right\}.$$

This last equation gives rise to the following proposition:

PROPOSITION 1: If $dP_2/dP^* \leq 0$ at $P^* = P_1^{ce}$, then a sufficient condition for the existence of a welfare-improving target price is that the following inequality be satisfied at the no-program competitive equilibrium:

$$(9) \qquad MRS_{consumer} = \frac{V_{1Y}}{V_{2Y}} < \frac{U_1'}{U_2'} = MRS_{farmer}$$

where P_s^{ce} denotes the no-Brannan-Plan (competitive equilibrium) price in state s. Note that condition (9) is equivalent to e of figure 1 lying at the southeast corner of the mutual benefit region. Expanding and interpreting the prior condition to this Proposition yields the following corollary:

COROLLARY 1.1: If (a) demand is price inelastic for $P_\varepsilon[P_1^{ce}, P_2^{ce}]$, (b) farmers are strictly risk averse with nonincreasing absolute risk aversion, and (c) η (the income elasticity of demand) is approximately zero for $P_\varepsilon[P_1^{ce}, P_2^{ce}]$, $Y_\sigma = Y$ ($\sigma = 1, 2$), then a positive target price, $P^* > P_1^{ce}$, will be socially optimal.

V. Production Controls in a Policy Vacuum

We now consider a control on ex ante output when it is the only policy instrument available. In this setting, the distributional effects of controls are clear: They hurt consumers and benefit producers.[3] However, their welfare implications require some analytical derivation which follows.

Let z^c denote the controlled output level. Further, define the (Bergson-Samuelson) social welfare function as follows:

$$(10) \qquad W(z^c, s) = E\{U[P\theta z^c - C(z^c) - s]\} + \lambda E[V(P, Y + s)]$$

where $s = s_f = s_c$ denotes a fixed (ex ante) transfer between producers and consumers, and $\lambda > 0$ is an arbitrary weight. Note that the welfare function defined in (10) is slightly different from that employed in section IV; chosen for analytical convenience, it implies the following equivalent welfare question:[4] Given that the government balances its budget, can all agents be made better off with the policy of interest?

Let government choose s optimally so that the following condition is always satisfied:

$$\text{(11)} \qquad \frac{\partial W}{\partial s} = E\left[U'\left(\frac{\partial P}{\partial s}\,\theta z^c - 1\right)\right] + \lambda E\left[V_Y\left(1 - \frac{\partial P}{\partial s}\,\theta z^c\right)\right] = 0$$

where, from the equilibrium conditions,

$$\frac{\partial P}{\partial s} = -\frac{x_Y^d}{x_p^d}\,.$$

The welfare effects of production controls can be discerned from the derivative of the welfare function with respect to z^c. In particular, if the sign of this derivative is positive for all $z^c < z^{**}$, where z^{**} denotes competitive equilibrium output, then production controls are welfare decreasing. Similarly, if the sign of this derivative is negative at $z^c = z^{**}$, then some control will be socially optimal. With these observations in mind, consider the following expression:

$$\text{(12)} \qquad \frac{\partial W}{\partial z^c} = E\left[\theta z^c \frac{\partial P}{\partial z}\,(U' - \lambda V_Y)\right] + E[U'(P\theta - C')]$$

where $\partial P/\partial z = \theta/x_p^d$ and, from (11),

(13)
$$\lambda = \frac{E[U'(1 + x_Y^d\, \theta z^c / x_p^d)]}{E[V_Y(1 + x_Y^d\, \theta z^c / x_p^d)]} .$$

Note that $x_Y^d\, \theta z^c/x_p^d = -\alpha\eta/\gamma$, where α is the expenditure share, η the income elasticity of demand, and γ the price elasticity of demand. Since the second term of (12) is always positive when $z < z^{**}$ (and zero when $z = z^{**}$), a sufficient condition for any production control to be welfare decreasing is that the first term be nonnegative. Clearly, if risk markets are redundant (i.e., $U_\sigma' = kV_{\sigma Y}$ in all states σ, k constant), the first term will be zero and production controls will make society worse off. Examples of redundant risk markets include (1) risk-neutral farmers and $V_{Yp} = 0$ and (2) unitary price elasticity of demand and $V_{Yp} = 0$ (Newbery and Stiglitz). These cases are naturally of little interest for this paper since they imply market completeness in the sense that no market in which there would be trade is absent; hence, in these cases, the standard result on the optimality of competitive equilibrium in a complete market setting applies.

For the case of incomplete markets, conditions under which (12) has an unambiguous sign are derived in Appendix A. These conditions can be signed provided the demand function is specified. Three functional forms--linear, constant elasticity, and unit income elasticity--are examined. This examination leads to the following Proposition:

PROPOSITION 2:

A. Sufficient conditions for any production control to be welfare decreasing are:

1. Constant price and income elasticity demand with either (a) $\gamma \leq 1$ and $V_{YP} \geq 0$ (i.e., consumer relative risk aversion $\equiv \phi^* \geq \eta \geq 0$) or (b) $\gamma \geq 1$ and $V_{YP} \leq 0$ (i.e., $\phi^* \leq \eta \geq 0$).
2. Demand linear in price and income, price elastic in the relevant range, and $V_{YP} \leq 0$, with $x_p^d \geq 0$.
3. Demand of the form, $x^d = Y/(a + bP)$.

B. Sufficient conditions for some control on production to be socially optimal are:

4. Demand linear in price and income, inelastic in the relevant range, and $V_{YP} \geq 0$, with $x_Y^d \geq 0$ and risk markets not redundant.

COROLLARY 2.1: If government could compel farmers to increase output beyond the competitive equilibrium level, such a policy would be socially optimal in cases 1 and 2 in Proposition 2, assuming risk markets are not redundant.[5]

The foregoing indicates that the qualitative similarities between the effects of production controls and those of a Brannan Plan evaporate when uncertainty is introduced in an incomplete markets model. While the distributional differences between these two policies are clear, Proposition 2 indicates some conditions which are plausible for the agricultural sector and under which production controls will be welfare decreasing though a Brannan Plan is welfare increasing.

Although the above results are of some theoretical interest in practice, production controls are not employed in a policy vacuum; rather, they are linked to support programs such as a Brannan Plan. The welfare properties of production controls in such a two-instrument framework are the subject of the next section.

VI. Production Controls with a Brannan Plan

When production controls and a Brannan Plan can be jointly employed, the social welfare function for the two-state setting can be written as follows:

$$W(s, P^*, z^c) = \sum_{\sigma=1}^{2} .5 \Bigg[U\{\max[P^*, P_\sigma(s, P^*, z^c)]\, \theta_\sigma\, z^c - C(z^c) - s\} \tag{14}$$

$$+ \lambda V\Big(P_\sigma(s, P^*, z^c),\ Y - \{P^* - \min\,[P^*, P_\sigma(s, P^*, z^c)]\}\theta_\sigma\, z^c + s\Big)\Bigg]$$

where $P_\sigma(s, P^*, z^c)$ denotes the equilibrium price in state σ.

