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**THE POLITICAL ECONOMY OF
PRODUCTIVE AND PREDATORY POLICIES:
A CASE STUDY FROM AGRICULTURE**

by

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THE POLITICAL ECONOMY OF PRODUCTIVE AND PREDATORY POLICIES: A CASE STUDY FROM AGRICULTURE

I. Introduction

Governments intervene in agricultural markets with a mix of policies that can be classified as "productive" or "predatory" (Rausser 1991). Predatory policies, frequently implemented as price supports, are designed to redistribute income from one group to another. Publicly funded research is an important example of a productive policy. Productive policies are designed to improve allocative efficiency.¹ The public choice literature has made a fundamental distinction between these two types of policies but has yet to develop an integrative framework. For example, Mueller (1989, p. 38) summarizes the debate around these two polar views:

"... one 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 redistributive activities."²

This tendency can be traced as far back as the writings of Wicksell (1896), 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 (1989) treatise typifies one approach to political economy in which 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 (Gardner 1987). 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).

Interactions between these two types of policies and the nonseparability between political and economic markets have not been lost upon agricultural economists. Long ago,

Heady (1962, p. 405) hinted at the complementarity between productive and predatory policies in agriculture when he stated:

"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."

More recently, Rausser (1982) outlined an analytical framework to analyze the interaction between these types of policies under the rubric of PERTs and PESTs. More formal representations of his argument are contained in Gardner (1989), Rausser and de Gorter (1990), and Rausser and Foster (1990).

Policies designed to improve allocative efficiency in agriculture also have important distributional consequences (de Gorter and Zilberman 1990). As a consequence, public good policies will inevitably be linked to the same motivational forces that lead to redistributive government policies. Because redistributive policies generate deadweight losses, they also will be linked to policies that impinge on allocative efficiency. Indeed, we show in this paper that the motivations for the two types of policies are intertwined and that their consequences are subject to interaction.

It has long been recognized that government research and extension policies have been significant contributors to technological advance in agriculture (Evenson and Kislev 1976; Evenson, Waggoner, and Ruttan 1979). Indeed, Schlesinger (1984) has argued that public-good provision in agriculture is one of the few major economic success stories of government intervention over the course of U.S. history. Nevertheless, one of the stylized facts about government policy intervention in agriculture is the overwhelming evidence of underinvestment in public research (Ruttan 1982). Concomitant to this notion, economists have alleged that governments "overinvest" in commodity policies because of the "excess" deadweight losses generated.

Social costs of commodity programs in agriculture have long been recognized. Several recent studies have demonstrated that commodity policy reduces the social benefits of

cost-reducing public research in agriculture (Ruttan 1982; Lichtenberg and Zilberman 1986; Alston, Edwards, and Freebairn 1988). Technological change induced by public research expenditures, they argue, simply exacerbates the social costs of commodity programs. These studies, in recognizing the interactions between research and commodity policies, argue that the benefits to research have been overstated in past studies. The implication is that commodity policies reduce the level of research expenditures. Unfortunately, none of these studies considers the mechanisms by which rational policymakers can be expected to incorporate these interactions in their policy decisions. In representing governments as maximizing a politically weighted criterion function, we demonstrate here that these interactions necessitate that rational policymakers choose levels of the two policy instruments jointly in order to achieve a "politically efficient" equilibrium. In contrast to the argument outlined above, when policymakers determine these policies jointly, it can turn out that the presence of commodity programs may allow for a greater level of agricultural research to occur than would have been generated in the absence of the commodity program.

Given the apparent preferences of government to weight producer welfare more heavily than that of consumers, price supports can be used to achieve potential Pareto improvements from the outcome which would be obtained in their absence. In such situations, policymakers use these two types of policies as complementary instruments in achieving their objectives. In the framework developed in this paper, the institutional structure determining government choice and the relative political weights between the farm and urban sectors are taken as given. With this framework, it is shown that exogenously imposed reductions in agricultural price supports can lead to reductions in both public research expenditures and social welfare. An explanation is provided for the persistent underinvestment in agricultural research. Following this presentation of the general formulation, the determination of the two types of policies are analyzed in a specific case study of the U.S. dairy sector.

II. Analyzing Public Research and Production Subsidy Expenditures in Agriculture

Consider a market for a commodity in which 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 equilibrium in the market for the commodity are assumed to be determined competitively. The market for the hypothetical agricultural commodity of interest is assumed to be free from distortions other than those imposed by the government in the form of two policy instruments. The first policy instrument is a support price program. This program involves supporting the prevailing price so that it does not fall below a specified level. This is achieved by purchasing surplus product when the price falls below the designated support price level. These purchases are denoted as net removals (NR). For the purposes of this paper, the choice variable which determines the level of the support price will be the difference between the desired support price level and what would otherwise, in the absence of government purchases, be the market equilibrium price. The support price level will be denoted as \bar{p} , the market-clearing price as p , and r will be their difference. This policy instrument (r) is "predatory" in that the purchases are financed by consumers for the direct benefit of a relatively small segment of society—namely, producers. The second policy instrument is denoted as E , and refers to the public expenditures on cost-reducing agricultural research. These expenditures are also assumed to be financed by consumers as taxpayers. However, this instrument is "productive" in that its benefits are widely dispersed. Its net effect is to push out society's production-possibility frontier.

The n identical consumers choose their optimal level of consumption of the agricultural commodity by maximizing a concave and twice differentiable additive and separable utility function. 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 act so as to solve the following maximization problem:

$$\max_{q^d} \left\{ w = U(q^d) + \lambda \left[m_0 - \bar{p}q^d - \frac{E}{n} - \frac{\bar{p}NR}{n} \right] \right\} \quad (1)$$

where

- q^d = the quantity of the agricultural good demanded by each consumer
- p = the price at which supply equals demand
- r = the level about p at which the price will be supported
- \bar{p} = $p + r$
- E = the government's expenditures on agricultural research
- S = the aggregate supply of the agricultural commodity
- n = the number of consumers (assumed to be identical)
- m_0 = the endowment of each individual consumer
- $U(q^d)$ = each individual consumer's utility as a function of the quantity of the commodity consumed
- λ = the marginal utility of income.

