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COMMODITY POLICY AND UNDERINVESTMENT IN AGRICULTURAL RESEARCH

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Abstract

This paper examines the joint determination of public policies which provide agricultural research and those which provide subsidies to farmers. The paper suggests that the puzzlingly consistent finding of "underinvestment" in agricultural research may be related to the inseparability of these two types of policies in the policy choice problem.

COMMODITY POLICY AND UNDERINVESTMENT IN PUBLIC AGRICULTURAL RESEARCH

When the interests and the resources of the constituents differ, policies whose aims are redistributive frequently emerge. Redistributive policies arise in some cases as a result of competitive rent-seeking among the various interest groups. In other cases, redistributive policy initiatives are generated in response to altruistic or ideological motivations. Magee, Brock, and Young (1989) have recently characterized the processes which determine the level of such policies as processes whose inner logic guides societies into political equilibrium, and in so doing can be thought of as establishing a state of "political efficiency". Although policies of market intervention which are motivated by redistributive goals are not economically efficient, they exist because they are politically efficient.

A second broad class of governmental policy is designed to improve allocative efficiency through collective action. Such policies become necessary as collective responses to situations in which competitive market forces do not result in Pareto optimal outcomes. These policies exist, it is somewhat more familiarly argued, because they are economically efficient.

Wicksell (1896) was early to recognize the distinction between these two types of policies and argued the necessity of organizing government so that the provision of the two types of policies would be decided upon in separate and qualitatively different processes. Mueller (1989), in his recent survey of the public choice literature, also indicates the conceptual and practical advantages of considering the two types of policies separately. Some authors have attempted to discover the desired properties of systems which would jointly determine the two types of policies. However, the outcomes of such systems are not generally characterized by unique or stable equilibria. They leave room for both indeterminacy and undesirable manipulation by those who manage initially to gain power. For this reason, in attempting to design democratic decision-making frameworks which will ensure Pareto optimal outcomes, the best the literature has been able to offer requires separate decision-making institutions and processes for each of the two types of policies.

However, it is frequently the case that public policies whose intended purpose is to establish allocative efficiency will also have distributional consequences (see de Gorter and Zilberman (1989)). Similarly, policies designed to be redistributive, in as far as they alter incentives and market behavior, will potentially impact upon the outcome of policies which are designed to establish allocative efficiency. When such interactions obtain, the socially optimal determination of either of the two types of policies will not generally be entirely separable from the determination of the other.

Interactions between the two types of policies have not been lost upon agricultural economists. Rausser (1982), de Gorter (1983), Rausser and de Gorter (forthcoming), and Gardner (1989) have all commented on the existence of such interactions. Their work has suggested the value of thinking of these two types of policies as jointly determined. In developing this theme, this paper will not concern itself with identifying optimal frameworks for organizing public policy decision making processes. Rather, this paper starts from the observation that within the existing governmental frameworks, governments do decide jointly on the levels of the two types of policies which they will provide. The paper suggests that this joint determination of the two types of policy instruments can lead to results which are puzzling and which are subject to misinterpretion if the joint determination of the policies is not explicitly recognized.

The paper examines the joint determination of public policies which provide agricultural research and which provide subsidies to farmers. The public provision of agricultural research is the most important way in which governments in capitalistic countries intervene in agricultural markets in pursuit of greater allocative efficiency. Policies designed to subsidize agricultural production processes are important examples of public policies which are essentially redistributive in their objectives and lead to political efficiency.

In examining the factors which affect how these two types of agricultural policy instruments are determined, the paper will attempt to throw light upon at least some of the reasons behind the puzzlingly consistent finding of "underinvestment" in agricultural research. The paper will also suggest that the notion that public expenditures on agricultural research are in some sense constrained by the side-effect which they have upon the budgetary costs of production subsidy programs may be misleading because it derives from an interpretation of the policy determination process which does not fully account for the jointness of the determination of the two policies. The interactions between the consequences of and the motivations for these two particular types of policies may result, when the policies are jointly determined, in a functional complementarity between the policies. This creates the possibility that, counter to traditional wisdom, government intervention in the form of a production subsidy may actually be potential-welfare-improving relative to the outcome which would obtain in its absence.

A SIMPLE MODEL OF GOVERNMENTAL INTERVENTION IN AN AGRICULTURAL MARKET

Suppose that a government behaves in its orientation towards agriculture as if it were choosing levels of policy instruments so as to maximize an objective function. The arguments of the government's objective function are taken to be income levels of farmers and consumers, both weighted by the government's relative level of concern with the welfare of the members of each group. The two instruments available to the government are: (1) a fixed production subsidy per unit of agricultural output which will be denoted as (r), and (2) the level of public expenditures upon agricultural research which will be denoted as (E). Each instrument will affect the level of welfare of both consumers and producers and the effects of either instrument upon the welfare of each group will not be separable from the effects of the other instrument. Thus, in order to maximize its objectives, the government will need to choose simultaneously the preferred level of the two instruments.

