Working Papers in
AGRICULTURAL ECONOMICS

December 90-17

Productive and Predatory Public Policies: Research Expenditures and Producer Subsidies in Agriculture

by
Harry de Gorter
David J. Nielson
and
Gordon C. Rausser

Department of Agricultural Economics
New York State College of Agriculture and Life Sciences
A Statutory College of the State University
Cornell University, Ithaca, New York, 14853-7801

Productive and Predatory Public Policies: Research Expenditures and Producer Subsidies in Agriculture

1. Introduction

Governments intervene in agricultural markets with a multiplicity of policies that can be classified as either 'productive' or 'predatory'. Predatory policies such as price supports are designed to redistribute income between groups in society. Publicly funded research is an important example of a productive policy in agriculture.[1] Productive policies are designed to improve allocative efficiency. The public choice literature has made a fundamental distinction between these two types of policies but has yet to develop an integrative framework. Mueller (p. 38) highlights the distinction between these two policy types:

> (O)ne can point to theories of the role of government that focus almost exclusively on either the allocative efficiency -- public good activities of government, or its redistributional activities.[2]

This tendency can be traced as far back as the writings of Wicksell who first argued for organizing government such that each type of policy would be decided upon in separate and qualitatively different processes. Magee, Brock and Young's recent treatise typifies modern political economy whereby government policies are viewed strictly as an outgrowth of predatory behavior.[3] This exemplifies the *political* market-failure view of government policy. Consistent with this approach are many studies that focus exclusively on the welfare costs of redistributive agricultural policies such as price supports and attendant trade barriers that are the dominant predatory policy mechanisms. A curiously separate branch of the literature focuses on the role of government in providing public goods such as research. This approach emphasizes that the role of government is to correct for *economic* market-failures (Ruttan 1982).

In response to these extreme views of either political or economic market failure,[4] Findlay notes that economists have failed to study the political economy of both productive and predatory policies. Interactions between these two types of policies and the non-separability between political and economic markets have, however been recognized by agricultural economists. For example, Heady (p. 405) hinted at the possible complementarity between commodity and technology policy in agriculture:

> "Society in the United States has conducted a dichotomous search for satisfactory policy to allow progress but to guarantee that the full cost of technical advance does not fall on agriculture".

Cochrane argued for price supports in order to compensate farmers for the adverse effects of technological change on farmer welfare. More recently, Rausser separates these types of policies under the rubric of PERTs and PESTs. More formal representations of this political economy of productive and predatory policies in agriculture are developed in Gardner (1989), Rausser and de Gorter, and Rausser and Foster.

Research expenditures improve allocative efficiency but also have important distributional effects (de Gorter and Zilberman). As a consequence, research expenditures will be linked to the same motivational forces that lead to government subsidies to farmers. Because subsidies generate deadweight losses, they also will be linked to research policy.[5] Indeed, the motivation for the two types of policies are intertwined.

A model of government behavior is developed in this paper that jointly determines expenditures on both production subsidies (the stylized commodity policy) and research. We do not try to identify optimal decision-making frameworks and we assume that the existing institutional and political structure is fixed.[6] In examining the factors which affect how these two types of policies are determined, an explanation for the observed underinvestment in agricultural research is also provided. In addition, we critically examine the notion that research expenditures are limited by their expansionary effect on the social costs of commodity policy (eg, Alston, Edwards and Freebairn). This notion is found to be misleading because it does not account for the manner by which governments make decisions on the two policies jointly. Assuming fixed political weights between producers and consumers, we determine the conditions under which research and subsidy policies are complementary. In such cases, commodity policy can compensate farmers for any losses generated by research. Thus, contrary to the received wisdom, underinvestment in agricultural research is less severe in the presence of commodity policies than it otherwise would be.

This paper is structured as follows. The theoretical model of governments choosing the optimal mix of production subsidy and research expenditures is developed in the next section. Section 3 gives a theoretical explanation for underinvestment in agricultural research and provides some empirical evidence. Section 4 determines the conditions under which production subsidies and research are used by governments as complementary policy instruments. It is shown that such an outcome is more likely to occur under conditions that characterize U.S. agriculture. Empirical evidence for this hypothesis in U.S. agriculture is provided in Section 5. Some concluding remarks are offered in the final section.

2. The Theoretical Model

Consider an agricultural market with government expenditures on both production subsidies and cost reducing research. The production subsidy represents a stylized measure that transfers income to farmers while research expenditures are viewed as pure public goods that improve allocative efficiency. The analysis to follow assumes competitive market conditions to otherwise prevail and uses a deterministic, static and partial equilibrium model.

Denote the production subsidy per unit output by r and the total level of research expenditures by E. Total expenditures on both policies are provided and financed by by the government with consumers as taxpayers paying for the entire budgetary costs. Each consumer and producer takes r, E and the market price p as given in determining their consumption and production choices.

Market Effects of Production and Research Expenditures

Suppose n identical consumers each choose a level of consumption by maximizing preferences represented by a concave and twice differentiable utility function which is additively separable in the agricultural good. Consumers act so as to solve the following maximization problem:

$$\max_{q_j^d} U_j = U_j(q_j^d) + \left[m_0 - pq_j^d - \frac{E}{n} - r\left(\frac{1}{n}\right)S(p+r)\right]\lambda \tag{1}$$

where

q_j^d = quantity demanded of the agricultural good,

m_0 = the endowment income of each consumer,

$U_j(q_j^d)$ = each consumer's utility as a function of the quantity of the commodity consumed,

λ = the marginal utility of income,

and all other variables are defined as before.

When n is large, the necessary condition which characterizes a utility maximizing level of consumption of the commodity for each consumer is described by $U_q(q_j^d) - \lambda p = 0$. This first-order condition can be inverted to yield the individual's Marshallian demand schedule, $q_j^d = q_j(p) = U_q^{-1}(p)$. The summation of the demands of individuals yields the industry demand schedule $D(p) = \sum_{j=1}^{n} q_j^d(p)$.

Assume that m identical producers each act so as to maximize profits (π_i):

$$\max_{q_i^s} \pi_i = (p+r)q_i^s - C_i(q_i^s, E) \tag{2}$$

where q_i^s represents the level of production for individual i and $C_i(q_i^s, E)$ represents the cost function of individual i. Profits are defined here to reflect the returns to owned assets such as land, capital and management. Accordingly, costs are defined to represent only the cost incurred in employing inputs which are purchased or rented as flow inputs. Given this specification of profits and costs, the necessary condition for profit maximization by each producer is $(p+r) - C_q(q_i^s, E) = 0$. This condition can be used to determine the individual's supply schedule as a function of $p+r$ and E:

$$q_i^s(p+r, E) .$$

Summation over the supply schedules of individuals yields the industry supply schedule, $S(p+r, E)$.