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

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

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

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 where E is a public good which reduces variable cost, and $C_{QE} < 0$. Profits are defined here to reflect the returns to owned assets such as land, unhired labor,

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 $(p+r) - C_q^s(q^s, E) = 0$. This condition can be used to determine the individual's supply schedule as a function of $p+r$ and E :

$$q_i^s(\hat{p}+r, E).$$

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

Both policy instruments r and E have impacts upon the quantities demanded and supplied as well as upon the prices which market participants face. The exact way in which each instrument affects quantities and prices is dependent, in general, upon the elasticities of supply and demand.

$$\frac{d\bar{p}}{dr} = 1 \quad (3)$$

and

$$\frac{d\bar{p}}{dE} = \frac{dp}{dE} = \frac{\eta^d \eta^s C_{QE}}{(\eta^s - \eta^d)^2} \leq 0 \quad (4)$$

where

η^s = the price elasticity of supply

η^d = the price elasticity of demand

C = the aggregate cost function

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

In a world of certainty, increases in the level of support for the market price (i.e., increases in r) have a one-for-one impact upon the effective support price as indicated by

expression (3). The research instrument (E) does impact upon the market-clearing price (p) because it shifts the supply curve. Consequently, increasing the level of research has the effect of lowering both the market-clearing price (p) and the support price (\bar{p} .) given a fixed level of support above the market (r).

The Government's Policy Decisions

Suppose that the government's objectives can be characterized by the preference function $V(V_1, V_2)$ which takes the form of a weighted sum of consumer (V_1) and producer welfare (V_2). The political preference weights are indicative of a politically efficient outcome of lobbying by producers and consumers, and support maximization by politicians. The government objective function can be characterized as a reduced-form political preference function (Rausser and Foster 1990). The government selects the level of the two policy instruments, r and E , so as to maximize $V(V_1, V_2)$. This maximization problem may be represented as

$$\max_{r, E} V = w_1 V_1(p, M) + w_2 V_2(\pi) \quad (5)$$

where

w_1 = preference weight assigned to consumers

w_2 = preference weight assigned to producers

$M = n[m_0 - E/n - (\bar{p}NR/n)]$

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

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

$C = C(S, E)$.

The necessary conditions for a maximum are

$$w_1 V_p + V_r [w_1 M_r + w_2 \pi_r] = 0 \quad (6)$$

and

$$w_1 V_p \bar{p}_E + V_Y [w_1 M_E + w_2 \pi_E] = 0 \quad (7)$$

where $V_{1_M} = V_{2_x} = V_Y =$ marginal utility of income.

Utilizing the definitions of M and π from above and employing Roy's Identity to the indirect consumer welfare function, $V_I(p, M)$, the necessary conditions can be expressed as

$$-w_1 \left[D + NR + \bar{p} \frac{dNR}{dr} \right] + w_2 S = 0 \quad (8)$$

and

$$-w_1 \left[p_E D + 1 - \bar{p} \frac{dNR}{dE} + p_E NR \right] + w_2 [p_E S - C_E] = 0. \quad (9)$$

Expressions (8) and (9) 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 (8) 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, $w_1 [D + NR + \bar{p} (dN)/(dr)]$, is just equivalent to the weighted marginal benefit of the subsidy to producers, $w_2 S$. Similarly, (9) 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., $w_1 [D p_E + 1 + \bar{p} (dNR/dE) + p_E NR]$ —is just equated with the weighted marginal benefit to producers, $w_2 (S p_E - C_E)$.

Expression (9) can be simplified and rearranged to obtain:

$$\frac{w_2}{w_1} [p_E S - C_E] = 1 + \bar{p} \frac{dNR}{dE} + p_E S. \quad (9a)$$

PROPOSITION 1. When producer welfare is weighted more heavily than consumer welfare (i.e., $w_2 > w_1$) and when producers' profits are injured at the margin by research (i.e., $\pi_E < 0$), then cost-benefit analyses will report *underinvestment* in agricultural research.

Producer profits π_E are affected by E at the margin in accordance with

$$\pi_E = Sp_E - C_E \gtrless 0.$$

Cost-benefit analyses have used the following condition as characteristic of an appropriate or "normal rate of return" level of investment in agricultural research in the presence of a support price.

$$-C_E = 1 + \bar{p} \frac{dNR}{dE}. \quad (10)$$

However, if $w_2 > w_1$ and $\pi_E < 0$, it can be seen from (9a) that the government will select its instruments so that

$$-C_E > 1 + \bar{p} \frac{dNR}{dE}. \quad (11)$$

This condition is consistent with what has been called "underinvestment" in agricultural research.

In choosing the level of the two instruments, r and E , jointly, under some circumstances the government will be able to exploit the nature of the interactions between the policies to its advantage. In such cases, it will elect to employ the two instruments in what can be thought of as a complementary fashion.

In examining this possibility, the first-order condition (9) can also 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 (8). Total differentiation of expression (9), after utilizing (8) 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 (12):

$$\frac{dE(r)}{dr} = - \frac{\left[\frac{S_E(S_p - \gamma D_p)}{S_p - D_p} - \frac{(\gamma - 1)S_E S_p}{S_p - D_p} \left(\frac{SS_{pE}}{S_p S_E} - \frac{d(S_p - D_p)}{dp} \frac{p}{(S_p - D_p)} \frac{1}{\eta^S} \right) \right]}{\frac{d^2V}{dr^2}}. \quad (12)$$

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 and the ways in which the two policies affect the welfare of each group. Consider the case in which producer welfare is given more weight than consumer welfare (i.e., $w_2 > w_1$, or $\gamma > 1$). It is possible for $[dE(r)]/dr$ to be negative when some combination of the following two conditions hold:

$$S_{pE} > 0 \quad \text{and} \quad \frac{d^2NR}{dp} < 0.$$

When neither of these conditions hold, $[dE(r)]/dr$ is always positive and the two instruments are chosen as complements at the margin. It is interesting to note that, when both the supply and the demand schedules are linear [i.e., $(d^2NR)/dp^2 = 0$], shifts in the supply curve due to research are either parallel ($S_{pE} = 0$) or pivot-like ($S_{pE} < 0$) and will result in $[dE(r)]/dr > 0$. This result indicates that, given these specifications of the demand and supply curves, an exogenously imposed reduction in the support level, r , would have the effect of inducing policymakers to lower E . These are the same specifications which have been adopted by several previous studies of the interactions between these two types of policies (Alston, Edwards, and Freebairn 1988). However, in contrast to the result reported here, these studies have implied that reductions in price-enhancing interventions would lead to higher levels of public research expenditures. The contrasting result is a consequence of the failure