The market for the hypothetical agricultural commodity is assumed to be free from distortions other than those imposed by the government in the form of the two policy instruments, r and E. It is further assumed that a large number of identical producers (m) are price takers and produce a product which is consumed by an even larger number (n) of identical consumers. The price and quantity which characterize market equilibrium are assumed to be determined competitively.

The n identical consumers are each assumed to behave as if they were choosing a level of consumption of the agricultural commodity so as to maximize a concave and twice differentiable utility function which is additively separable in the consumption of the agricultural good. Consumers as taxpayers are coerced by the government, through the collection of tax revenues, to pay the entire budgetary cost of both governmental policy instruments. Consumers solve the following maximization problem:

$$(1) \qquad \max_{q^d} U = U(q^d) + [m_0 - pq^d - E/n - r(1/n)S(p + r)]\ \lambda$$

where

q^d	=	the quantity of the agricultural good demanded,
p	=	the price of the agricultural good,
E	=	government expenditures on agricultural research,
r	=	the per unit output subsidy to producers,
S	=	the total supply of the agricultural commodity,
n	=	the number of consumers (assumed to be identical),

m_0	=	the endowment of each individual consumer,
$U(q^d)$	=	individual consumer's utility from q,
λ	=	the marginal utility of income.

The summation of the demands of individuals yields the industry demand schedule D(p).

The m identical producers are assumed each to act so as to maximize profits (Π_i). Profits are defined here to be the difference between the gross revenues generated from the production and marketing of the commodity in one crop year and the costs incurred in providing each of the variable inputs other than management effort and the manager's labor. It is assumed that an exogenously determined wage rate is paid to each variable input. Thus, profits are taken to be the monetary return to the manager (farmer) for the effort, the knowledge and the services of capital inputs which he provides to the production enterprise. In order to maximize these profits, the producer chooses the level of output to solve the following expression:

$$(5)\quad \max_{q^s} \Pi_i = (p + r)\, q^s - C_i(q^s, E)$$

where q_i^s represents individual i's level of production and the function $C_i(q_i^s,E)$ reports the minimum level of cost required for producer i to produce each quantity of output. The summation of the individuals' supply schedules 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). Examination of the maximization problems for consumers and producers reveals that both policy instruments have positive impacts upon the market clearing level of quantity and that both (r) and (E) have negative impacts upon the market clearing price level. The exact way in which each instrument impacts upon output and price is dependent upon the elasticities of supply and demand with respect to price and upon the nature of the impact of E upon the cost of production. The more elastic are the supply and demand schedules, the greater the impact each instrument has on output. The effect of either instrument upon the market clearing price is greater the more elastic is the supply schedule relative to the demand schedule. The impact of the research expenditure instrument upon market clearing prices and quantities is also dependent upon the particular way in which research affects marginal costs of production.

THE GOVERNMENT'S POLICY DECISIONS

Suppose that the government's objectives can be characterized by the indirect welfare function V(P*, Y) where Y reflects aggregate social income and is derived as a weighted sum of consumer income (net of consumption expenditures) and producer profits. This maximization problem is written as:

$$(13) \quad \max_{r,E} . \; V = w_1 V_1(P, M) + w_2 V_2(\Pi)$$

where

V_Y	=	$V_m = V_\Pi$ = marginal utility of income
w_1	=	welfare weight assigned to consumers
w_2	=	welfare weight assigned to producers
M	=	$n \cdot [m_0 - E/n - r(1/n)S]$
Π	=	$m \cdot [(p + r)S/m - C]$
Y	=	weighted aggregate social income

The government chooses the instruments r and E so as to satisfy the necessary conditions for a maximum. Utilizing the definitions of M and Π from above and employing Roy's Identity, the necessary conditions can be expressed as:

$$(14a) \quad -w_1[DP_r + S + r \frac{dS}{dP}(1 + P_r)] + w_2[S(1+P_r)] = 0$$

and

$$(15a) \quad -w_1[DP_E + 1 + r \frac{dS}{dE}] + w_2[SP_E - mC_E] = 0.$$

Expressions (14a) and (15a) 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. (14a) 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 is just equivalent to the weighted marginal benefit of the subsidy to producers. Similarly, (15a) indicates that E should be chosen so that the weighted marginal cost to consumers of E is just equated with the weighted marginal benefit to producers.

Given that S = D, conditions (14a) and (15a) can be simplified and rearranged to read as follows:

$$(14b) \quad r = \left(\frac{w_2}{w_1} - 1\right) \frac{P}{\eta^s}$$

and

$$(15b) \quad -mC_E = \left(\frac{w_1}{w_2}\right) \left[1 + r\frac{dS}{dE}\right] - \left(1 - \frac{w_1}{w_2}\right) QP_E$$

Expression (14b) indicates that a government which acts so as to maximize the objective function V 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 is the industry supply schedule with respect to output price.