The market clears at the combination of quantity and price levels at which $D(p) = S(p+r, E)$. The market-clearing level of price is denoted as $p^* = p^*(r, E)$ and the market-clearing level of output is denoted as $Q^* = Q^*(r, E) = D^*(p^*) = S(p^*+r, E)$ where the superscript star denotes the market-clearing levels. Total differentiation of the necessary conditions for maximum levels of profit and utility reveal that, given identical consumers and identical producers,

$$(3) \qquad \frac{dQ^*}{dr} = \frac{\eta^d \eta^s Q^*}{(\eta^d - \eta^s)p^*} \geq 0$$

and

$$(4) \qquad \frac{dQ^*}{dE} = -\left(\frac{dQ^*}{dr}\right)C_{QE} = -\left(\frac{\eta^d \eta^s Q^*}{(\eta^d - \eta^s)p^*}\right)C_{QE} \geq 0$$

where

η^s = the price elasticity of supply,

η^d = the price elasticity of demand,

C = the aggregate cost function, and

C_{QE} = the derivative of aggregate marginal cost with respect to E.

Likewise,

(5) $$\frac{dp*}{dr} = -\left(\frac{\eta^s}{\eta^s - \eta^d}\right) \leq 0$$

(6) $$\frac{dp*}{dE} = -\left(\frac{dp*}{dr}\right)C_{QE} = \left(\frac{C_{QE}\eta^s}{\eta^s - \eta^d}\right) \leq 0$$

Expressions (3) through (6) reveal that both policy instruments have positive impacts upon the market-clearing level of quantity. Both r and E have negative impacts upon the market-clearing price level. The exact way in which the subsidy instrument affects output and price is dependent upon the elasticities of supply and demand with respect to price. The more elastic the supply and demand schedules, the greater the impact the subsidy has on output. The effect of a subsidy on the market-clearing price is greater the more elastic is the supply schedule. The effect of a subsidy on the market-clearing price is less the more elastic is the demand schedule. The impact of the research expenditure instrument upon market clearing prices and quantities is dependent upon the price elasticities of supply and demand schedules as well as upon C_{QE}. The magnitude of C_{QE} reflects the particular way in which the effects of research affect marginal costs.

The Government's Policy Decisions

The government's choice problem is to jointly choose the politically optimal level of r and E.[7] The arguments of the government's objective function are assumed to be the the politically weighted welfare of consumers and producers. We take the weights as given and are assumed to be invariant to changes in the level of welfare for each group.[8] Consider a governmental preference function of the general form $V(P^*,Y)$ where P^* is a vector of all prices and Y is aggregate social income. The specific form of the preference function is to be linear in the weighted sum of consumer welfare V_1 and producer welfare

V_2.[9] This maximization problem is represented by

(7)
$$\max_{r,\,E} V = w_1 V_1(p^*, M^*) + w_2 V_2(\pi^*)$$

where

w_1 and w_2 are preference weights assigned to consumers and producers, respectively

$M^* = n[m_0 - E/n - r(1/n)S^*]$

$\pi^* = (p^*+r)S^* - C$

$S^* = S^*(p^*+r, E)$

$p^* = p^*(r,E)$

$C = C(S^*,E)$

In order to solve its optimization problem, the government chooses the instruments, r and E, so as to satisfy the following necessary conditions for a maximum

(8)
$$w_1 V_p P_r + V_Y[w_1 M_r^* + w_2 \pi_r^*] = 0$$

and

(9)
$$w_1 V_p P_E + V_Y[w_1 M_E^* + w_2 \pi_E^*] = 0$$

where

$V_{1M^*} = V_{2\pi^*} = V_Y =$ the marginal utility of income,

$M_E^* = -r(S_p P_E + S_E) - 1 < 0,$

$M_r^* = -S - r[S_p(1+P_r)] < 0,$

$\pi_E^* = SP_E - C_E \gtrless 0,$

$\pi_r^* = S(1+P_r) \geq 0.$

Because $S_E = C_{QE}S_P$ and recall that $P_E = -C_{QE}P_r$, then M_E can be rewritten as $-rS_pC_{QE}(1-P_r)-1$ where $-1 \leq P_r \leq 0$. Hence, the maximum value of M_E is $-rS_E - 1$ and the minimum value is -1. Subsidies have no effect on producer profits if the demand curve is perfectly inelastic or the supply curve is perfectly elastic, i.e., $\pi_r = 0$ only when $P_r = -1$. These expressions emphasize that each policy affects each group differently with farmers always gaining from production subsidies but possibly losing from publicly funded research expenditures. Consumers lose as taxpayers but the loss due to research expenditures can easily be offset by the gains to consumers generated by price reductions resulting from the cost-reducing effects of research.

Utilizing the definitions of M^* and π^* from above and employing Roy's Identity to the indirect consumer welfare function $V_1(p^*,M^*)$, the necessary conditions are

$$(10a) \qquad -w_1\left[DP_r + S + r\frac{dS}{dp}(1+P_r)\right] + w_2[S(1+P_r)] = 0$$

and

$$(11a) \qquad -w_1\left[DP_E + 1 + r\frac{dS}{dE}\right] + w_2[SP_E - C_E] = 0.$$

Expressions (10a) and (11a) characterize the way in which the welfare of consumers and producers are balanced against each other in the government's choice of r and E. Expression (10a) indicates that, if the government objective function is to be maximized with respect to r, the level of the subsidy must be chosen such that the weighted marginal cost to consumers of increasing the subsidy, $w_1[DP_r + S + r(dS/dp)(1 + P_r)]$, is just equivalent to the weighted marginal benefit of the subsidy to producers, $w_2S(1 + P_r)$. Similarly, (11a) indicates that government should, in the interest of maximizing its objective function, choose E such that the weighted marginal cost to consumers of additional E (i.e., $w_1[DP_E + 1 + r(dS/dE)]$) is just equated with the weighted marginal benefit to producers, $w_2(SP_E - C_E)$.

Given that the market is assumed to clear in response to market forces at the level of output at which $S = D$, conditions (10a) and (11a) can be simplified and rearranged to read as follows:

$$(10b) \qquad r = \left(\frac{w_2}{w_1} - 1\right)\frac{p}{\eta_s}$$

and

$$(11b) \qquad -C_E = \left(\frac{w_1}{w_2}\right)\left[1 + r\,\frac{dS}{dE}\right] - \left(1 - \frac{w_1}{w_2}\right) QP_E$$

Expression (10b) can be interpreted to indicate that a government which acts so as to maximize the objective function $V(V_1,V_2)$ will offer the positively (negatively) valued per unit subsidy r to producers if it has assigned a larger (smaller) welfare weight to producers (w_2) than it has assigned to consumers (w_1). Further, the chosen level of subsidy r will have larger absolute value, the less elastic the supply schedule is with respect to the output price.