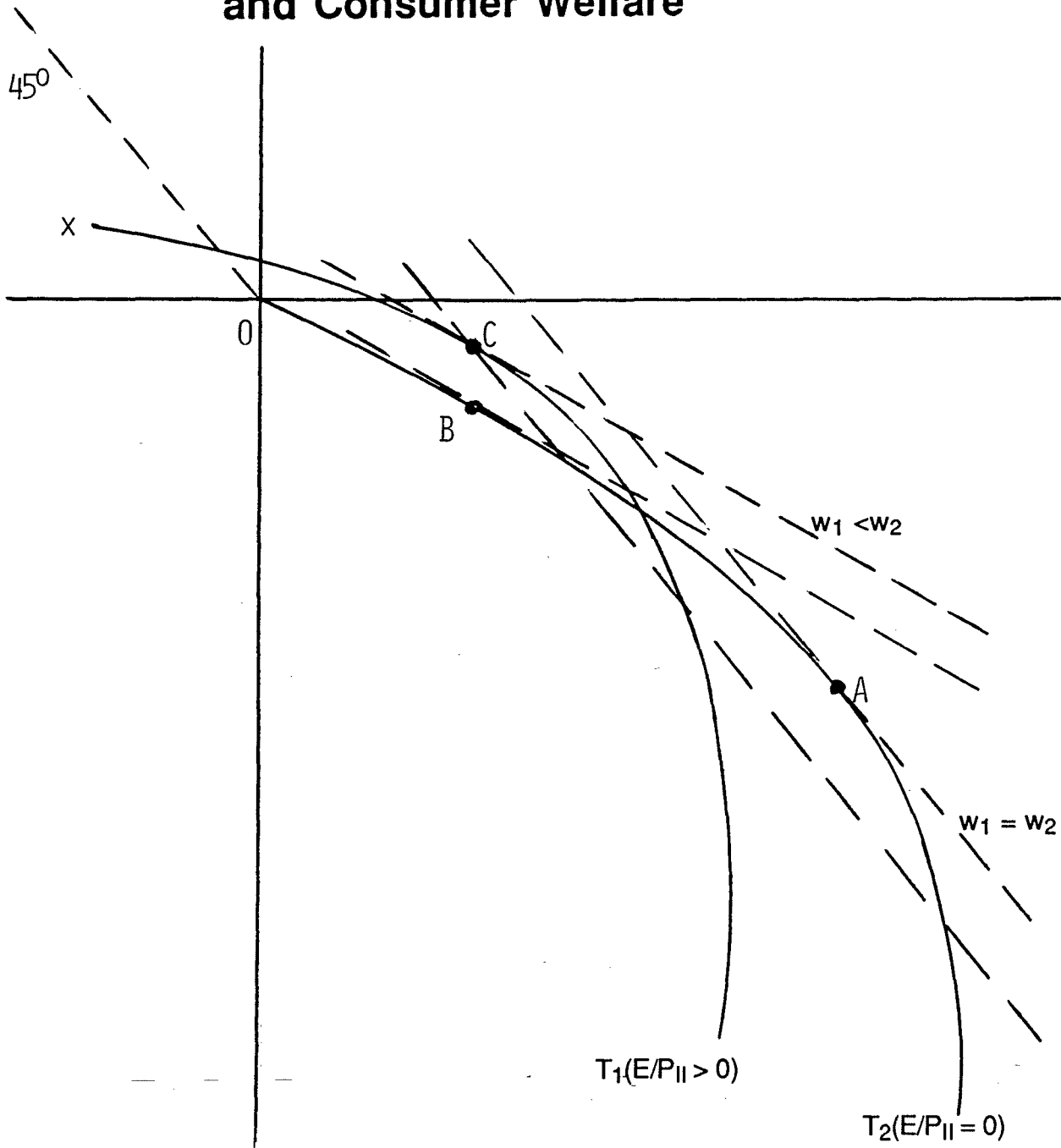
of previous studies to fully examine the joint maximization problem which is being solved by the government.

As previously noted, 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 selected 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.

PROPOSITION 2: Under specific conditions, the government can compensate producers through commodity policy for the losses which they suffer as a result of research policies; this 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 may actually be Pareto improving.

An example of this outcome is presented graphically in figure 1. At the origin, neither policy is employed. The transformation curve, $T_0(E|r=0)$, describes the change in welfare for each group as the level of research is increased. Movement away from the origin along this curve corresponds to increased public expenditures on research. The particular curve depicted in figure 1 is drawn to lie entirely in the South-East quadrant. This depicts the case in which π_E is everywhere negative. If consumers and producers have equal political weights, the level of research which corresponds to point A will be chosen. This results in a socially optimal level of research expenditures in the absence of a price support instrument. If producers are favored politically and governments are not allowed to use production subsidies, then the chosen level of research expenditures would correspond to point B and an "underinvestment" in research results.

Figure 1. Impact of Policy Instruments on Producer and Consumer Welfare



Instruments Available
Research Only:

If $w_1 = w_2$: Choose point A
If $w_1 < w_2$: Choose point B

Research and Production Subsidy:

If $w_1 < w_2$: Choose point C

w_1 = weight given to consumers and taxpayers

w_2 = weight given to producers

The introduction of a price support instrument results in a new transformation $T_1(ElP_{II})$ curve. This new transformation curve is derived from $T_0(Elr=0)$ and originates from a point somewhere below the 45 degree line in the North-West quadrant. The curve originates at such a point because producer welfare increases with the price support by less than the decrease in consumer welfare as a result of the deadweight losses generated by the price support. As was the case for transformation curve T_0 , movement along transformation curve T_1 , away from point X, corresponds to increased public research expenditures. Moving along T_0 , additional deadweight losses can be generated as research expenditures increase. This interaction effect between production subsidies and research expenditures has the additional effect of changing the shape of the transformation frontier $T_0(Elr=0)$ so that it pivots to the left.

If both policy instruments are available, policymakers are able to achieve a point such as C. The transformation curves are 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 associated with 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 than consumers, the final equilibrium represents a case of underinvestment in research. Therefore, the model developed in this paper provides an explanation for the chronic underinvestment in agricultural research. That it is possible for consumer 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, the existence of the price support can be Pareto dominant to the alternative situation in which the availability of production subsidies is absent.⁴

III. Price Supports and Research Expenditures in the U. S. Dairy Industry

In the above section, a general framework was developed to analyze the government's choice of two interrelated instruments: price support and research expenditures. In this section, the forms of the price support instrument employed in the U.S. dairy policy are presented. Further, it is shown how the analytical framework developed in section II is modified to capture the specific features of U.S. dairy price-support policy.

The price of milk at the farm level is supported in the United States through a standing offer by the Commodity Credit Corporation (CCC) to purchase several of the manufactured dairy products at pre-announced price levels.⁵ These purchases guarantee that the market price of Class II milk does not fall below the support price. Class II milk refers to that milk which is purchased for use in producing a variety of manufactured dairy products such as cheeses and butter. Class I milk is used for fluid milk consumption. It is purchased at a fixed differential above the Class II support price. The difference between these two prices is called the Class I differential and is assumed to be set exogenously in the analysis to follow.