Note that choice of z^c will be constrained by the condition: $z^c \leq z^{**}(P^*, s)$, the producer's optimal choice in the absence of controls. The question to be examined in this section is: Assuming a positive target price is optimal, will this constraint be binding at the optimum?[6] To answer this question, the first-order necessary conditions for the unconstrained maximization problem may be derived and analyzed to determine whether the constraint is violated.

With $P^* < P_2$, the necessary conditions for the unconstrained maximization of (14) are as follows (after some simplification):

$$\frac{\partial W}{\partial s} = [\lambda E(V_Y) - E(U')] + .5\,\frac{\alpha_2 \eta_2}{\lambda_2}(U_2' - \lambda V_{2Y}) = 0 \tag{15}$$

$$\frac{\partial W}{\partial P^*} = .5\theta_1\, z^c(U_1' - \lambda V_{1Y}) = 0 \tag{16}$$

$$\frac{\partial W}{\partial z^c} = E\{U'[\max(P^*, P)\,\theta - C']\} + \frac{\theta_2 P_2}{\gamma_2}(\lambda V_{2Y} - U'_2) - \lambda V_{1Y}(P^* - P_1)\,\theta_1 = 0. \tag{17}$$

Now consider equation (17). The first term is the partial derivative of farmer-expected utility with respect to ex ante output; if positive, production z^c is less than the farmer would choose in the absence of a control and the constraint will not be binding. Hence, given that (17) is satisfied, a necessary and sufficient condition for production controls to be optimal is that the sum of the second and third terms be negative. A sufficient condition is that one term be negative and the other nonpositive. Since $P^* > P_1$ by the assumption that a positive target price is optimal, the third term is negtive and, therefore, the sufficient condition reduces to the nonpositivity of the second term. A little manipulation of conditions (15) and (16) reveals that this term must be zero; specifically, solving for λ from (16), substituting into (15), and rewriting gives:

$$(15') \qquad .5U_1'\left(1 - \frac{\alpha_2 n_2}{\gamma_2}\right)\left(\frac{V_{2Y}}{V_{1Y}} - \frac{U_2'}{U_1'}\right) = 0, \ \lambda = \frac{U_1'}{V_{1Y}} = \frac{U_2'}{V_{2Y}}$$

(15') and (17) not only imply that $E\{U'[\max(P^*, P)\,\theta - C']\} > 0$; they are also equivalent to the conditions for a full Pareto optimum, namely, $E[U'(P\theta - C')] = 0$ and $(V_{1Y}/V_{2Y}) = (U_1'/U_2')$. It is easily verified that all of these conclusions carry over to the case of $P^* > P_2$ (and of unequal state probabilities), thus proving the following Proposition:

PROPOSITION 3: In a two-state world, production controls will be an optimal complementary policy to a Brannan Plan whenever a Brannan Plan is socially desirable. Further, in this setting, the optimal Brannan Plan/production control program will yield a full Pareto optimum.

So far, production controls have been treated without regard to the willingness of farmers to restrain their output. When these controls are not linked to any other policy, this is a necessary abstraction. However, when both Brannan Plan and output control policies are pursued, entitlement to a target price can be linked to output constraints. In this case, assuming government cannot impose controls, an additional constraint is added to the welfare maximization problem--namely, that, given prevailing market prices with full farmer participation in the Brannan Plan/control program, farmers prefer participation (i.e., receipt of the target price in low price states in exchange for output control) to nonparticipation (i.e., receipt of market prices without control). Though this constraint may bind the government planner's choice of z^c, the following proposition demonstrates that it will not alter the implications of the above discussion with respect to the optimality of some production control.

PROPOSITION 4: If a joint Brannan Plan/production control policy is socially optimal when the social planner does not face a voluntary participation constraint, some production control will also be a socially optimal complement to the Brannan Plan when the planner does face a voluntary participation constraint.

Proof: If the participation constraint is not binding, a production control is optimal by supposition. Now suppose that the constraint is binding and a production control is not optimal. Then participation in the Brannan Plan/control program costs farmers nothing and gives them the benefit of the target price/deficiency payment; therefore, they will choose to participate and the constraint will not be binding--a contradiction.

VII. Land Controls with a Brannan Plan

In the preceding sections, it was assumed implicitly that the social planner could costlessly monitor z. However, in practice, z may be either unobservable to the planner or observable only at considerable cost.[7] In this case, production controls may only be achievable by control of some input in production which can be monitored inexpensively. The obvious candidate is land, the subject of this section.

The key question to be examined here is: Under what circumstances, if any, can land controls be a socially optimal complement to a Brannan Plan policy? For analytical convenience in addressing this issue, this section also employs the two-state framework and assumes that land is the only fixed factor of production. The latter assumption implies a cost function of the form,

$$C(z, L) = Lc\,\frac{z}{L}\,, \; c' > 0, \; c'' > 0 \tag{18}$$

where L = land units cultivated. At the outset, note that (18) implies the following:

OBSERVATION 1: In the absence of monitoring costs, production controls are always preferable to land controls. (For a given z, the cost of output is lower as L is higher.) This result points out the allocational cost of using a land control to reduce production. For a given production target, the magnitude of this cost will depend on the extent to which production responds to land controls; for example, if land restrictions lead to more intensive cultivation of the acreage remaining in production (i.e., there is slippage), this cost will be large. Clearly, the desirability of land restrictions will hinge on the trade-off between this allocational cost and the prospective gain to controls identified in section VI.

Proceeding with the analysis, the welfare function can be expressed as follows:

$$W(s, P^*, L) = EU[\max(P^*, P)\, \theta z^{**} - C(z^{**}, L) - s] \qquad (19)$$
$$+ \lambda EV\{P, Y - [P^* - \min(P^*, P)]\, \theta z^{**} + s\}$$

where $z^{**} = z^{**}(s, P^*, L)$ = farmer equilibrium choice of z, and $P = P_\sigma(s, P^*, L)$ = equilibrium market price in state σ. Assuming that a Brannan Plan program is optimal in the absence of land controls, the following two conditions will be satisfied at an optimum [assuming $P^* < P_2$(case 1)]:[8]

$$\frac{\partial W}{\partial s} = .5\left[(\lambda V_{1Y} - U_1') + (\lambda V_{2Y} - U_2')\left(1 - \theta_2\, z^{**} \frac{\partial P_2}{\partial s}\right) \qquad (20)\right.$$
$$\left. - \lambda V_{1Y}(P^* - P_1)\, \theta_1 \frac{\partial z^{**}}{\partial s}\right] = 0$$

$$\frac{\partial W}{\partial P^*} = .5\left[\theta_1 z^{**}\, (U_1' - \lambda V_{1Y}) + \theta_2 z^{**} \frac{\partial P_2}{MP^*}\, (U_2' - \lambda V_{2Y}) \qquad (21)\right.$$
$$\left. - \lambda V_{1Y}(P^* - P_1)\, \theta_1 \frac{\partial z^{**}}{\partial P^*}\right] = 0.$$

To determine whether or not land controls will be socially desirable, we will want to sign the derivative of the welfare function with respect to L, evaluated at the uncontrolled land supply and the associated optimal s and P*; if negative, land controls will be socially desirable. Writing down this derivative (again for case 1):

$$(22) \quad \frac{\partial W}{\partial L} = .5\left[-(U_1' + U_2')\, C_L + \frac{\partial P_2}{\partial L}\,\theta_2\, z^{**}(U_2' - \lambda V_{2Y}) - \lambda V_{1Y}(P^* - P_1)\,\theta_1\,\frac{\partial z^{**}}{\partial L}\right]$$

where $C_L = c - c' \cdot (z^{**}/L) < 0$, c evaluated at (z^{**}/L). The three terms in (22) can be interpreted as follows: the first term (positive) represents the allocational cost; the second term, the benefit/cost of interstate income transfers attributable to the effect on state 2 price; and the third term (negative), the marginal savings in deficiency payments due to the supply response.