THE PHENOMENON OF UNDERINVESTMENT IN AGRICULTURAL RESEARCH

The interpretation of expression (15b) is instructive with regard to the existence of underinvestment in agricultural research. Equation (15b) indicates that if the costs and benefits of public investment in agricultural research are evaluated implicitly assuming equality between the welfare weights which government assigns to consumers and producers and without recognizing the effect which existing subsidies have upon the social costs of research at the margin, the condition which will seem to characterize the appropriate choice of E will be that which assures that the following holds:

$$(15c) \quad -mC_E = 1.$$

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

In the industrialized countries, subsidies to agricultural producers are, in general, positive. Thus, agricultural research efforts have the effect of shifting downward and outward the supply function will result in an increase in the cost to taxpayers of any existing commodity subsidization scheme. In terms of the expression (15b): $r(dS/dE) \neq 0$, but is instead positive. If this effect is properly incorporated into the measurement of the social costs associated with expenditures upon research, ignoring for the moment the implicit differential between w_2 and w_1, which is implied by $r > 0$, the resulting first-order condition characterizing the optimal choice of E is the following:

$$(15d) \quad -mC_E = 1 + r(dS/dE).$$

Expression (15d) describes a condition characterized by less investment in research, i.e., by a lower E than that which is prescribed by expression (15c). 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 will those analyses which have not included this additional cost. Analysts who include this factor would be expected to report less severe underinvestment than would the latter group. This hypothesis is confirmed in the empirical literature. However, as seen from conditions (14a) and (15a), if the hypothesis of this paper is correct, analyses based upon (15d) have still not fully captured the nature of the underlying causal mechanism. Such analyses are still likely to have misinterpreted the empirical evidence.

The hypothesis of this paper implies that a correct interpretation of the available empirical evidence requires the recognition of the role of the implicit welfare weights and of the joint nature of the choice of r and E. In developing this point it is useful to consider two possibilities in examining the implications of (15a):

Case 1: With $w_2 > w_1$, when the marginal impact of E upon producer profits is negative, at the chosen level of E and r, i.e., when $\Pi_E = SP_E - mC_E < 0$, then it must also be the case that:

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

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 have described the observed E as underinvestment.

Case 2: With $w_2 > w_1$, when the marginal impact of E upon producer profits is positive at the chosen combination of E and r, i.e., when $\Pi_E = SP_E - mC_E > 0$, it follows that:

$$-mC_E < 1 + r(\partial S/\partial E).$$

The chosen and observed level of E will be above that which would be described as the appropriate level of 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.

These two cases illustrate why empirical analyses of the returns of 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 be led to interpret the available evidence as implying the existence of unexplained underinvestment (overinvestment) whenever the characteristics of the situation are such that $w_2 > w_1$ and $\Pi_E < (>) 0$.

The stylized facts of agriculture have suggested that farmers' welfare is weighted more heavily than consumers' welfare in the United States. In examining the issue of reported underinvestment, let us then turn our attention to the determinants of the way in which producer profits are affected by E at the margin. By definition, profits respond positively to an increase in E when:

$$\Pi_E = SP_E - mC_E \gtrless 0.$$

At the margin, producers' profits respond positively to increases in research expenditures if revenues fall by less than do total costs or if revenues rise by more than costs rise. Substitution from above reveals the following expression of the determinants of the marginal response of producer profits to changes in research expenditures:

$$(16)\quad SP_E - mC_E \gtrless 0 \quad \text{as} \quad \frac{d(mC_E)}{dQ}\frac{Q}{mC_E}\left(\frac{\eta^s}{\eta^s - \eta^d}\right) \lesseqgtr 1.$$

The larger is the absolute value of the price elasticity of demand relative to the elasticity of supply, the more positive will be the response of farmer's profits to increased levels of research. The nature of the shift in the supply schedule which is induced as a result of research must also be understood in order to determine the full marginal impact of research upon profits. From (16), it can be seen that the larger is the elasticity of the marginal effect of research on cost with respect to the level of output, the less beneficial will be the impact of increased research upon producer's profits. This elasticity takes a value of zero if technical change produced by E affects only fixed costs. The greater the extent to which research expenditure lower variable costs relative to fixed costs, the larger the absolute value of the elasticity. Larger values for this elasticity tend to result in the benefits of research being captured by consumers rather than by producers.