In the notation adopted here, Class I and Class II prices are linked by a fixed differential, α :

$$P_I = P_{II} + \alpha.$$

The price received by farmers is a blend price which is calculated as a weighted average of the Class I and the Class II prices. The blend price received by farmers (P_b) is given by:

$$P_b = \frac{P_I D_I + P_{II} (D_{II} + NR)}{S}.$$

The total demand is made up of the three components D_I , D_{II} and NR ; D_I and D_{II} are the Class I and Class II levels of milk demand, respectively, and NR represents the milk equivalent units of CCC purchases of manufactured dairy products.⁶ Net removals (NR) are determined endogenously according to the following expression:

$$NR = S - D_I - D_{II}.$$

The government choice variable for the commodity policy is the Class II price support, P_{II} . The fluid milk price faced by consumers and the blend price received by farmers are uniquely related to the choice variable P_{II} as described in equations above.⁷

Government costs (G) due to the CCC price support program are given by:

$$G = \delta P_{II} NR = \delta P_{II} (S - D_I - D_{II}) \quad (13)$$

where $\delta = 0.85$. The value of δ indicates that 15 percent of CCC removal costs are eventually recovered from sales of the excess product (Tauer and Kaiser 1990). This number is an average figure for the past 30 years and indicates that much of the CCC resale revenues are offset by the processing, storage, and handling costs incurred by the CCC after the product has been purchased at the support price.

The government is postulated to maximize the political preference function in equation (5) with respect to P_{II} and E where $M^* = M_0 - E - P_{II}\{S^*[P_b(P_{II},E),E] - D_I(P_I) - D_{II}(P_{II})\}$ and $\pi^* = [P_b(P_{II},E)]S[P_b(P_{II},E),E] - C\{S[P_b(P_{II},E),E],E\}$. The net effect of the price supports on taxpayers income is described by

$$\frac{\partial M}{\partial P_{II}} = -\delta \left[NR + P_{II} \left(\frac{\partial S}{\partial P_{II}} - \frac{\partial D_I}{\partial P_I} - \frac{\partial D_{II}}{\partial P_{II}} \right) \right] < 0. \quad (14)$$

Tax costs are higher with values of δ , the levels of net removals, the Class II price support, and the absolute values of both the supply and the demand elasticity.

The effect of price supports on the level of producer profits is described in the following equation,

$$\frac{\partial \pi}{\partial P_{II}} = S \frac{\partial P_b}{\partial P_{II}} \geq 0. \quad (15)$$

This expression depends critically on the effect of a change in Class II support prices on the blend price, which is indirect and complex as shown by

$$\frac{\partial P_b}{\partial P_{II}} = \left(\frac{S + \frac{\partial D_I}{\partial P_I} (P_I - P_{II})}{S^2 + \frac{\partial S}{\partial P_b} (P_I - P_{II}) D_I} \right) S. \quad (16)$$

The effect of research expenditures on taxpayer income, M_E , is given by $-\delta P_{II} (dS/dE) - 1 < 0$. This demonstrates that the cost of research to consumers is affected by the presence of a price support. The price support has an impact upon taxpayer costs, not only through CCC purchases as reflected in the values of δ and the Class II price support but also as a result of the responsiveness of supply to research expenditures.

The impact of research on producer profits, π_E , is as before with the exception that the blend price (instead of the market price plus subsidy) is the appropriate price variable. The effect of research on this blend price is determined by

$$\frac{\partial P_b}{\partial E} = \frac{-dS}{dE} \frac{D_I (P_I - P_{II})}{S^2}. \quad (17)$$

Substitution of the expression for dS/dE from before gives

$$\frac{\partial P_b}{\partial E} = \frac{-S_E D_I (P_I - P_{II})}{S^2 + \frac{\partial S}{\partial P_b} D_I (P_I - P_{II})}. \quad (18)$$

The effect of research expenditures on the blend price of milk received by farmers is indirect in that it operates through changes in the relative weights in the blend price formula. Because

research expenditures ultimately have the effect of shifting out the industry supply schedule, they increase the amount of milk produced at any given price. A change in production at given price levels affects the total consumption of Class II milk via increased NR but leaves the demand for Class I milk unchanged. Thus, it is the change in the relative percentage of the milk which is used for Class I and Class II purposes which alters the weights in the blend price formula shown in equation (2) and which results in an indirect change in the blend price, even if the Class I and Class II prices remain unchanged.