3. An Explanation for Underinvestment in Research

Expression (11b) is instructive in contributing another potential explanation for the phenomenon of underinvestment in agricultural research. If it is assumed that consumers and producers have equal political weights (i.e., as if $w_2/w_1 = 1$) and that the additional social costs of commodity policy due to research is ignored (i.e., implicitly $r(dS/dE) = 0$), then the optimal choice of E is given by the condition

$$(11c) \qquad -C_E = 1.$$

This is the benchmark condition used in the underinvestment literature to characterize an efficient allocation of resources to research.

However, research shifts the supply curve such that the social costs of the commodity programs increase (Ruttan 1982; Alston, Edwards, and Freebairn; Lichtenberg and Zilberman; Oehmke). If this effect is properly incorporated into the measurement of the social benefits associated with research expenditures, still ignoring for the moment any differential between w_2 and w_1, the resulting first-order condition characterizing the optimal choice of E becomes

(11d) $$-C_E = 1 + r(dS/dE).$$

Other costs not explicitly accounted for like the deadweight losses incurred in the imposition of the taxes necessary to generate government revenues would also appear as positively valued terms on the right side of expression (11d). This would have the effect of increasing the value of the right-hand side even further above the value of 1.

Expression (11d) describes a condition characterized by less investment in research than is prescribed by expression (11c). Analyses which have incorporated the positive effect of E upon the cost of existing subsidy programs will expect a lower level of E to be chosen than otherwise would be the case. In other words, studies that include the interaction of r and E will report less severe underinvestment in E than those studies which fail to incorporate this interaction. However, it is clear from conditions (10a) and (11a) that analyses based upon (11d) have still not fully captured the nature of the underlying causal mechanism.

An hypothesis of this paper implies that a correct interpretation of the available empirical evidence requires recognition of the implicit welfare weights and of the joint nature of the choice of r and E. As is evident from (10a and b), the government will only choose to provide subsidies to producers ($r > 0$) if producer welfare is weighted more heavily than consumer welfare ($w_2 > w_1$). Therefore, E being chosen according to (11a) implies that studies that do not incorporate the effects of E on the social cost of r and implicitly assume that w_2 equals w_1 will discover underinvestment in E that still appears to be unexplainable (even if all other factors like spill-in effects are meticulously incorporated).

It is useful to consider both potential cases of under or over investment in E in examining the implications of (11a). First, assuming $w_2 > w_1$, if the marginal impact of E

upon producer profits is negative at the chosen level of E and r, i.e., if $\pi_E = SP_E - C_E < 0$, then it must also be the case that:

$$-C_E > 1 + r(dS/dE).$$

This implies that the chosen and observed level of E will be below that which would be described as the appropriate level of investment by analyses performed under the assumption that $w_2 = w_1$ and which did not take into account the consequences for the chosen E of the joint determination of E and r. Simply stated, such analyses would describe the observed E as underinvestment.

Second, again assuming that $w_2 > w_1$, if the marginal impact of E upon producer profits is positive at the chosen combination of E and r, i.e., if $\pi_E = SP_E - C_E > 0$, it follows that

$$-C_E < 1 + r(dS/dE).$$

The implication is that the chosen and observed level of E will be above that which would be described as the appropriate level at investment by analyses which were performed under the assumption that $w_2 = w_1$ and which did not treat E and r as jointly chosen. The evidence would cause such analyses to describe the observed E as overinvestment.

The two cases outlined above suggest that empirical analyses of the returns to public investment in agriculture which have correctly measured all costs and benefits but which have been guided by an underlying framework which implicitly assumed that $w_1 = w_2$ would interpret the evidence to imply the existence of unexplained underinvestment (overinvestment) whenever $w_2 > w_1$ and $\pi_E < (>) 0$. Two factors, the implicit weights which reflect the way in which government values the relative welfare of producers and consumers and the direction in which producer profits respond at the margin to the results of research, combine to determine whether or not traditional studies will have come to a conclusion of underinvestment.

What Determines the Value of π_E?

The foregoing discussion places emphasis on the effects of E on producer welfare. From above, the sign of π_E is determined in accordance with SP_E - C_E. At the margin, producers' profits respond positively to increases in research expenditures if revenues fall by less than do total costs or if revenues actually rise (de Gorter and Zilberman). In the analysis developed here, the results of research are never allowed to increase costs for a given level of output. Therefore, if revenues to producers actually rise as a consequence of research results, profits to producers must rise. Substitution from above reveals the following expression for the determinants of marginal response of producer profits to changes in research expenditures:

$$(12) \qquad \pi_E \ \substack{\geq \\ <} \ 0 \qquad as \qquad \frac{d(C_E)}{dQ}\,\frac{Q}{C_E}\left(\frac{\eta^s}{\eta^s - \eta^d}\right) \ \substack{\leq \\ >} \ 1$$

Factors which work in the favor of farmers' profits at the margin include a large absolute value of the demand elasticity, an inelastic supply schedule, and a small absolute value of the elasticity of the marginal research effect on cost with respect to the level of output.

An approximate measure is derived for this latter elasticity of the marginal effect of research on cost with respect to output. This, together with information on supply and demand elasticities, will enable us to determine the sign of π_E for U.S. agriculture. The ratio of marginal to average cost (using the definition of cost above) is used as an approximation of the elasticity of the marginal effect of research on cost with respect to output. This approximation contains a bias, the direction of which is shown in Table 1. The resulting bias of such a measure errs on the conservative side; that is the constructed approximation is an underestimate of the true value of the elasticity of the marginal effect of research on cost with respect to output.[10] This is because the bulk of the literature considers agriculture to be a constant returns to scale industry. It is also commonly known that the share of inputs in total revenues of farmers declines with economic development, and therefore, presumably with technical advancement in agricultural production (Johnson).

Marginal costs are approximated by the average price received by farmers (inclusive of government program payments). Average cost is calculated as the sum of all costs other than those allocated as "return to owned inputs" in the cost of production estimates. Thus, using this methodology, the difference between marginal cost and average cost represents the per-unit return to owned inputs (land, capital, unpaid labor, and management) as calculated by the USDA. This constructed ratio of marginal cost to average cost is reported in Table 2 for several of the important commodities in U.S. agriculture for each of the years from 1972 through 1988. The imputed values for this elasticity are greater than one.

But before we can determine the sign of π_E, we also need estimates of the demand and supply elasticities making up the term in parenthesis in equation (12). Generally, demand elasticities for agricultural commodities are found to be inelastic while the opposite is the case for supply elasticities. A brief survey of long run elasticities are presented in Table 3.

We construct a matrix of possible values for the term in parenthesis in equation (12) above and these estimates are presented in Table 4. As in Table 2, all estimated values in Table 4 are also greater than one. The expected value for the product of the two terms in the right-hand side of equation (12) must therefore be greater than one. This implies that farmers' welfare is reduced at the margin from technical improvements induced by E. An empirical study by Braha and Tweeten also finds that farmers may lose from research depending on the relative values of market parameters. Our empirical findings in Tables 2 and 4 along with that of Braha and Tweeten give support to the hypothesis generated from our theoretical model in explaining underinvestment in E. The sign of π_E will be important in the analysis to follow.