The stylized facts which have been thought to characterize agricultural production make it seem plausible that in the terms of this model, according to condition (16), farmers' welfare is injured at the margin from technical improvements which are produced by E. The agricultural economics literature reports a rather large range of estimated price elasticities for agricultural commodities. However, if it is possible to characterize the accumulated wisdom of the profession, it might be tentatively concluded that demand elasticities are relatively inelastic, while supply elasticities are relatively elastic. This, combined with increasing costs and a significant share of revenues accruing to fixed and capital factors of production, makes it likely that farmer's profits are negatively impacted at the margin by the effects of agricultural research.

ARE SUBSIDIES AND RESEARCH EXPENDITURES USED AS COMPLEMENTS?

Because the existence of a commodity subsidy increases one component of the social costs associated with investments in agricultural research, it has been tempting to suggest that lowering subsidies would lead to increases in research expenditures because it would reduce such associated costs. However, the analysis here suggests that such a conclusion might well be empirically mistaken. Further, in those cases in which this conclusion proves to be empirically accurate, the analytical path employed in arriving at such a conclusion may turn out to be logically mistaken even on its own terms. Such a mistake is possible as a consequence of failing to capture the full nature of the incentives which characterize the allocation problem facing the government. The problem arises if the analytical framework does not recognize that factors which determine the extent to which governments engage in funding agricultural research also influence the incentives which determine the government's choices with regard to instruments of commodity policy. This interaction necessitates that the two types of policy instruments be chosen jointly if the government is to rationally pursue its objectives. When this interaction is not explicitly recognized, and when only the choice of the level of research expenditures is considered as endogenous, the analytical framework developed in this paper indicates that the government's choice of E will be a positive function of the level of the subsidy r. This result is guaranteed by the concavity of the government's objective function.

This result is in direct contrast to the conclusion which has been thought to have been informally implied by previous studies. The result reflects the fact that when the level of the subsidy is exogenously increased, the government is able to use the increase in the level of the subsidy to compensate producers for the losses which will accompany increases in E. In effect, when operating according to these conditions, it utilizes the two instruments as if they were complements.

When the analysis is allowed to reflect the joint determination of the two instruments r and E, the issue of whether or not r and E will be observed to behave as if they have been chosen by an agency which employs the two instruments as complements to each other is not as easily resolved. The information contained in the first order conditions (15a) and (15c) can be employed to examine the way in which the choice of E is conditional upon the prevailing level of r, given that r has been chosen to satisfy (14a). The exact way in which the choice of E will respond 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 (15a), after utilizing (14a) 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 (17):

$$(17) \quad \frac{dE(r)}{dr} = \frac{\dfrac{d^2V}{dE\,dr}}{\dfrac{d^2V}{dE^2}}$$

or

$$\frac{dE(r)}{dr} = \frac{\frac{Q}{P}\frac{C_{QE}}{(\eta^{s}-\eta^{d})^{2}}\left[\gamma\eta^{s}\eta^{d}\eta^{d} - (\gamma-1)\eta^{s}\eta^{d}\left(\frac{dS_{p}}{dP}\frac{P}{S_{p}}\right) - (\gamma-1)(\eta^{d}\eta^{d}-\eta^{s}\eta^{d})\left(\frac{dS_{E}}{dP}\frac{P}{S_{E}}\right)\right]}{\frac{d^{2}V}{dE^{2}}}$$

The sign of dE(r)/dr at the chosen level of r and E is determined by the nature of the tradeoffs which exist at the margin between weighted consumer and producer welfare. If producer's welfare is weighted more heavily than is consumer's welfare, the government's reaction function which determines E as a function of r will be positively sloped in the neighborhood of the equilibrium unless the marginal costs to consumers of supporting these policies become large enough to dominate the marginal benefits to producers.

Consumer costs can dominate producer gains and force dE(r)/dr to be negative when the expression within the brackets in (17) takes a negative value. It is possible for this expression to become negative when the supply response to marginal increases in the subsidy become large. This can happen in two ways. One condition which can contribute to this possibility is characterized by significant concavity of the supply schedule with respect to output price. A second characteristic which can contribute to costs to consumers more than offsetting producer benefits at the margin is a strong response by the supply schedule to research-induced technical change. A pivot-like shift in the supply schedule, which is consistent with a large impact of the technical improvement upon variable costs relative to the impact upon fixed costs of production, is consistent with consumer costs which are capable of offsetting producer benefits at the margin. A strong combination of these two conditions can result in public expenditures upon research responding positively to decreases in subsidy levels of the subsidy. Otherwise, research expenditures will respond to changes in r as if they were complementary to production subsidies.

Several commonly adopted functional forms yield the outcome of observed complementarity between the two instruments. For example, a linear supply function, or a constant elasticity supply function with elasticity less than one, combined with technical change which shifts the supply curve in a parallel fashion ensure that r and E behave as complements. These examples are of particular interest because they represent the cases which have been most frequently analyzed in previous studies. That these commonly employed functional forms are potentially consistent with complementarity would seem to justify future empirical work to confirm or deny the complementarity hypothesis of this paper.

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