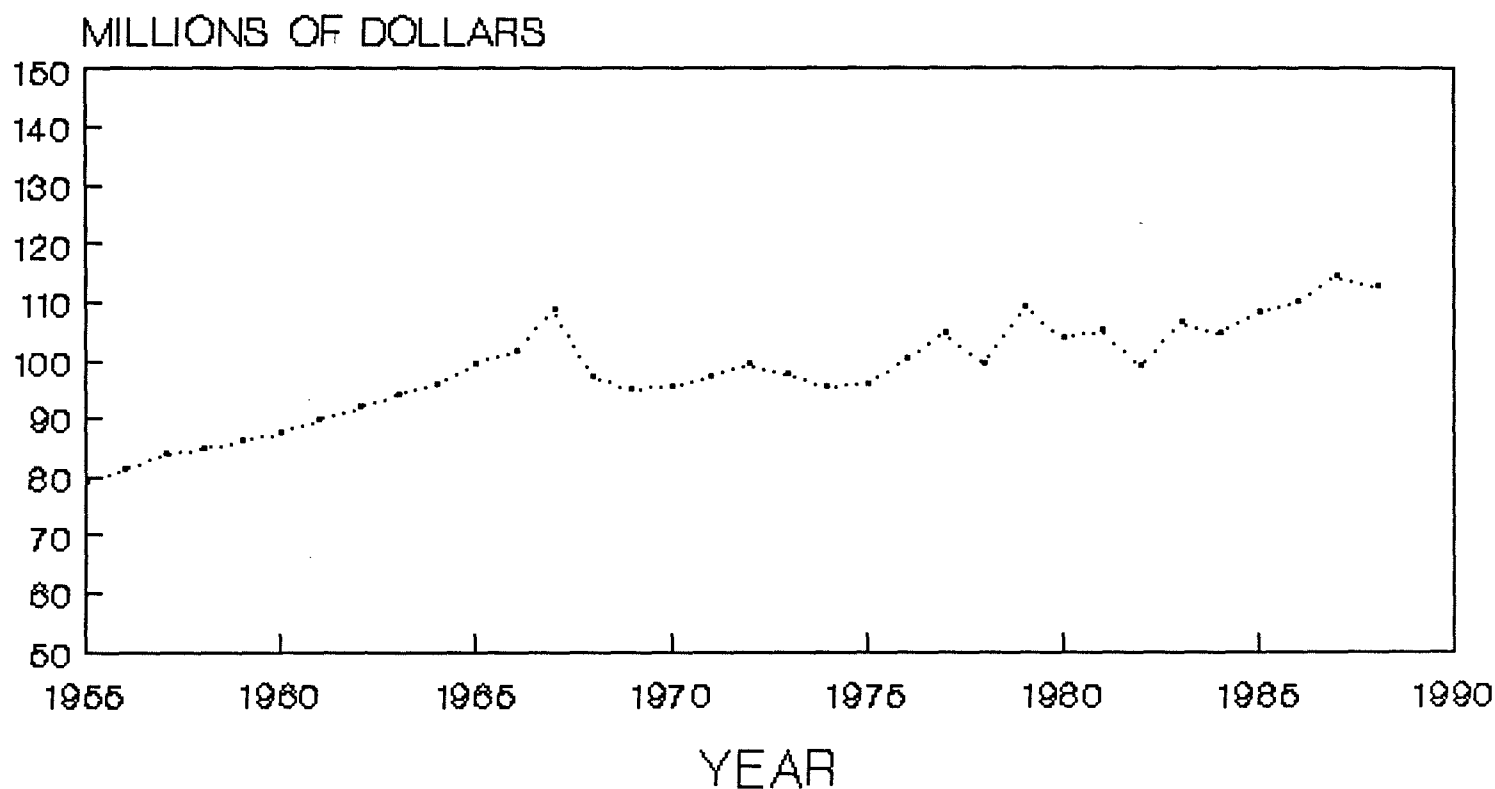
IV. Empirical Evidence

The hypothesis presented in Propositions I and II are tested in an empirical study of the market for milk at the level of the farm gate in the United States by asking the questions: Are public research expenditures higher in the presence of price supports than they would be otherwise? Are both consumers/taxpayers and farmers better off with the existence of price supports than they would be in their absence? If the answers to these questions are yes, the price-support policy and public-research expenditures appear to be employed as complements and the availability of the price-support policy may allow a potential Pareto improvement to be achieved, relative to the outcome which would otherwise be obtained.

Public Research and Milk Supply

As in other agricultural sectors, the real level of public expenditures upon agricultural research has increased steadily over time in the U.S. dairy sector (figure 2). Meanwhile, productivity in the production of milk has increased dramatically. Two measures of productivity, labor per unit of output and milk produced per cow, are reported in figure 3. These two figures demonstrate the dramatic productivity improvement in milk production. This increase in productivity has resulted in a sharp reduction over the same period of time in the number of milk cows as well as in the number of operating dairy farms in the United

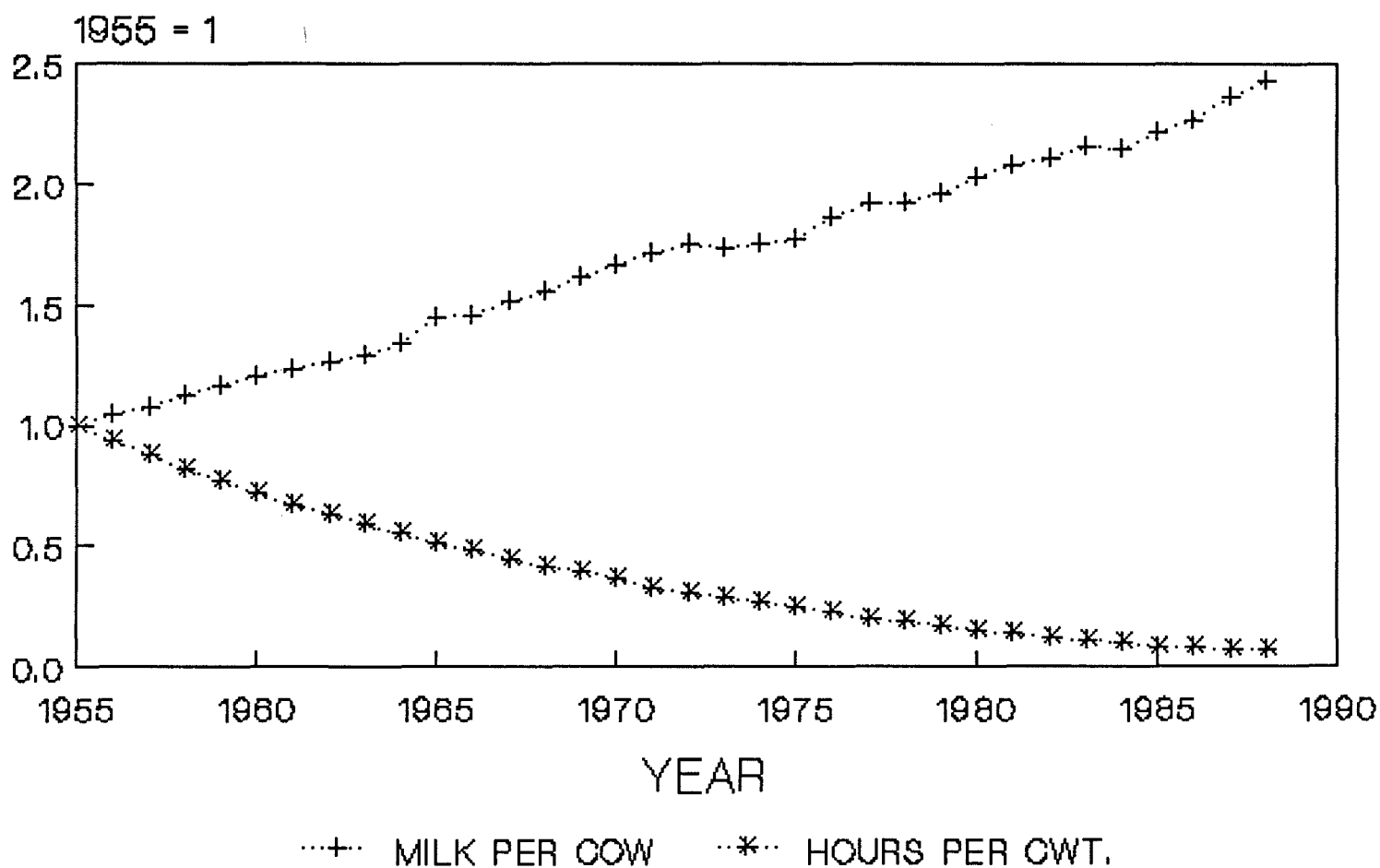
FIGURE 2: PUBLIC RESEARCH EXPENDITURES ON U.S. DAIRYING 1955 - 1988



..... DAIRY RES. EXPEND.