Explaining Underinvestment in Agricultural Research in Developing Countries

There are two stylized facts about agriculture in developing countries that are characteristic of agriculture in industrial countries as well: a high productivity of research expenditures and of public good investments in general, and an underinvestment in agricultural research. However, farmers are in general taxed and consumers subsidized (Krueger, Valdes and Schiff). This implies that $\gamma < 1$ because from (10b), r is negative only if $w_1 > w_2$. Furthermore, the demand elasticity in developing countries is hypothesized to be much more elastic than in industrial countries because the Cournot aggregation constraint in consumer demand theory indicates that the absolute value of direct price elasticities of demand are directly related to the income elasticity of demand. This latter elasticity in developing countries are considered to be rather high. The value of supply elasticities in developing countries are also determined to be sharply different from those in industrial countries. Binswanger, Mundlak, Yang and Bowers find supply elasticities in developing countries to be extremely inelastic, ranging from 0.06 to 0.3. From equation (12), highly productive research expenditures with elastic supply and elastic demand implies farmers are more likely to benefit from research expenditures financed by consumers (i.e. π_E is more likely positive). This result coupled with the fact that $\gamma < 1$ has the first order condition (11b) indicating that underinvestment in agricultural research will result. Given these stylized facts on developing country agriculture, the results of our model are consistent with the observation of underinvestment in agricultural research in these countries.

4. When Are Subsidies and Research Expenditures Complements?

It is clear that the existence of a commodity subsidy increases one component of the social costs associated with investments in agricultural research. This has made it tempting to suggest that lowering subsidies to farmers will lead to an increase in research expenditures. According to this line of reasoning, this would happen because reducing subsidy levels would effectively increase the social return to research.

As obvious as this may seem, the analysis here suggests that such a conclusion might well be misleading. Traditional analysis fails to capture the full nature of the allocation problem facing the government. If one incorporates the fact that the factors which motivate and determine the extent to which governments engage in funding research also influence their choice of commodity policy, then an increase in production subsidies can *increase* research expenditures.

The information contained in the first-order conditions (11a) and (11c) can be employed to examine how the choice of E is conditional upon the prevailing level of r, given that r has been chosen to satisfy (10a). The exact response of E to changes in r is dependent upon the values of the parameters and the functional forms which describe the demand and supply sides of the industry. Total differentiation of expression (11a), after utilizing (10a) to substitute for the level of r, allows the slope of the choice of E as a function of r to be determined in the neighborhood of the optimally chosen pair (r,E). This slope is described by expression (13):

$$(13) \qquad \frac{dE}{dr} = \frac{\dfrac{dQ}{dE}\left\{(\gamma-1)\left[\dfrac{Q\dfrac{d^2S}{dpdE}}{S_p S_E}\right]-\gamma\dfrac{dQ}{dr}\right\}}{\dfrac{d^2V}{dE^2}}.$$

The sign of equation (13) is critically dependent on the sign and value of the term in square brackets, assuming $\gamma > 1$. This entire term in square brackets represents the 'elasticity of complementarity' between r and E.[11] Either a negative or zero value for this elasticity of complementarity is a sufficient condition for equation (13) to be positive; that is, for $dE(r)/dr > 0$ so that an increase in r will have governments increase E as well.

However, a sufficiently positive value of this elasticity of complementarity can result in the reaction function in (13) to be negative, provided it is greater than the term $\gamma dQ/dr$.

It is therefore instructive to evaluate the factors affecting the elasticity of complementarity. A positive value for this elasticity implies that higher levels of E increases the marginal effect of price on output and vice-versa; a higher price increases the value of dS/dE. Only when these influences are sufficiently large and positive will $dE(r)/dr$ in condition (13) be negative. Because Q, S_p and S_E are all positive, the sign of the elasticity of complementarity is critically dependent on $d^2S/dpdE$, which can be described by

$$\frac{d^2S}{dpdE} = S_{pp}\frac{dp}{dE} + S_{pE} \tag{14}$$

The term S_{pp} in equation (14) reflects the degree of concavity of the supply schedule with respect to output price. Indeed, the entire first term $S_{pp}dp/dE$ in (14) is more likely to be negative as π_E is negative. This is because the sign and values of S_{pp} and dp/dE are determined by the same factors that determine π_E. The implication is that $dE(r)/dr$ in (13) is more likely to be positive under conditions that are thought to characterize agriculture in the United States, that is, conditions contributing to a negative value for π_E.

The second term S_{pE} in (14) reflects the particular form of the response of the supply schedule to research induced technical change. A pivot-like shift in the supply schedule, reflecting a large impact of the technical improvement upon variable costs relative to the impact upon fixed costs of production, can result in S_{pE} to be sufficiently positive to result in dE/dr to be negative. Although a negative or zero value for (14) is a sufficient condition for (13) to be positive, a positive value for (14) does not necessarily result in (13) to be negative. Only a strong combination of the two terms in (14) can result in research expenditures to decrease in response to the introduction of production subsidies. Otherwise, research and production subsidy expenditures are complementary policy instruments.[12]

It should be noted that several commonly adopted functional forms yield this latter outcome of observed complementarity between the two instruments. For example, a linear supply function combined with technical change that shifts the supply curve in a parallel fashion ensure (14) to be zero such that r and E are complementary instruments. These examples are of particular interest because they represent the cases which have been most frequently analyzed in previous studies (Alston, Edwards, and Freebairn).

As indicated above, under the conditions in which the two policies behave as complements, the opportunity to choose r and E jointly allows a larger E to be chosen than otherwise would have been chosen. Under these circumstances, losses to producers which may be incurred as a result of research results can be offset through the use of the income redistributing subsidy instrument r. This leads to the suggestion that commodity policies which subsidize producers may not be as costly to society as has generally been thought. In providing a way for the government to compensate producers for the losses which they suffer as a result of research policies, commodity policy allows the government to invest more heavily in agricultural research endeavors than it otherwise would. For this reason, it is possible that, when government (and/or society) values producer welfare more highly than consumer welfare, the use of subsidies in this way may actually be Pareto improving.

A Graphical Explanation

An example of when governments can compensate farmers through subsidies for the losses resulting from public research expenditures is illustrated in Figure 1. At the origin, neither policy instrument is employed, i.e. both r and E equal zero. The transformation frontier $T_0(E{:}r=0)$ describes the change in welfare for producers and consumers as the level of research is increased in the absence of a production subsidy. This particular curve depicted in Figure 1 lies everywhere in the South-East quadrant. This depicts the case in which π_E is everywhere negative.[13] If consumers and producers have equivalent political weights, then an equilibrium at point A would occur. This would represent a socially optimal level of research expenditures when no production subsidies exist. If producers are favored politically and governments are not allowed to use production subsidies, then the outcome would be at point B and an underinvestment in research results.