With the algebra presented in Appendix B, (22) can also be written as follows:

$$(23) \qquad \frac{\partial W}{\partial L} = .5\left[-(U_1' + U_2')\, C_L + A\,\frac{\partial z^{**}}{\partial L}\right]$$

where

$$A \equiv \left[\theta_2\,\frac{\partial P_2}{\partial P^*} - \theta_1\left(1 - \frac{\partial P_2}{\partial s}\;\theta_2\, z^{**}\right)\right]^{-1} \theta_1^2\left(1 - \frac{\alpha_2 \eta_2}{\gamma_2}\right) \lambda V_{1Y}(P^* - P_1).$$

As before, the first term of (23) gives the allocational cost of land controls, which is higher as c'' is larger. The second term of (23) gives the benefit of the land control as an explicit function of the responsiveness of output to these controls $(\partial z^{**}/\partial L)$. More particularly, let

$$z^* \equiv z^*[\max(P^*, P_1), \max(P^*, P_2), s, L]$$

denote the outcome of the farmer's maximization problem and z_i^*, $i\varepsilon(1, 2, 3, 4)$, the associated partial derivatives, Appendix B shows that A is negative when (1) $z_1^* > 0$ (i.e., an increase in the state 1 received price, holding the state 2 price constant, induces positive supply response); (2) η_2 (the income elasticity of demand in state 2) is not too large; and (3) the farmer has nonincreasing absolute risk aversion (Arrow and Pratt). Under these conditions, land controls' contribution to welfare will be positively related to output responsiveness as predicted at the outset.

Now consider the following expansion of the output responsiveness derivative:

$$\frac{\partial z^{**}}{\partial L} = z_4^* \frac{x_{2p}^d}{x_{2p}^d - \theta_2 \, z^*_2} \,. \tag{24}$$

The first component, z_4^*, represents the partial effect of land controls on output, holding prices fixed. Appendix B reveals that this effect is larger, the larger are c'' and the rate of decrease in absolute risk aversion. The second component, the price effect, can be described as follows: When output goes down, the second state price goes up, inducing farmers to increase z and thereby partially offsetting the original output decrease. This interaction is reflected in $x^d/(x^d - \theta_2 z_2^*) < 1$ (assuming $z_2^* > 0$).

For an example, suppose absolute risk aversion is constant and $z_2^* > 0$; then $z_4^* < z/L$ and, thus, $\partial z^{**}/\partial L << z/L$. The latter inequality implies that farmers respond to land controls by significantly increasing the intensity of cultivation of the acreage remaining in production and that these controls are, therefore, a costly means to restrict output.

As was expected, the offsetting terms in (22) and (23) imply that the sign of $\partial W/\partial L$ is analytically ambiguous. However, the last discussion and the numerical example in the next section suggest that costs of slippage are likely to overwhelm any benefits of supply control, rendering land constraints socially harmful.

VIII. A Numerical Example

To illustrate and elucidate the foregoing discussion, the following simple example will be examined here:

(25) $$U(\Pi) = -e^{-\phi\pi}$$

(26) $$C(L, z) = L\left(\frac{z}{L}\right)^{\delta}$$

(27) $$V(P, Y) = \frac{P^{1-\gamma}}{\gamma - 1} + Y$$

(28) $$x = \theta_s z, \; s\varepsilon\{1, 2\}, \; \theta_1 = 1 + q, \; \theta_2 = 1 - q.$$

This specification leads to a constant price elasticity, zero income elasticity demand function,[9]

(29) $$x^d(P, Y) = P^{-\gamma}$$

and the following exact surplus measures:

(30) $$\begin{matrix}\text{Consumer} \\ \text{surplus}\end{matrix} \equiv CS = E\left[\frac{(P^{ce})^{1-\lambda}}{1 - \lambda} - \frac{(P')^{1-\lambda}}{1 - \lambda}\right] - E(T)$$

where P^{ce} and P' denote pre- and postintervention prices, respectively, and T represents the tax costs of the government program;

(31) $$\begin{matrix}\text{Producer} \\ \text{surplus}\end{matrix} \equiv PS = \ln\left[\frac{EU(\pi_0)}{EU(\pi_1)}\right] \Big/ \phi$$

where π_0 and π_1 denote pre- and postintervention farmer profits, respectively, and ln represents the natural logarithm. This specification is particularly convenient in that it implies identical compensated and uncompensated equilibria; farmer output choices do not depend on fixed income transfers, and consumer demand is income independent.[10]

For a range of relevant parameter values and a variety of policy regimes, equilibrium outcomes are derived using a bisection algorithm.[11] In particular, the cost elasticity (δ) is varied between 2 and 3 and the production risk coefficient (q) between .1 and .2. Further, the demand elasticity (γ) is varied between .2 and .8 (Huang; Blanciforti, Green, and King for empirical estimates). Farmer relative risk aversion is approximately varied between 1 and 5 (Arrow, Antle, and Binswanger); specifically, the certainty competitive equilibrium problem is solved, giving farmer profits π^*; $\phi\pi^*$ is then used as the relative risk aversion proxy, varied as indicated. Notably, a preponderance of empirical evidence indicates that a price elasticity close to .2 and a relative risk aversion coefficient close to 1 characterize staple food markets.

With respect to policy regimes, the objects of sections V-VII are considered: production controls, production controls with a Brannan Plan, and land controls with a Brannan Plan. To examine land controls, total available land is normalized to one; thus, (1 - L) represents the proportion of land withdrawn from production.