(RESEARCH EXPENDITURES
MEASURED IN CONSTANT 1988 DOLLARS)

**FIGURE 3:
PRODUCTIVITY IMPROVEMENTS IN U.S.
DAIRYING 1955 - 1988**



States. These developments in agriculture are not limited to the livestock sector but also characterize developments in the crop sectors (Griliches 1958).

The estimated effects of public research expenditures on milk supply and on each of the inputs—grain concentrates, hay, labor, cows, and capital—are reported in table 1. The model is constructed such that the aggregate expressions for output and for the input demands are exactly consistent with the theory of the profit-maximizing behavior of the individual heterogeneous firms. At the aggregate level, substitution between each of the inputs is possible in response to changes in the economic environment. This is in contrast to the fixed coefficient technology which prevails between some of the inputs at the microeconomic level. This feature of substitutability at the aggregate level is a consequence of the entry and exit from the industry to firms with differing abilities (Nielson 1989).

The aggregation procedure, combined with the distribution of the efficiency abilities between individual producers, leads to long-run expressions for aggregate output and aggregate input demands which are log linear in the prices. The parameters of these aggregate expressions are related to each other both within as well as across equations as a direct implication of the theory.⁸ These restrictions are imposed to comply with the implications of the theoretical model.

The empirical results reported in table 1 indicate that the long run elasticity of milk supply with respect to public research is 0.25. This estimate is similar to that found in a recent study on the effects of research on milk supply in Canada by Fox, Roberts, and Brinkman (1990). Their study reported long-run elasticities of Canadian milk supply to be 0.258, 0.57, and 0.707 with respect to provincial, federal, and U.S. research expenditures, respectively. The estimate of 0.25 is somewhat below the estimate of 0.538 for the United States which was reported by Bredahl and Peterson (1976) in one of the earliest studies to report an elasticity of milk supply with respect to research expenditures. Although the elasticity of research found in this study is somewhat lower than those reported in those benchmark studies, the level of estimated responsiveness of milk production to research

Table 1. Estimated Milk Supply and Input Demand Functions: 1955-1988

Independent Variables	Dependent Variables					
	S	G	H	L	K	C
P_b	0.94722	1.9472	1.9472	1.9472	1.9472	1.9472
E	0.25521	0.25521	0.25521	0.25521	0.25521	0.25521
PG	-0.85502	-1.8550	-1.8550	-1.8550	-1.8550	-1.8550
PH	0.54771	0.54771	-0.45229	0.54771	0.54771	0.54771
PL	0.70151	0.70151	0.70151	-0.29849	0.70151	0.70151
PK	-0.36867	-0.36867	-0.36867	-0.36867	-1.36867	-0.36867
PC	0.02725	0.02725	0.02725	0.02725	0.02725	0.97275
PAST	-0.0247	-0.00636	-0.014244	-0.00630	0.00589	-0.00555
Trend	0.00102	0.00922	-0.01259	-0.05700	0.06087	0.00428
Interest Rate	0.02512	-0.00523	0.02100	-0.00939	-0.05995	0.02172
Constant	1.5443	1.1351	4.0687	4.0491	9.2980	9.6684
R*Squared	0.52	0.52	0.50	0.94	0.52	0.64
Durbin Watson	0.85	0.86	0.96	0.52	0.86	1.17

P_b	= ln(price received for milk) ^a
E^b	= ln(publish research expenditures) ^b
PG	= ln(price of grain concentrates)
PH	= ln(price of hay)
PL	= ln(price of hired agricultural labor)
PK	= ln(index price of farm machinery)
PC	= ln(non-feed cost of owning one cow one year)
Trend	= time period (1955=1, ..., 1988 = 34)
PAST	= measure of pasture conditions as a percent of normal (100% indicates normal conditions)
S	= ln(milk production in the United States)
G	= ln(grain concentrates fed to dairy cows)
H	= ln(hay fed to dairy cows)
L	= ln(labor allocated to milk production)
K	= ln(shipments of dairying equipment (\$1,000 units))
C	= ln(milking cows)

^aAll prices and dollar denominated variables are deflated to constant 1988 dollars.

^bThis variable is constructed as a weighted average of the total public expenditures on dairy-related research each year for the 10 years prior to the current year. The weights employed are the inverse of the degree of lag of the year in which the expenditures were made. This corresponds roughly to the declining, yet lingering effect of research dollars over time which other studies have adopted.

Source: D.J. Nielson, G.C. Rausser, and H. de Gorter. "A Supply Model for Studying Change in the U.S. Dairy Industry." Working Paper No. 551, Department of Agricultural and Resource Economics, University of California, Berkeley, April, 1990.

expenditures is still quite sufficient to allow research expenditures to have an important impact upon the industry.

The long-run own-price elasticity of milk supply is estimated to be 0.94. This estimate is lower than is reported in most of the previous studies, many of which estimate supply to be significantly own-price elastic (perhaps as high as 5) in the long run (for example, see Chavas and Klemme 1986). Most estimates of the own-price elasticity of the supply of milk have not incorporated the impact of research. The positive influence of research on productivity has been confounded with the price term in past studies. As a result, higher supply elasticities have been generated than would have occurred had the two effects been explicitly separately incorporated as in this study.

The Simultaneous Determination of the Policy Mix

Are milk consumers better off when the government implements price supports to compensate dairy farmers for the negative effects of research on profits? To answer this question, model simulations are presented that embrace all of the theoretical features and empirical supply estimates of the U.S. dairy sector derived above. Along with the empirical supply model presented in table 1, constant elasticity demand functions are specified for Class I and Class II milk consumption with elasticities of -0.25 and -0.55, respectively.⁹ All parameters are evaluated at their long-run values in the simulations. Note also that specific details of U.S. dairy policy, e.g., producer assessments levied in the early 1980s, are also included in the analysis.¹⁰

From the baseline simulation, values of the relative political weights, γ , were calculated for each of the two first-order conditions. Taken separately, each first-order condition from the government's maximization problem implies an unique value for γ . We will use γ_p to denote the relative political weight determined from the first-order condition corresponding to the choice of r , and γ_E to denote the value of the relative weight implied in the first-order condition corresponding to the choice of E . These calculated relative weights are the revealed

preferences of the government with respect to the choice of each policy instrument. If the government behaves according to the hypothesis in this paper and selects the two instruments jointly rather than separately, the theory would imply that the condition, $\gamma_p = \gamma_E$, should be found to hold.