The introduction of production subsidies results in the transformation frontier $T_1(E{:}r>0)$. This new transformation frontier is derived from $T_0(E{:}r=0)$ and its origin (point X in Figure 1) lies somewhere below the 45 degree line in the North-West quadrant. The curve originates from such a point because producer welfare increases with the subsidy by less than the decrease in consumer welfare as a result of the deadweight losses generated by the subsidies. However, the existence of production subsidies can result in a lower social benefit of research expenditures. This interaction effect between subsidies and research has the additional effect of changing the shape of the transformation frontier such that the shape of $T_1(E{:}r>0)$ will become more bowed inward (pivot left or be everywhere to the left of $T_0(E{:}r=0)$ if the frontiers had shared the same origin).

With both policy instruments available, policymakers are able to achieve a point such as C. The transformation frontier $T_1(E{:}r>0)$ is constructed such that point C is Pareto-preferred to point B. Given unequal welfare weights, point C is preferred to both point A and point B. Due to deadweight losses generated by production subsidies, point A continues to represent a potential Pareto improvement from the outcome at point C. Because farmers lose from research expenditures in this scenario, and farmers have a larger political weight, the final equilibrium represents a case of underinvestment in research. That it is possible for consumers welfare at point C to be higher than at equilibrium B demonstrates that it is possible for both producers and consumers to benefit when the government chooses the two instruments as complements. Thus, Figure 1 illustrates the major normative and positive conclusions of our model; subsidies can be Pareto dominant compared to the no subsidies, and an explanation for the underinvestment in agricultural research is provided.

5. Some Evidence for U.S. Agricultural Policy

The extent to which governments intervene in commodity markets can be approximated by producer subsidy equivalents (PSEs) calculated by the U. S. Department of Agriculture. These data for several commodity sectors in the United States are reported in column (1) of Table 5. The commodities are separated into three groups according to their elasticities of demand. Sugar, milk, rice, and wheat are categorized as being very inelastic in demand, compared to the other commodities reported in Table 5. The feedgrains, on the other hand, are regarded as modestly inelastic while soybeans and the red meat sectors are viewed as least inelastic among agricultural commodities.

In terms of percent unit value, the inelastic demand sectors of sugar, milk, rice, and wheat have by far the highest level of support, well above that of the other sectors. The feedgrains have an intermediate level of support as shown in Table 5 while the sectors with less demand curves, such as soybeans and the red meats, have the lowest level of support.

The breakdown of support between productive and predatory policies are given in Table 5 by the corresponding "subsidy equivalents" in columns 2 and 3, respectively. The definitions of each are given in the footnote of Table 5. Productive subsidy equivalents represent cost reducing public goods for the most part and include both federal and state government expenditures. Hence, these figures are a broad approximate measure of cost reducing expenditures in agriculture. The data in Table 5 show that the level of productive and predatory subsidy equivalents are inversely related. Furthermore, the level of productive policy interventions are higher than those of predatory policies for the crops least inelastic in demand but are much lower for the most inelastic crops in demand. Notice that the productive subsidy equivalents, as a percent unit value of production, are stable across all commodity sectors at around five per cent. On the other hand, predatory subsidy equivalents are very high as a percent unit value of production for the most inelastic sectors and fall well below that of PSEs for the least inelastic sectors.

Column 4 depicts the ratio of productive to predatory subsidy equivalents in terms of percent. The data indicate that, as a percent of productive subsidy equivalents, predatory subsidy equivalents are lower in the inelastic demand sectors while the elastic sectors have the highest ratio of productive subsidy equivalents.

As shown in the previous section, the relative producer gains to research increase as the elasticity of demand is increasing (in absolute value), the elasticity of supply is decreasing, and the output elasticity of the marginal impact of research on cost is decreasing. To obtain a crude estimate of the latter, one can use productivity levels as positively related to the marginal effect of research expenditures on output. Barkema, Drabenstott and Tweeten report productivity improvements in milk and field crops, sectors with inelastic demands, to be double that of the livestock sector. The data in table 5 partially confirms these observations. Studies have reported supply elasticities greater than one for wheat and milk (Burt and Worthington; Chavas and Klemme). Hence, one can conclude that the demand elasticities are low and relatively higher supply elasticities exist in agriculture. It is confirmed in Table 5 that these same sectors have relatively (and in absolute terms) higher levels of predatory subsidy equivalents and lower levels of productive subsidy equivalents. Three studies (Ruttan 1983; Judd, Boyce, and Evenson; Furtan) indicate that the allocation of research among commodity groupings is inconsistent with economic efficiency with field crops underfunded relative to livestock. This evidence, combined with that in Table 5, partially confirms the predictions of the model. Furthermore, our theory indicates that, in certain cases, eliminating predatory policies in the inelastic demand/elastic supply sectors would result in a more pronounced degree of underinvestment in productive policies.

6. Concluding Remarks

In this paper, we have provided a framework for explaining why so many studies have concluded that agricultural research is the victim of chronic underinvestment. We have also determined the conditions under which commodity policy and research expenditures are chosen by governments as complementary policy instruments. The implication is that production subsidies in situations thought to characterize U.S. agriculture may not be as detrimental to social welfare as has commonly been argued. Rather, by providing a vehicle through which to compensate producers for losses incurred as a result of research expenditures, production subsidies may be necessary components of potentially Pareto-improving portfolios of policy instruments. This can occur despite the presence of deadweight losses which accompany production subsidies. This paper shows that if the two policies are jointly determined and that the interaction effects are incorporated, then society can be better off with 'overinvestment' in production subsidies yet have less severe 'underinvestment' in research.

Consistent with the model results, data indicates that governments will intervene in sectors with a more inelastic demand, a more elastic supply and a highly productive effect of research in reducing costs. These same sectors are expected to have a greater level of underinvestment in research. We also hypothesize that the major results of the model developed in this paper are potentially relevant in explaining underinvestment in research in developing country agriculture as well.

Table 3. Estimates of Own-Price Elasticities for Demand and Supply of Agricultural Commodities Reported in the Literature

Reported by	Category	Time Period	Estimate
Elasticities of demand, η^d			
L.G. Tweeten. "The Demand for U.S. Farm Output." *Food Res. Inst. Studies* Vol. 7 (1967)pp. 343-369.	Long-run aggregate demand for	(1948-1965)	
	food at farm level:		
	domestic		-0.1
	total		-1.11
	food & feed		
	domestic		-0.076
	export		-0.841
G.E. Brandow. "Interrelations Among Demands for Farm Products and Implications for Control of Market Supply Bulletin # 680 Pennsylvania Agricultural Experiment Station, Penn State University University Park, PA, August, 1961	Farm level demand for:	(1955-1957)	
	corn		-0.03
	wheat		-0.02
	barley		-0.07
	beef		-0.68
	pork		-0.46
	chicken		-0.74
	turkey		-0.92
	milk and cream		-0.14
	sugar		-0.18
	lamb		-1.78
T.W. Hertel, V.E. Ball, K.S. Huang, and M.E. Tsigas. "Farm Level Demand Elasticities for Agricultural Commodities." Research Bulletin #988, Agricultural Experiment Station, Purdue University, West Lafayette, Indiana, 1989.	Long-run farm level demand for:	1977	
	dairy		-0.513
	poultry		-0.205
	red meats		-0.407
	cotton		-0.997
	food grains		-0.956
	feed grains		-1.021
	sugar crops		-0.044
	oil seeds		-0.793
	aggregate		-0.53

Table 3 continued.