Numerical Results

Some results of the numerical analysis are given in tables 1-3 and figure 6. Table 1 presents, for a variety of parameter values, selected characteristics of equilibria with no government intervention (CE), the socially optimal Brannan Plan (BP), ex ante output controlled at 90 percent of its competitive level (PC), the joint optimal target price/production control (PCBP) and, finally, land utilization controlled at 90 percent of available land and the

TABLE 1

Equilibria With No Government Intervention (CE), an Optimal Brannan Plan (BP), Production Controls (PC), an Optimal Brannan Plan/Production Control Mix (PCBP), and a Land Control/Brannan Plan Mix (LCBP)[a]

A) $\delta = 2$, $\gamma\varepsilon(.2, .5, .8)$, $q\varepsilon(.1, .2)$, and $\phi\pi^* = 1$

γ	q	EQU	P*	z^{**}_{LCBP} z^c	z^{**}_{BP}	P_1	P_2	PS	CS	W
		CE	--	--	.85	1.35	3.69	0.0	0.0	0.0
		BP	1.70	--	.95	.79	2.15	-.0799	0.4206	0.3407
.2	.1	PC	--	.77	.85	2.29	6.24	.8716	-1.3484	-0.4768
		PCBP	2.28	.90	1.10	1.10	2.76	.4600	-0.1064	0.3536
		LCBP	1.86	.93	.95	.86	2.35	-.0134	0.2636	0.2502
		CE	--	--	.78	1.31	9.92	0.0	0.0	0.0
		BP	1.65	--	1.02	.35	2.67	-.1056	2.2491	2.1435
.2	.2	PC	--	.71	.78	2.21	16.80	.7693	-2.4606	-1.6913
		PCBP	2.42	.96	1.07	.49	3.73	.7475	1.4304	2.1779
		LCBP	1.81	1.00	1.03	.38	2.91	-.0280	2.0704	2.0424
		CE	--	--	.79	1.32	1.97	0.0	0.0	0.0
		BP	1.47	--	.81	1.23	1.84	.0320	-0.0208	0.0112
.5	.1	PC	--	.71	.79	1.63	2.43	.2578	-0.2838	-0.0260
		PCBP	1.58	.79	.83	1.30	1.94	.1164	-1.1034	0.0130
		LCBP	1.58	.79	.82	1.32	1.97	.0562	-0.1129	-0.0567
		CE	--	--	.78	1.13	2.55	0.0	0.0	0.0
		BP	1.38	--	.84	.96	2.16	.0579	-0.0081	0.0498
.5	.2	PC	--	.70	.78	1.39	3.14	.2519	-0.2958	-0.0439
		PCBP	1.60	.80	.87	1.07	2.40	.2370	-0.1809	0.0561
		LCBP	1.48	.81	.85	1.03	2.33	.0807	-0.1006	-0.0199
		CE	--	--	.73	1.30	1.67	0.0	0.0	0.0
		BP	1.34	--	.74	1.28	1.65	.0103	-0.0098	0.0005
.8	.1	PC	--	.66	.73	1.48	1.91	.1315	-0.1443	-0.0128
		PCBP	1.37	.73	.74	1.30	1.67	.0272	-0.0265	0.0007
		LCBP	1.42	.70	.75	1.36	1.75	.0158	-0.0726	-0.0568
		CE	--	--	.73	1.16	1.94	0.0	0.0	0.0
		BP	1.23	--	.75	1.14	1.89	.0194	-0.0171	0.0023
.8	.2	PC	--	.66	.73	1.33	2.21	.1316	-0.1450	-0.0134
		PCBP	1.29	.73	.75	1.16	1.93	.0562	-0.0534	0.0028
		LCBP	1.31	.71	.76	1.20	2.00	.0261	-0.0814	-0.0553

[a]Production controls were set at .9 of the competitive equilibrium 7. Land controls were at .9 of available land and the target price set at an associated social optimum; z^{**}_{BP} denotes the ex ante output with target price P* (which equals zero in the CE case) and no production or land control; and z^{**}_{LCBP} denotes the ex ante output choice with L = .9 and with target price P*.

Source: Computed.

TABLE 2

A Breakdown of Benefits and Costs of Land Controls When $\delta = 2$, $\gamma = (.2, .5, .8)$ $q = (.1, .2)$, and $\phi_\pi^* = 1$

Case			Surplus measure	Benefit of Brannan plan	Benefit of production control	Allocational costs of land controls		Benefit of land controls with a Brannan Plan[a]
γ	q	P*				No slippage	Cost of slippage	
				1	2	3	4	1+2+3+4
.2	.1	1.86	CS	.3640	-.1004	--	--	-.2636
			PS	-.0304	.1145	-.0214	-.0761	-.0134
			W	.3336	.0141	-.0214	-.0761	.2502
.2	.2	1.81	CS	2.1892	-.1188	--	--	2.0704
			PS	-.0503	.1354	-.0260	-.0871	-.0280
			W	2.1389	.0166	-.0260	-.0871	2.0424
.5	.1	1.58	CS	-.0567	-.0562	--	--	.1129
			PS	.0651	.0605	-.0291	-.0403	.0562
			W	.0084	.0043	-.0291	-.0403	-.0567
.5	.2	1.48	CS	-.0402	-.0604	--	--	.1006
			PS	.0871	.0679	-.0332	-.0411	.0807
			W	.0469	.0075	-.0332	-.0411	.0199
.8	.1	1.42	CS	.0315	-.0411	--	--	-.0726
			PS	.0300	.0415	-.0327	-.0230	.0158
			W	-.0015	.0004	-.0327	-.0230	-.0568
.8	.2	1.31	CS	-.0404	-.0410	--	--	-.0814
			PS	.0405	.0425	-.0336	-.0233	.0261
			W	.0001	.0015	-.0336	-.0233	-.0553

[a]Table 2 presents statistics for a land control of .9 with the associated optimal target price.

[b]Col. 3 = $-\{[z^{**}(L, P^*)/z^{**}(P^*)]^{1-\delta} - 1\}\ z^{**}(L, P^*)\delta$.

[c]Col. 4 = $-(L^{1-\delta} - 1)\ z^{**}(L, P^*)^{\delta} - c$.

Source: Computed.