The calculated values for γ_p and γ_E are presented in table 2. The estimated values of γ_p are very stable. Furthermore, it is surprising how close the values of γ_p are to those of γ_E for many of the time periods under consideration. The values of each weight are derived from very different estimated parameters on how each instrument affects the dairy market. Nevertheless, the estimated weights are in the same range of values for the entire time period. This result lends strong support to the hypothesis that governments rationally choose price supports and research expenditures jointly and that the interaction effects between the two policies are explicitly recognized by politicians.

The baseline values for the key parameters are given in table 3. The actual blend price received by farmers, predicted supply, actual research expenditures, and initial (status quo) producer welfare are presented. Because the absolute value of consumer welfare is undefined in the constant elasticity case, only changes in consumer, and hence in net social welfare, are reported.

To determine the importance of how governments choose price supports and research expenditures jointly, a special policy simulation was conducted in which research expenditures were set to zero and price supports remained endogenous; i.e., determined by the political process. This scenario evaluates the implication of fixing research (in this particular example, it is set at zero) and allowing commodity policy to be determined by governments. The results are given in table 4. The blend price increases substantially but not enough to offset the supply decreasing effects of zero research expenditures. Hence, output declines compared to the baseline solution. Farmers benefit in this scenario while consumers lose substantially. Taxpayers, on the whole, benefit because supplies have decreased and costs of surplus disposal declines. Farmers gain in this scenario due to the

Table 2

Table 2. The Predicted Values of γ_p and γ_e -- 1955-1988

γ_p									
1955	2.190	1956	2.198	1957	2.311	1958	2.350	1959	2.273
1960	2.271	1961	2.383	1962	2.374	1963	2.530	1964	2.320
1965	2.305	1966	2.186	1967	2.157	1968	2.227	1969	2.194
1970	2.188	1971	2.151	1972	2.080	1973	2.243	1974	2.518
1975	2.293	1976	2.170	1977	2.144	1978	2.119	1979	2.192
1980	2.189	1981	2.173	1982	2.112	1983	2.214	1984	2.196
1985	2.224	1986	2.239	1987	2.318	1988	2.275		

γ_e									
1955	2.422	1956	2.325	1957	2.842	1958	3.261	1959	3.259
1960	3.130	1961	5.652	1962	5.339	1963	30.377	1964	4.269
1965	4.422	1966	3.182	1967	3.407	1968	4.505	1969	4.133
1970	3.802	1971	3.578	1972	2.970	1973	4.071	1974	8.327
1975	4.140	1976	3.563	1977	3.169	1978	2.695	1979	2.878
1980	2.510	1981	3.032	1982	2.951	1983	3.678	1984	3.281
1985	3.185	1986	3.201	1987	2.898	1988	2.570		

Table 3. Baseline Values of Key Variables

	Blend Price (\$/cwt)	Predicted Milk Supply (bill. lbs.)	Research Expenditures (mill. \$)	Initial Producer Welfare (10 mill. \$)
1969	5.49	122.301	90.50103	1054.976
1970	5.71	122.761	94.39174	1039.875
1971	5.87	130.145	97.34285	1086.583
1972	6.07	151.464	100.3818	1265.831
1973	7.14	111.208	107.1495	1029.180
1974	8.33	86.768	119.9956	844.208
1975	8.75	104.950	130.7995	982.870
1976	9.66	130.308	137.1910	1273.619
1977	9.72	132.899	145.4188	1227.809
1978	10.6	140.471	158.4417	1314.672
1979	12	124.828	179.5407	1188.736
1980	13	125.111	202.5284	1137.001
1981	13.8	124.358	230.7399	1086.943
1982	13.55	143.015	244.5635	1156.407
1983	13.57	126.941	254.1655	960.712
1984	13.46	134.356	260.2187	966.869
1985	12.75	128.014	274.6003	866.214
1986	12.51	131.880	280.6629	844.156
1987	12.54	118.829	295.5395	741.682
1988	12.24	123.663	312.7387	736.304

Table 4. Effects of Eliminating Research Expenditures with Endogenous Price Supports

	Milk Supply (bill. lbs.)	Blend Price (\$/cwt)	Δ in Consumer Welfare	Δ in Producer Welfare	Δ in Taxpayer Welfare	Δ in Net Social Welfare
			- - - - - 10's of million \$ - - - - -			
1969	92.420	9.155	-1127.977	274.455	123.547	-729.976
1970	92.842	9.530	-1108.503	272.716	114.599	-721.188
1971	98.707	9.827	-1107.096	292.999	77.477	-736.620
1972	115.653	10.234	-1175.139	363.779	-14.776	-826.137
1973	89.161	12.674	-1443.006	435.566	-2.376	-1009.816
1974	81.400	17.454	-2113.333	815.270	-325.827	-1623.889
1975	87.310	16.150	-1586.360	526.331	-90.136	-1150.165
1976	99.288	16.250	-1416.303	358.876	107.094	-950.333
1977	101.509	16.393	-1324.148	353.870	72.390	-897.888
1978	107.699	17.949	-1385.764	392.095	33.129	-960.540
1979	96.692	20.541	-1474.183	387.422	83.275	-1003.486
1980	95.875	22.001	-1347.728	337.604	107.866	-902.258
1981	95.846	23.487	-1329.552	339.466	93.506	-896.5808
1982	109.176	22.757	-1212.466	317.418	70.944	-824.1046
1983	98.288	22.872	-1191.486	312.209	82.838	-796.4399
1984	102.175	22.253	-1118.500	267.385	124.608	-726.5077
1985	101.989	22.383	-1200.217	350.600	8.265	-841.3538
1986	104.561	21.682	-1145.781	329.920	22.298	-793.5637
1987	102.698	23.865	-1379.697	489.942	-147.340	-1037.0958
1988	103.770	22.798	-1234.718	414.531	-87.058	-907.2444

inelasticity of demand. Limiting supply by reducing E to zero allows them to capture more profits than was possible in the base scenario. However, the final column in table 4 indicates that society as a whole is worse off under this set of policies relative to the base scenario.

The results in table 4 confirm the model's prediction that, under conditions of an inelastic demand curve, a relatively more elastic supply curve, and a significant effect of research on costs, farmers can be hurt as a result of research expenditures. Since dairy farmers do lose from research, price supports can be used to partially compensate them. This suggests the possibility that, if price supports were not available to governments but research was determined endogenously, farmers would lose so much from the elimination of price supports that research expenditures would also be eliminated. Results in table 5 confirm that, when price supports are eliminated and no price discrimination occurs, research expenditures and when determined endogenously through the political process by using the calculated political weights, are driven to zero. Farmers benefit relative to the status quo, but consumer and net social welfare decline sharply. Hence, given government's apparent preferences, it is in the interest of both society, in general, and consumers to use price supports to compensate farmers for the profit-reducing effects of public research expenditures.