Reported by	Category	Time Period	Estimate
M.K. Wohlgenant. "Demand for Farm Output in a Complete System of of Demand Functions." *American Journal of Agricultural Economics* Vol. 1, No. 2 (May, 1989), pp. 241-252.	Farm-level demand for	1956-1983	
	beef and veal		-0.76
	pork		-0.51
	poultry		-0.42
	eggs		-0.15
	dairy -0.61		
	vegetable		-0.43
Elasticities of supply, η^s			
L. G. Tweeten. *Foundations of Farm Policy*. Lincoln, University of Nebraska Press, 1979.	Long-run farm level supply of	1926-1959	
	crops		1.56
	livestock		2.90
	total aggregate supply		1.79
D. G. Johnson. *World Agriculture in Disarray*. London: Macmillan St. Martin's Press, 1973.	Long-run farm output	1952-1961	2.96
T. W. Hertel. "Technology and Factor Mobility," *American Journal of Agricultural Economics*, 71(1989): 559-573.	Long-run farm output	1977	3.31
V.E. Ball. "Output, Input, and Productivity Measurement in U.S. Agriculture, 1948-79." *American Journal of Agricultural Economics*, Vol 67 (1985), pp. 475-86.	Long-run farm output	1948-1979	3.6

Table 4. Matrix of Sample Calculated Values [$(\eta^s - \eta^d)/\eta s$ calculated at sample values]

	η^s						
η^d	0.5	1.0	1.5	2.0	2.5	3.0	3.5
-0.10	1.20	1.10	1.07	1.05	1.04	1.03	1.03
-0.25	1.50	1.25	1.17	1.13	1.10	1.08	1.07
-0.50	2.00	1.50	1.33	1.25	1.20	1.17	1.14
-0.75	2.50	1.75	1.50	1.38	1.30	1.25	1.21
-1.00	3.00	2.00	1.67	1.50	1.40	1.33	1.29

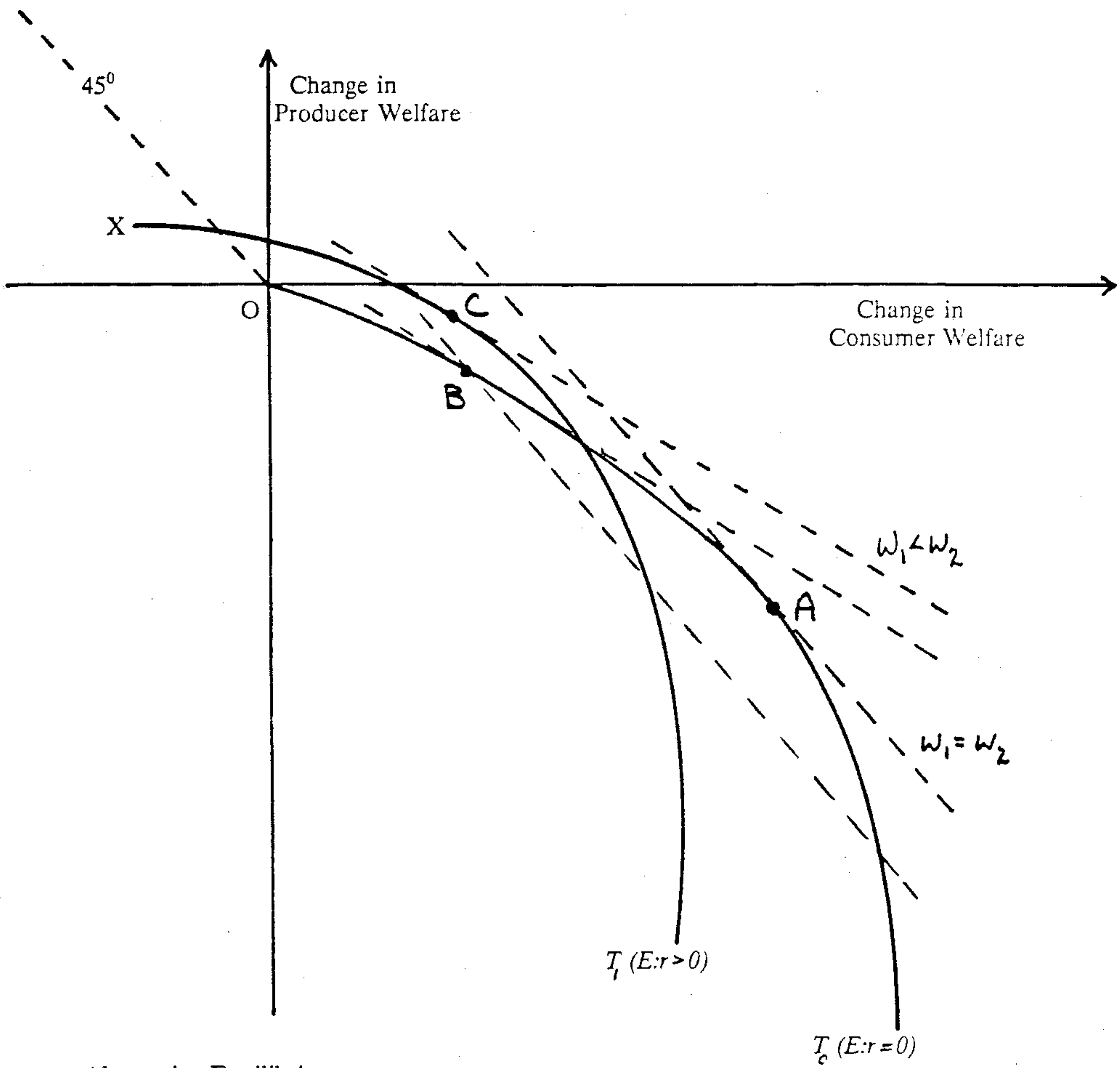
NOTE: η^s = own-price elasticity of supply
η^d = own-price elasticity of demand

Table 5: Productive versus Predatory Subsidy Equivalents in U.S. Agriculture (1982-1986 average)