TABLE 3

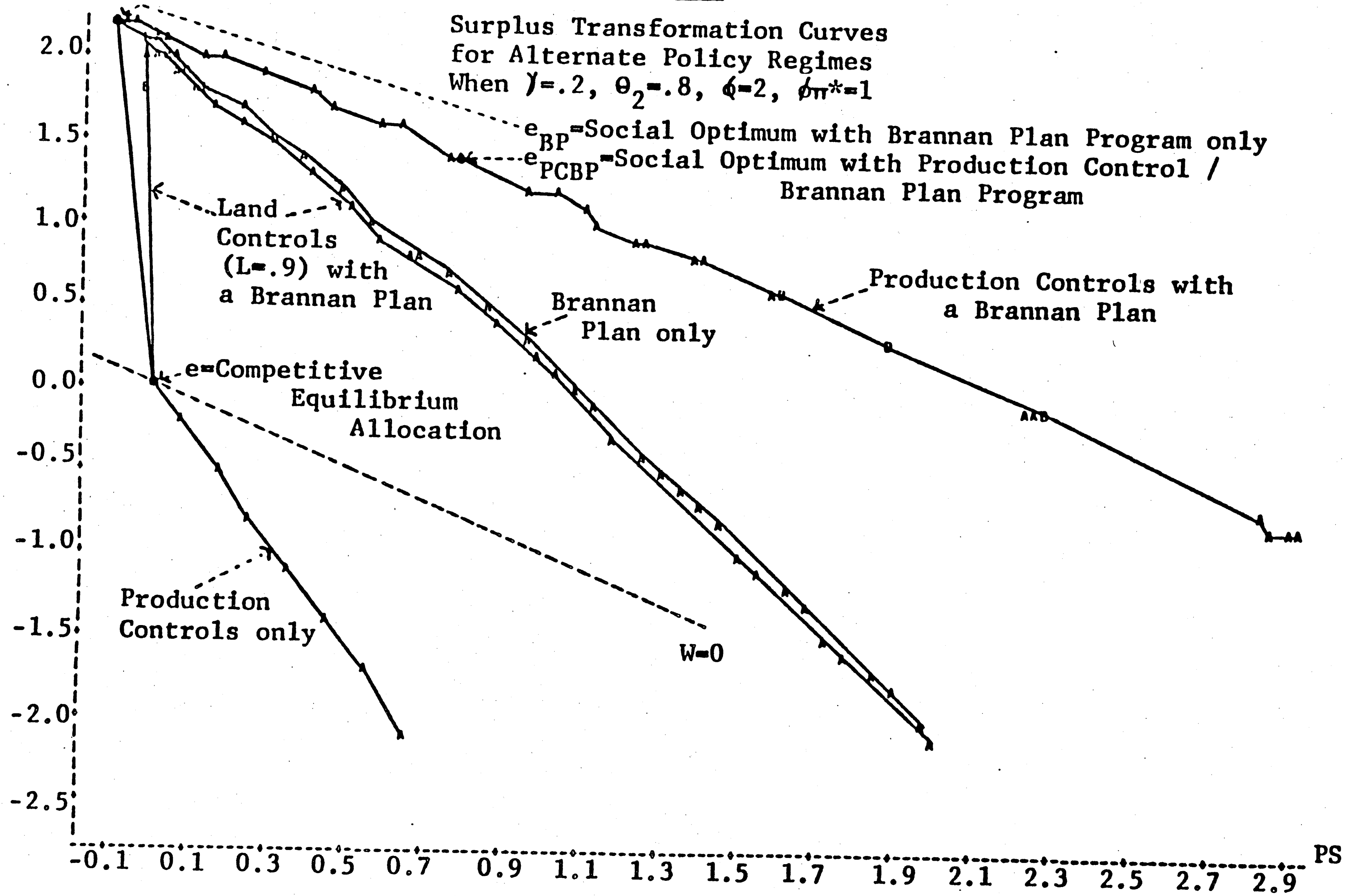
Tax Costs of Brannan Plan with Different Policy Regimes and $\delta = 2$, $\gamma = 2$, $q = (.1, .2)$, and $\phi_\pi^* = 1$

Policy regime	q	Tax costs in state 1	dW	Commodity expenditure in state 1
BP	.1	.9573	.3407	.8285
	.2	1.6010	2.1435	.4340
PCBP	.1	1.2687	.3535	1.0123
	.2	2.2302	2.1779	.5672
LCBP	.1	1.0312	.2501	.8879
	.2	1.7237	2.0424	.4650

Source: Computed.

FIGURE 6

Surplus Transformation Curves for Alternate Policy Regimes When $\gamma=.2$, $\theta_2=.8$, $\phi=2$, $\phi\pi^*=1$



target price set at an associated social optimum (LCBP). Table 2 breaks down the costs and benefits of land controls for a few relevant cases. Table 3 gives tax cost statistics for the optimal Brannan Plan in BP, PCBP, and LCBP contexts. Finally, figure 6 shows, for one important case, the surplus transformation curves associated with different policy regimes.

The following observations attempt to summarize these and other results:[12]

1. Voluntary participation. A voluntary participation constraint is never binding at an LCBP or PCBP equilibrium nor is it binding at any of the target price/control mixes associated with the figure 6 transformation curves. Hence, participation is not an issue in this example.

2. Inferiority of production controls. Production controls cause decreases in social welfare in all cases. The control of .9 was arbitrarily selected to illustrate the negative effects of this policy.

3. Superiority and distributional implications of a production control/target price mix. Consistent with the foregoing theoretical findings, table 1 reveals that production controls are an optimal complement to a Brannan Plan policy. However, the gains from these controls are small. Their more significant effect appears to be in the realm of distribution. Whereas an optimal Brannan Plan can make farmers worse off (or not very much better off) and consumers much better off, the joint optimal Brannan Plan/production control program shifts benefits to producers (see Table 1).

4. Inferiority of land controls. In all cases, the socially optimal Brannan Plan without land or production controls dominates any target price program with land controls. This outcome can be explained by the small social gains associated with production controls and the large allocational costs which result from slippage, the more intensive cultivation of acreage remaining in production. From table 1, it is evident that slippage is substantial

in the cases examined here. Moreover, table 2 reveals that this phenomenon is responsible for large allocational costs of land controls.

Despite the inferiority of land controls when compared to a socially optimal target price program, figure 6 shows that a large range of the Brannan Plan transformation curve is indistinguishable from the land control/Brannan Plan transformation curve. For high enough target prices and sufficiently small controls, the latter curve can actually rise above the former; thus, if agricultural policy is intended as a pro-farmer redistributive device and ex ante production cannot be limited, land controls may still be desirable.

5. Tax costs. Table 3 reveals that large social benefits of agricultural policy can be associated with large state 1 costs of the target price program.

6. Parametric determinants of policy gains. As one would expect, policy gains are positively related to the degrees of farmer risk aversion and production risk due to the insurance benefits of intervention which they imply.

7. Parametric determinants of land control costs. Table 1 shows that the absolute cost of a 10 percent land control is remarkably insensitive to the degrees of farmer risk aversion and production risk. However, this cost (measured by the difference between w under PCBP and LCBP regimes) appears to be negatively related to the demand elasticity and positively related to the cost elasticity, while remaining in the range .06-.18.

IX. Conclusion

A Brannan Plan policy can yield positive social benefits in an economy with stochastic production and incomplete markets under conditions which are plausible for an agricultural commodity. This paper takes these results as a point of departure, asking whether production controls, both as an isolated policy and as one employed with a Brannan Plan, can have desirable welfare properties in such an economy. In a variety of cases, these controls are found to be both socially harmful in a single-policy context and socially beneficial in the presence of a target price/deficiency payment scheme. Further, when monitoring costs prevent direct control of production, the use of an indirect control--namely, land set-asides--is shown to yield ambiguous welfare effects in the presence of a Brannan Plan; however, a numerical example indicates that the allocational costs of land set-asides, exacerbated by slippage, outweigh the benefits of supply cutbacks for a wide range of parameter specifications.

From a positive point of view, the foregoing analysis indicates that qualitative implications of policy in a complete markets setting are altered in the most fundamental ways when the reality of imperfect contingency trading is considered. From a normative point of view, the merits of a Brannan Plan program are shown to far outweigh any marginal contribution of output controls to social welfare even though this contribution can be positive. Notably, this prescriptive implication can find further affirmation in a model of nutritional externalities wherein output controls lead to external costs and output inducements lead to external benefits.

The latter subject, like the incomplete market focus of this analysis, represents one of many avenues which deserve academic exploration in an endeavor to bring agricultural policy analysis into the realm of real world imperfection.

Footnotes

[1]For example, see Barry, Nelson, and the Commodity Futures Trading Commission for evidence on risk problems and lack of perfect risk trading in agriculture.

[2]The solutions to (5) will be required for sections in which the two-state framework is employed. For this setting, the $[P_\sigma(P^*, s)]$ will be assumed existent, unique, continuous everywhere, and differentiable at all points other than where $P^* = P_2(P^*, s)$. (At the latter points, the functional relationship between P^* and farmer first-order conditions change.) These assumptions imply that $z^{**}(P^*, s)$ is continuous everywhere and differentiable at all points other than $\overline{P}_s^*$ which satisfies $\overline{P}_s^* = P_2(\overline{P}_s^*, s)$. [Twice differentiability of U and C imply--from the implicit function theorem--that z^* is a differentiable function of its arguments; thus, the continuous and composite mapping theorems (Marsden, p. 84 and p. 168) imply these properties of $z^{**}(P^*, s)$.]

[3]These effects can be verified by differentiating farmer and consumer expected utilities with respect to z, substituting from the equilibrium conditions, and inferring the implied signs from the assumptions made earlier. Though a very tight control can also hurt producers, this perverse case is of no interest since all agents would prefer relaxation of the control.

[4]By varying λ, the solutions to maximization of this social welfare function trace out the utility possibility frontier. Hence, for some λ, the solution to the maximization problem stated above will give the optimal choices according to the compensation criterion. Since λ is arbitrary, this approach is perfectly general.

[5]As shown in Newbery and Stiglitz, constrained efficiency is achieved in case 3. Hence, any change in z is socially costly.

[6]If no Brannan Plan is optimal, the relevant setting is that discussed in section V.

[7]One explanation for unobservable z is as follows: Suppose that, though the social planner knows the distribution of θ, she cannot observe its realization (ex post). In this case, the planner cannot discriminate between a case of high θ and a case of high z (or low θ and low z).

[8]Qualitatively, the case of $P^* < P_2$ (case 2) is a little different from case 1 with respect to implications for the welfare properties of land controls. Hence, to conserve space, it is omitted from the above discussion.

[9]Notably, a monotonic transformation of the consumer's indirect utility function will change nothing here.

[10]An apparent shortcoming of this example is the zero income elasticity constraint. However, if the supported sector is small relative to the overall economy (i.e., $T_1 + CS << Y$), this constraint does not compromise the generality of the results. In this case, equilibrium calculations will be unaffected by a positive income elasticity, as will farmer utility changes and surplus measures. Consumer surplus will be changed but can be shown to be increasing in η (so long as $\eta < 1$), thus strengthening qualitative implications of the analysis.

[11]For a detailed description of the bisection algorithm, see Innes.

[12]Myers has argued that the welfare gains from completing markets in agriculture are small, which contradicts the numerical results presented here. The reason for these divergent conclusions is as follows: In his analysis, Myers measures the welfare gain from moving to the complete market

(first-best) equilibrium which must be greater than any gain from second-best policies such as those examined here. However, in concluding that this gain is small, he divides the gain by an economywide measure of welfare. Hence, his conclusion is attributable to the small size of agriculture as a sector, rather than to small gains within the sector. If, instead, Myer's welfare gain were divided by a measure of sectoral welfare, his numerical results would indicate that large gains are possible, consistent with present findings.

References

Antle, J. "Econometric Estimation of Producers' Risk Attitudes." Amer. J. Agri. Econ. 69(1987):509-22.

Arrow, K. Essays in the Theory of Risk Bearing. Markham, Chicago, 1971.

Barry, P., ed. Risk Management in Agriculture. Ames: Iowa State University Press, 1984.

Binswanger, H. "Attitudes Toward Risk: Experimental Measurement in Rural India." Amer. J. Agri. Econ. 62(1980):395-407.

Blanciforti, L., R. Green, and G. King. U. S. Consumer Behavior Over the Postwar Period: An Almost Ideal Demand System Analysis. Giannini Foundation of Agricultural Economics, Monograph No. 40, University of California, Berkeley, 1986.

Borch, K. The Economics of Uncertainty. Princeton, New Jersey: Princeton University Press, 1968.

Cochrane, W. "Some Further Reflections on Supply Control." J. Farm Econ. (1959):697-717.

Commodity Futures Trading Commission (C.F.T.C.). "Agricultural Options Update." Agricultural Report 6, 1985.

Debreu, G. Theory of Value. New Haven, Connecticut: Yale University Press, 1986.

Gardner, B. "Redistribution Through Commodity Markets." Amer. J. Agri. Econ. 65(1983):225-34.

Grilliches, Z. "Research Costs and Social Returns: Hybrid Corn and Related Innovations." J. Polit. Econ. (1958):419-31.

Harberger, A. "Monopoly and Resource Allocation." Amer. Econ. Rev. (1954): 77-88.

Hicks, J. Value and Capital. 2nd ed. Oxford: Clarendon Press, 1946.

Hotelling, H. "The General Welfare in Relation to Problems of Taxation." Econometrica (1938):242-69.

Huang, K. U. S. Demand for Food: A Complete System of Price and Income Effects. Washington, D. C.: U. S. Department of Agriculture, ERS Tech. Bull. No. 1714, 1985.

Innes, R. "Government Target Price Intervention in Economics with Incomplete Markets: Welfare and Distribution." Working Paper, University of California, Davis, 1986.

Marsden, J. Elementary Classical Analysis. San Francisco: W. H. Freeman and Co., 1974.

Marshall, A. Principles of Economics. 8th ed. New York: Macmillan Co., 1948.

Myers, R. "The Value of Ideal Contingency Markets in Agriculture." Working Paper, Michigan State University, 1987.

Nelson, R. "Should Commercial Grain Farmers Use Futures Markets to Hedge Agricultural Price Risk." Ph.D. dissertation, University of California, Berkeley, 1981.

Newbery, D., and Stiglitz, J. "The Choice of Techniques and the Optimality of Market Equilibrium with Rational Expectations." J. Polit. Econ. 90 (1982):222-46.

Pratt, J. "Risk Averion in the Small and in the Large." Econometrica 32 (1964):1-20.

Rausser, G. C. "Political Economic Markets: PESTs and PERTs in Food and Agriculture." Amer. J. Agri. Econ. 64 (1982):821-33.

Runge, C., and Myers, R. "Shifting Foundations of Agricultural Marketing Policy Analysis: Welfare Economics When Risk Markets Are Incomplete." Amer. J. Agri. Econ. 67 (1985):1010-16.

Wallace, T. D. "Measures of Social Costs of Agricultural Programs." J. Farm Econ. 44 (1962):580-94.