	(1) Total Subsidy		(2) Productive Subsidy		(3) Predatory Subsidy		(4) Ratio of Productive to Predatory Subsidies(%)
	Percent unit value	Dollars per ton	Dollars per ton	Percent unit value	Dollars per ton	Percent unit value	
Sugar	77.4	221.0	17.5	6.1	203.5	71.3	8.6
Milk	53.9	152.0	11.8	4.2	140.2	49.7	8.4
Rice	45.0	145.0	9.4	2.9	135.6	42.1	6.9
Wheat	36.5	57.0	7.7	4.9	49.3	31.6	15.7
Sorghum	31.5	36.4	5.3	4.6	31.1	26.9	17.0
Barley	28.8	32.0	6.7	6.0	25.3	22.8	26.5
Corn	27.1	31.5	5.6	4.8	25.9	22.3	21.6
Oats	7.6	7.3	4.5	4.7	2.8	2.9	160.7
Soybeans	8.5	18.0	13.4	6.3	4.6	2.2	291.3
Beef	8.7	175.8	97.7	4.8	44.5	3.9	125.0
Poultry	8.3	82.0	53.3	5.4	28.7	2.9	285.7
Pork	5.8	85.4	67.6	4.8	17.8	1.0	380.0

Source: U. S. Department of Agriculture (USDA), "Estimates of Producer and Consumer Equivalents: Government Intervention in Agriculture", (April, 1988), ERS, ATAD Staff Report No. AGES 880127, 1988.

'Productive subsidy equivalents' are defined to be the costs associated with inspection, land improvements, research and extension, information and marketing services, transportation facilities, pest and disease control, FmHA, crop insurance, emergency feed, farm storage facility and disaster payments. All other programs as listed in USDA (1988, pp. 141-147) are defined as 'predatory subsidy equivalents'.



Alternative Equilibria:

pt A if $\gamma = 1$, $r = 0$
pt B if $\gamma > 1$, $r = 0$
pt C if $\gamma > 1$, $r > 0$
(C potentially Pareto-superior to B for $\gamma \geq 1$)

FIGURE 1. Political Equilibrium with Research and Production Subsidy Expenditures

Footnotes

1. There are many other important examples of productive policies in agriculture including extension, irrigation, rural electrification and transportation facilities (Stiglitz).

2. Mueller (p. 38) states further "although allocative efficiency and redistributional issues are inevitably intertwined, it is useful analytically to keep them separate, and we shall endeavor to do so wherever possible." Although the public choice literature has made a distinction between the two types of policies, it has intentionally advocated considering them in isolation from each other.

3. Magee, Brock and Young claim (p. xv) that the intellectual foundation of their analysis is founded upon the view expressed in the following quotation: "When you have an economy, you have goods and services. When you have politics, you have laws and statesmen. However, when you put the two together, you ain't got nothin." This extreme view of public policy as being strictly predatory or parasitic ignores government's role and desire to provide productive policies as well.

4. Wittman argues that each are equally likely to occur.

5. A predatory policy can generate a positive by-product effect on economic efficiency. For example, a price support can reduce uncertainty and therefore improve social welfare. Interactions of this type, however, are not pursued in this paper.

6. There is a large literature on determining the optimal properties of institutions and processes to determine the two types of policies (Mueller, chapter 24). We take the political structure as given in this paper and then isolate the factors affecting government decisions on these two policy types.

7. This formulation treats different levels and branches of government as one decision-making unit. In reality, for example, different sub-committees in Congress make decisions on commodity and research policy. Likewise, state government research expenditures above the required federal government match represent approximately 27 per cent of total research expenditures. Our model does not capture the interaction between differing levels and branches of government. The government's criterion function described later reflects the outcome of a collective decision-making process. One could view the process underlying our model specification as a two-stage, iterative decision process. The federal government takes state research expenditures as given and then makes its optimal decision on research and commodity policy. And the state government would do the same; it takes the research expenditure and commodity policy decisions of the federal government as given and determines its optimal research expenditures. The federal government would then revise their policy settings and so would the state governments, resulting in an iterative process that in the long run determines the observed outcome. This would not detract in any way from our hypothesis that research expenditures and commodity policy are jointly determined nor is there reason to believe that disaggregation of the decision processes would refute the results of our paper.

8. These weights reflect the relative political concern governments put on the welfare of farmers and consumers. The underlying assumption is that politicians maximize political support and that political support from each group is some function of their economic welfare. This results in implicit weights on producer and consumer welfare along the lines determined in Rausser and Freebairn and assumed throughout Gardner's (1987b) influential text. We do not analyze why governments give differential weights on producer and consumer welfare; it may be due to either pressure activities by interest groups (eg, Becker, Gardner, 1987a) or to the interaction of politicians and voters (eg, Downs) or a combination of factors. Rausser and Foster for example show that the weights are indicative of an efficient outcome of actions taken by each interest group. The purpose of this paper is only to analyze the joint determination of commodity and research policy, given the 'revealed preference' of governments.

9. Cornes and Sandler and Khanna, Huffman and Sandler specify the arguments of the government's objective function to contain the level of the policy instruments themselves rather than economic welfare which in turn is affected by the instruments. The latter specification is the approach taken here so that the effects of both policies on both the level and distribution of income is taken into account. Khanna, Huffman and Sandler "ignore distributional issues" while in this paper both research decisions and income distribution are endogenous.

10. To determine the bias resulting from this approximator, differentiate $C_Q Q/C$ with respect to E and solve for $C_{QE}Q/C_E - C_Q Q/C = (C/C_E)[d(C_Q Q/C)/dE - Q_E d(C_Q Q/C)/dQ]$. Note that returns to scale are increasing (decreasing) as $d(C_Q Q/C)/dQ > (<) 0$. The share of revenue which accrues to owned inputs rises (falls) with E as $d(C_Q Q/C)/dE < (>) 0$. The conditions under which $C_Q Q/C$ is an under-estimate or an over-estimate of $C_{QE}Q/C_E$ are summarized in Table 1.

11. This definition is analogous to the elasticity of complementarity for two inputs in a production function described by Layard and Walters (p. 272).

12. The results surrounding the discussion of equation (13) are invariant to the particular form of commodity policy. That is, exactly the same factors in (14) also determine the sign of (13) for a fixed price support with a government support purchases, or a target price with deficiency payments. Hence, there is no loss of generality in our results by using a production subsidy as the stylized commodity policy instrument.

13. There are three other possible general forms of the transformation frontier (not shown in Figure 1): concave in the North-East quadrant, and backward bending in either the North-East or North-West quadrants. For an analysis of both possibilities in the North-East quadrants, see de Gorter and Zilberman; for all four possibilities with either consumers or producers paying for research, see de Gorter. Note that in this paper, we assume that consumers as taxpayers exclusively finance research.

References

Alston, J., G. Edwards, and J. Freebairn. "Market Distortions and Benefits from Research," *Amer. J. Agr. Econ.* 70(1988):281-288.

Bardhan, P. "Symposium on the State and Economic Development" *J. of Econ. Perspectives* 4(1990):3-8.

Becker, G.S. "A Theory of Competition Among Pressure Groups for Political Influence," *Quar. J. Econ.* 98(1983):371-400.