Appendix A

Production Controls in a Policy Vacuum: Signing Equation (12)

To sign (12) when markets are incomplete, rewrite the first term as follows:

$$(A.1) \qquad z^c\, E\left[\frac{\theta^2}{x_p^d}(U' - \lambda V_Y)\right] = z^c\, E\left(\frac{\theta^2}{x_p^d}\right) E(U' \lambda V_Y) + z^c\, \mathrm{Cov}\left(\frac{\theta^2}{x^d}, U' - \lambda V_Y\right).$$

Consider the covariance first. The following derivatives will help sign this term:

$$(A.2) \qquad \frac{d}{d\sigma}\,\frac{\theta^2}{x_p^d} = \frac{\theta\theta'}{x_p^d \gamma}(2\gamma - q)$$

where $q \equiv -x_{pp}^d\, P/x_p^d$ and $\theta' \equiv d\theta/d\sigma \leq 0$,

$$(A.3) \qquad \frac{d}{d\sigma}(U' - \lambda V_Y) = U''\,\pi' - \lambda V_{Yp}\,\frac{z\theta'}{x_p^d}$$

where $\pi' \equiv d\pi/d\sigma = (zP/\gamma)\,\theta'(\gamma - 1)$. In general, each of these derivatives may not have a single sign in the whole range of states. However, for the three demand functions described in section V, (A.2) was a uniform sign:

1. Linear Demand: In this case, $q = 0$ and (A.2) is everywhere positive.
2. Constant Elasticity Demand: In this case, $q = \gamma + 1$ and (A.2) is everywhere positive (negative) as γ is greater than (less than) one.

3. $x^d = Y/(a + bP)$: In this case, $q = 2\lambda$ and (A.2) is everywhere zero.

Further, (A.3) will have a uniform positive (negative) sign when, in the relevant range (i.e., $\theta_b z^{**} < x < \theta_a z^{**}$), demand is price elastic (inelastic) and V_{Yp} is nonpositive (nonnegative).

These observations give conditions under which (A.2) and (A.3) will have uniformly the same (opposite) signs, implying that the covariance term in (A.1) will be positive (negative) or zero for demand case 3.

The first term in (A.1) will be positive (negative) as $E[U' - \lambda V_Y] <$ $(>)\ 0$, or, equivalently, $\lambda > (<)\ E(U')/E(V_Y)$. Clearly, from (13), the direction of the inequality depends on the covariances between $\alpha\eta/\gamma$ and, respectively, U' and V_Y. To sign these covariances, the following derivative expression is useful:

$$\frac{d}{d\sigma}\frac{\alpha\eta}{\gamma} = \frac{x_Y^d}{\gamma}(\nu + q - \gamma) \tag{4.A}$$

where $\nu = x_{Yp}^d \ P/x_Y^d$. Again, the three demand cases described above are convenient for evaluating the first term in (A.1):

1. Linear Demand: When demand is elastic in the relevant range and $V_{Yp} \leq 0$, U' varies positively with $(1 - \alpha\eta/\gamma)$ and V_Y varies negatively. Hence, $\lambda > E(U')/E(V_Y)$. Similarly, when demand is inelastic in the relevant range and $V_{Yp} \geq 0$, $\lambda < E(U')/E(V_Y)$.
2. Constant Price and Income Elasticity Demand: In this case, U' always varies positively with $(1 - \alpha\eta/\gamma)$ and V_Y varies negatively with either (a) $\gamma < 1$ and $V_{Yp} \geq 0$, or (b) $\gamma > 1$ and $V_{Yp} \leq 0$. Hence, $\gamma E(U')/E(V_Y)$ when either (a) or (b) holds.

3. $x^d = Y/(a + bP)$: In this case, $\alpha\eta/\gamma$ is constant and $\lambda = E(U')/E(V_Y)$.

The implications of this discussion are summarized in the following proposition and Proposition 2 in the text:

<u>Proposition A.1</u>

A. The following conditions, holding in the relevant range of x (i.e., $\theta_a z^{**} < x < \theta_b z^{**}$), with $x_Y^d \geq 0$, are sufficient for any production control to be welfare decreasing:

1. $\gamma \leq 1$ (or $U'' = 0$), $V_{Yp} \geq 0$, $q \geq 2\gamma$, $\nu + q \geq \gamma$, OR
2. $\gamma \geq 1$ (or $U'' = 0$), $V_{Yp} \leq 0$, $q \leq 2\gamma$, $\nu + q \leq \gamma$, where $\gamma = -x_p^d P/x^d$, $q = -x_{pp}^d P/x_p^d$, $\nu = x_{Yp}^d P/x_Y^d$.

B. The following conditions, holding in the relevant range of x, with $x_Y^d \geq 0$, are sufficient for some production control to be welfare increasing:

3. $\gamma \leq 1$ (or $U'' = 0$) and $V_{Yp} \geq 0$ (with one of these two inequalities strict if $U'' < 0$ and $V_{Yp} > 0$ if $U'' = 0$), $q \leq 2\gamma$ and $\nu + q \leq \gamma$ (with one of these two inequalities strict if $x_Y^d > 0$ and $q < 2\gamma$ if $x_Y^d = 0$), OR

4. $\gamma \geq 1$ (or $U'' = 0$) and $V_{Yp} \leq 0$ (with one of these inequalities strict if $U'' < 0$ and $V_{Yp} < 0$ if $U'' = 0$), $q \geq 2\gamma$ and $\nu + q \geq \gamma$ (with one of these two inequalities strict if $x_Y^d > 0$ and $q > 2\gamma$ if $x_Y^d = 0$).

Appendix B

Land Controls with a Brannan Plan: Some Algebra

Differentiating the equilibrium conditions gives:

(B.1)
$$\begin{bmatrix} \partial P_2/\partial s \\ \\ \partial P_2/\partial P^* \\ \\ \partial P_2/\partial L \end{bmatrix} = \begin{bmatrix} (\theta_2 z_3^* - x_{2Y}^d)/(x_2^d - \theta_2 z_2^*) \\ \\ \theta_2 z_1^*/(x_2^d - \theta_2 z_2^*) \\ \\ \theta_2 z_4^*/(x_2^d - \theta_2 z_2^*) \end{bmatrix}$$

$$z^* = z^*[\max(P^*, P_1), \max(P^*, P_2), s, L]$$

is the outcome of the farmer's maximization problem (with the first two arguments representing the received prices in the two states of nature) and z_i^* denotes the partial derivative with respect to the ith argument.

Using (B.1),

(B.2)
$$\begin{bmatrix} \partial z^{***}/\partial s \\ \\ \partial s^{**}/\partial P^* \\ \\ \partial z^{**}/\partial L \end{bmatrix} = \begin{bmatrix} (z_3^* x_2^d - x_{2Y}^d z_2^*)/x_2^d - \theta_2 z_2^*) \\ \\ z_1^* x_2^d/(x_2^d - \theta_2 z_2^*) \\ \\ z_4^* x_2^d/(x_2^d - \theta_2 z_2^*) \end{bmatrix} .$$

Expanding the z_i^* (by differentiating the farmer's F.O.C.),

$$\begin{bmatrix} z_2^* \\ z_2^* \\ z_3^* \\ z_4^* \end{bmatrix} = -Q \begin{bmatrix} U_1' \theta_1 + U_1''(P^* \theta_1 - c') \theta_1 z^{**} \\ U_2' \theta_2 + U_2''(P_2 \theta_2 - c') \theta_2 z^{**} \\ E\{\phi U'[\max(P^*, P) \theta - c']\} \\ [(c' z^{**}/L) - c] E\{\phi U'[\max(P^*, P) \theta - c']\} - (c'' z^{**}/L^2) E(U') \end{bmatrix}$$

(B.3)

where

$$Q = \left(\frac{c''}{L} E(U') - E\{U'' \cdot [\max(P^*, P) \theta - c']^2\} \right)^{-1} > 0$$

$$\phi = -U''/U' = \text{index of absolute risk aversion.}$$

Note that the term common to z_3^* and z_4^* can be rewritten (using the farmer's F.O.C.):

(B.4) $$E\{\phi U'[\max(P^*, P) \theta - c']\} = .5(\phi_1 - \phi_2) U_1'(P^* \theta_1 - c').$$

With decreasing absolute risk aversion, this expression will always be negative; when $P^* \theta_1 > \max(P^*, P_2) \theta_2$, $U_1'(P^* \theta_1 - c') > 0$ from the F.O.C. and $(\phi_1 - \phi_2) < 0$ due to higher profits in state 1; when $P^* \theta_1 < \max(P^*, P_2) \theta_2$, $U_1';(P^* \theta_1 - c') < 0$ and $(\phi_1 \text{ and } \phi_2) > 0$.

These expansions permit conversion of equation (22) to equation (23). From (20) and (21), $(U_2' - \lambda V_{2Y})$ can be rewritten:

(B.5) $$z^{**}(U_2' - \lambda V_{2Y}) = D\lambda V_{1Y}(P^* - P_1) \theta_1 \left[\frac{\partial z^{**}}{\partial P^*} + \theta_1 z^{**} \frac{\partial z^{**}}{\partial s} \right]$$

where

$$D = \left\{ \theta_2 \frac{\partial P_2}{\partial P^*} - \theta_1 \left[1 - \frac{\partial P_2}{\partial s} \theta_2 z^{**} \right] \right\}^{-1} .$$

Using (B.5), (B.1), and (B.2), (22) can be written:

$$\frac{\partial W}{\partial L} = .5 \left[(U_1' + U_2') C_L + \theta_1^2 D \frac{\partial z^{**}}{\partial L} \left(1 - \frac{\alpha_2 \eta_2}{\gamma_2} \right) \lambda V_{1Y} (P^* - P_1) \right]$$

which is equation (23). From (B.1) and (B.2), note that D and $(U_2' - \lambda V_{2Y})$ will be negative if (1) $z_1^* > 0$, (2) $z_3^* \geq 0$ (i.e., the farmer has nonincreasing absolute risk aversion), and (3) x_{2Y}^d is small. Further, since a small η_2 implies (3), A of equation (23) will be negative under the conditions stated in the text.

TABLE 1

Equilibria With No Government Intervention (CE), an Optimal Brannan Plan (BP), Production Controls (PC), an Optimal Brannan Plan/Production Control Mix (PCBP), and a Land Control/Brannan Plan Mix (LCBP)[a]

A) $\delta = 2$, $\gamma\varepsilon(.2, .5, .8)$, $q\varepsilon(.1, .2)$, and $\phi\pi^* = 1$

γ	q	EQU	P*	z^c / z^{**}_{LCBP}	z^{**}_{BP}	P_1	P_2	PS	CS	W
		CE	--	--	.85	1.35	3.69	0.0	0.0	0.0
		BP	1.70	--	.95	.79	2.15	-.0799	0.4206	0.3407
.2	.1	PC	--	.77	.85	2.29	6.24	.8716	-1.3484	-0.4768
		PCBP	2.28	.90	1.10	1.10	2.76	.4600	-0.1064	0.3536
		LCBP	1.86	.93	.95	.86	2.35	-.0134	0.2636	0.2502
		CE	--	--	.78	1.31	9.92	0.0	0.0	0.0
		BP	1.65	--	1.02	.35	2.67	-.1056	2.2491	2.1435
.2	.2	PC	--	.71	.78	2.21	16.80	.7693	-2.4606	-1.6913
		PCBP	2.42	.96	1.07	.49	3.73	.7475	1.4304	2.1779
		LCBP	1.81	1.00	1.03	.38	2.91	-.0280	2.0704	2.0424
		CE	--	--	.79	1.32	1.97	0.0	0.0	0.0
		BP	1.47	--	.81	1.23	1.84	.0320	-0.0208	0.0112
.5	.1	PC	--	.71	.79	1.63	2.43	.2578	-0.2838	-0.0260
		PCBP	1.58	.79	.83	1.30	1.94	.1164	-1.1034	0.0130
		LCBP	1.58	.79	.82	1.32	1.97	.0562	-0.1129	-0.0567
		CE	--	--	.78	1.13	2.55	0.0	0.0	0.0
		BP	1.38	--	.84	.96	2.16	.0579	-0.0081	0.0498
.5	.2	PC	--	.70	.78	1.39	3.14	.2519	-0.2958	-0.0439
		PCBP	1.60	.80	.87	1.07	2.40	.2370	-0.1809	0.0561
		LCBP	1.48	.81	.85	1.03	2.33	.0807	-0.1006	-0.0199
		CE	--	--	.73	1.30	1.67	0.0	0.0	0.0
		BP	1.34	--	.74	1.28	1.65	.0103	-0.0098	0.0005
.8	.1	PC	--	.66	.73	1.48	1.91	.1315	-0.1443	-0.0128
		PCBP	1.37	.73	.74	1.30	1.67	.0272	-0.0265	0.0007
		LCBP	1.42	.70	.75	1.36	1.75	.0158	-0.0726	-0.0568
		CE	--	--	.73	1.16	1.94	0.0	0.0	0.0
		BP	1.23	--	.75	1.14	1.89	.0194	-0.0171	0.0023
.8	.2	PC	--	.66	.73	1.33	2.21	.1316	-0.1450	-0.0134
		PCBP	1.29	.73	.75	1.16	1.93	.0562	-0.0534	0.0028
		LCBP	1.31	.71	.76	1.20	2.00	.0261	-0.0814	-0.0553

[a]Production controls were set at .9 of the competitive equilibrium 7. Land controls were at .9 of available land and the target price set at an associated social optimum; z^{**}_{BP} denotes the ex ante output with target price P* (which equals zero in the CE case) and no production or land control; and z^{**}_{LCBP} denotes the ex ante output choice with L = .9 and with target price P*.

Source: Computed.