Binswanger, H., Y. Mundlak, M. Yang and A. Bowers, "Estimation of Aggregate Agricultural Supply Response", Mimeo, Agriculture and Rural Development Department, World Bank, Washington, August 1985.

Braha, H., and L. Tweeten. "Evaluating Past and Prospective Future Payoffs from Public Investments to Increase Agricultural Productivity". Technical Bulletin T-163, Agricultural Experiment Station, Oklahoma State University, September 1986.

Burt, O.R., and V. E. Worthington. "Wheat Acreage Supply Response in the United States," *West. J. of Agric. Econ.* 13(1988):100-11.

Chavas, J.P., and R. M. Klemme. "Aggregate Milk Supply Response and Investment Behavior on U. S. Dairy Farms," *Amer. J. Agr. Econ.* 68(1986):55-66.

Cochrane, W.W. *Farm Prices, Myth and Reality*. Minneapolis: University of Minnesota, 1958.

Cornes, R., and T. Sandler. "Easy Riders, Joint Production and Public Goods", *Econ. J.* 94(1984):580-598.

de Gorter, H. "Agricultural Policies: A Study in Political Economy". Ph.D. Dissertation, University of California, Berkeley, 1983.

de Gorter, H., and D. Zilberman. "On the Political Economy of Public Good Inputs in Agriculture," *Amer. J. Agr. Econ.* 72(1990):131-7.

Downs, A. *An Economic Theory of Democracy*. New York: Harper and Row, 1957.

Findlay, R. "The New Political Economy" Working Paper, Department of Economics, Columbia University, July 1987.

Fox, G. "Optimal Public Investment in U.S. Agricultural Research. A Study of the Management of Technical Change", Ph.D. Dissertation, University of Minnesota, 1985.

Furtan, W.H. "Economics of Crop and Oilseed Research in Canada." Paper presented to the Outlook Conference, Ottawa, Canada, December, 1983.

Gardner, B.L. "Causes of U.S. Commodity Program". *J. Polit. Econ.*, 95(1987a):290-310.

_________. *The Economics of Agricultural Policies*. New York: Macmillan Publishing Co., 1987b.

_________. "Price Supports and Optimal Spending on Agricultural Research." Working Paper, Department of Agricultural and Resource Economics, University of Maryland, April, 1989.

Heady, E.O. *Agricultural Policy Under Economic Development*. Ames, Iowa: Iowa State University Press, 1962.

Hertel, T.W. "Technology and Factor Mobility," *Amer. J. Agric. Econ.* 71(1989):559-73.

Johnson, D.G. *World Agriculture in Disarray*. London: Macmillan, St. Martin's Press, 1973.

Judd, M.A., J.K. Boyce, and R.E. Evenson. "Investing in Agricultural Supply." Discussion Paper No. 442, Economic Growth Center, Yale University.

Khanna, J., W. Huffman, and T. Sandler. "State Government Decisions on Goods Having Joint Public-Private Characteristics: An Econometric Examination of Agricultural Research". Journal Paper, Iowa Agriculture and Home Economics Exp. St., June 1990.

Krueger, A., M. Schiff and A. Valdes. "Agricultural Incentives in Developing Countries: Measuring the Effect of Sectoral and Economywide Policies", World Bank Review 2(1988):255-72.

Layard, P.R.G., and A.A. Walters. *Microeconomic Theory*, New York: McGraw Hill Book Co., 1978.

Lichtenberg, E., and D. Zilberman. "The Welfare Economics of Price Supports in U.S. Agriculture." *Amer. Econ. Rev.* 76(1986):1135-41.

Magee, S.P., W.A. Brock, and L. Young. *Black Hole Tariffs and Endogenous Policy Theory*. Cambridge: Cambridge University Press, 1989.

Mueller, D.C. *Public Choice II*. New York: Cambridge University Press, 1989.

Oehmke, J.F. "The Calculation of Returns to Research in Distorted Markets." *Agr. Econ.* 2(1988):291-302.

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

Rausser, G.C., and H. de Gorter. "Endogenizing Policy in Models of Agricultural Markets," *Agriculture and Governments in an Interdependent World*, ed. A. Maunder. Aldershot:

Gower (1990).

Rausser, G.C., and W. E. Foster. "Political Preference Functions and Public Policy Reform," *Amer. J. Agr. Econ.* (1990).

Rausser, G.C., and J.W. Freebairn. "Estimation of Policy Preference Functions: An Application to U. S. Beef Import Policy," *Rev. Econ. and Stat.*, 56(1974):437-49.

Ruttan, V.W. *Agricultural Research Policy*. Minneapolis: University of Minnesota Press, 1982.

_________. "Agricultural Research Policy Issues." *Hort. Science*, 108(1983):809-18.

Stiglitz, J.E. "Some Theoretical Aspects of Agricultural Policies". *Research Observer*, 2(1987):43-60.

Wicksell, K. "A New Principle of Just Taxation," in *Finanztheoretische Untersuchungen*, Jena, 1896, reprinted in *Classics in the Theory of Public Finance*, (ed.) Musgrave and Peacock, New York: St. Martin's Press, 1967.

U.S. Department of Agriculture. "Estimates of Producer and Consumer Equivalents: Government Intervention in Agriculture," Economic Research Service, ATAD Staff Report No. AGES 880127, April, 1988.

Wittman, D. "Why Democracies Produce Efficient Results". *Journal of Political Economy*, 97(1989):1395-1424.

Other Agricultural Economics Working Papers

No. 90-5	Measuring Total Factor Productivity, Technical Change and The Rate of Return, to Research and Development	Edward Kokkelenberg
No. 90-6	Clean Power Supply Through Cogeneration	Gary Dorris
No. 90-7	Mozambique in the 1980's: Economic Reform and Armed Conflict	Steven C. Kyle
No. 90-8	National Factor Markets and the Macroeconomic Context for Environmental Destruction in the Brazilian Amazon	Steven C. Kyle Aercio S. Cunha
No. 90-9	Pitfalls in the Measurement of Real Exchange Rate Effects on Agriculture	Steven C. Kyle
No. 90-10	Policy Analysis in an Imperfectly Competitive Market: A Conjectural Variations Model for the Food Manufacturing Industry	Leo Maier
No. 90-11	Control in a Dynamic Economy: Modeling the Behavior of the Chinese Village Leader	Scott Rozelle Richard N. Boisvert
No. 90-12	Demographic and Income Distribution Factors in Demand Systems for Food	Deborah Peterson Timothy Mount
No. 90-13	Welfare Impacts of Generic Certificates on U.S. Corn Producers	Douglas J. Miller Jason A. Karszes
No. 90-14	A Bioeconomic Model of the Pacific Whiting	Jon M. Conrad
No. 90-15	Optimal Depletion of Non-Renewable Resources under Linear Homogeneous Stock-Dependent Cost	Robert W. Jefferson
No. 90-16	The Economics of a Stock Pollutant: Aldicarb on Long Island	Jon M. Conrad Lars J. Olson