Finally, the "social optimal" levels of research expenditures as prescribed by welfare economists who typically ignore the political process (i.e., in our model, setting γ_E and γ_P equal to one) are reported in table 6. As expected, price supports are not employed in this scenario and prices are determined solely by market supply and demand forces. The results indicate that optimal research expenditures with farmers and consumers having equal political weights are slightly over 4 times actual research expenditures (table 3). This result is consistent with Griliches (1964, p. 969) who estimated that a fourfold increase in research expenditures for agriculture would yield positive net social benefits for the U.S. economy¹¹. Hence, the results of this paper are entirely consistent with recent studies. As expected, farmers lose with research expenditures inducing an increase in supply compared to the

Table 5. Effects of Eliminating Price Supports with Endogenous Research Expenditures

	Milk Supply (bill. lbs.)	Blend Price (\$/cwt)	Δ in Consumer Welfare	Δ in Producer Welfare	Δ in Taxpayer Welfare	Δ in Net Social Welfare
			- - - - -	10's of million \$	- - - - -	
1969	90.059	8.908	-1044.075	205.581	163.244	-675.250
1970	89.950	9.217	-1009.017	190.044	172.191	-646.782
1971	91.781	9.100	-886.389	101.357	264.499	-520.533
1972	98.494	8.638	-695.179	-94.451	509.885	-279.745
1973	88.390	12.559	-1412.135	409.638	-2.376	-1004.873
1974	80.468	17.243	-2065.589	776.461	-325.827	-1614.955
1975	86.510	15.994	-1552.447	498.017	-90.136	-1144.566
1976	96.079	15.696	-1295.264	252.255	202.716	-840.293
1977	95.508	15.372	-1118.629	167.625	267.502	-683.502
1978	98.479	16.331	-1081.782	105.269	358.974	-617.538
1979	96.162	20.422	-1453.950	369.720	83.275	-1000.955
1980	95.253	21.851	-1325.015	317.988	107.866	-899.161
1981	95.532	23.416	-1319.507	329.872	93.506	-896.129
1982	100.422	20.911	-971.380	96.678	323.536	-551.165
1983	98.475	22.442	-1140.169	316.998	82.838	-740.332
1984	102.352	21.797	-1064.527	271.913	128.442	-664.172
1985	101.701	22.187	-1177.348	343.635	8.265	-825.448
1986	104.519	21.324	-1104.208	329.033	22.298	-752.876
1987	102.529	23.574	-1347.618	485.846	-147.340	-1009.112
1988	103.228	22.673	-1220.729	402.223	-87.058	-905.564

Table 6. The Effects of 'Social Optimal' Levels of Research (Prices determined where supply=demand)

	Milk Supply (bill. lbs.)	Blend Price (\$/cwt)	Research Expendi- tures (mill. \$)	Δ in Producer Welfare (10's of million \$)	Δ in Net Social Welfare
1969	125.472	3.85	371.300	-294.797	406.797
1970	125.739	3.97	397.796	-298.455	411.445
1971	128.407	3.93	407.883	-368.113	499.635
1972	139.030	3.70	448.631	-556.726	733.208
1973	124.561	5.33	491.357	-167.149	265.829
1974	113.294	7.27	564.999	118.087	168.933
1975	122.324	6.75	623.843	-98.848	170.773
1976	137.255	6.60	687.760	-355.760	534.104
1977	136.228	6.47	722.444	-389.031	560.100
1978	142.013	6.77	872.355	-465.570	660.795
1979	138.984	8.42	1016.078	-259.397	417.132
1980	138.146	8.92	1204.774	-275.158	417.940
1981	136.518	9.992	1102.576	-223.021	363.145
1982	142.961	9.099	1070.620	-380.163	543.214
1983	138.906	9.947	1002.231	-161.846	366.567
1984	145.280	9.566	1090.792	-195.143	414.416
1985	144.022	9.741	1139.142	-113.996	220.385
1986	147.980	9.386	1152.238	-113.015	256.893
1987	146.360	10.160	1355.084	13.533	58.850
1988	147.061	9.768	1424.773	-37.555	71.149

status quo. As a result, market prices fall substantially. However, net welfare for society as a whole improves.

V. Implications and Concluding Remarks

In the evaluation of agricultural policy, it should be recognized that interactions between research and commodity policy may result in these two types of policies being selected jointly. Research increases social welfare but, under the conditions which characterize the dairy industry, producers lose while consumers gain. Because dairy farmers have significant political influence, it appears that commodity policy allows governments to partially compensate producers and increase research expenditures from what they otherwise would be so that a Pareto improvement can occur. This is the case, despite the presence of the deadweight losses which accompany price intervention policies. The model results also indicate the way in which the joint determination of the two policies can lead to underinvestment in research in U.S. agriculture.

Strong support for the hypothesis that governments choose research and price supports jointly was given by the almost identical values of the political weights generated from each of the two policy-decision rules. Empirical results support the hypothesis of the paper that price supports and public research expenditures are used as complementing instruments. Consistent with intuition, the model predicts that governments will intervene with price supports more heavily in sectors with a more inelastic demand, elastic supply, and highly productive research. These same industries are expected to have a greater level of underinvestment.

A current empirical example of the interaction between the two types of policies in the U.S. dairy industry has arisen in the public debate over the introduction of the bovine growth hormone. This growth hormone is a protein which occurs naturally in cows. When the natural level of the hormone is supplemented by injections, the amount of milk which each cow can

produce is increased, even if all other inputs are held constant. The research efforts which have made this biotechnology available were to a significant degree publicly funded. The adoption of the bovine growth hormone will push out the supply schedule for milk and will increase the amount of milk which will be produced for any fixed level of price support.

It is widely recognized that such a development will increase the cost of maintaining any given level of the price support. It is also widely feared among farmers that this will lead to a lowering of the level of the price support. These farmers feel that the price of milk will be lowered to the point that, despite their now lower per-unit costs of production, they will generate less profit in the new environment than they are currently able to generate. Accordingly, they expect the price policy to react to the presence of the new technology. They realize that the research policy has results which interact with the price policy selection.

Dairy industry participants also recognize that the research policy which has made the introduction of the growth hormone possible is endogenous to the market for milk. Of course, the characteristics of this market are heavily influenced by the level of the support price. The endogeneity of the research policy to such characteristics is evident in the public response to the anticipated widespread adoption of the bovine growth hormone. Many have called for a halt to the further development of the growth hormone. Wisconsin and Minnesota, both important dairying states, have passed temporary legislation to ban the use of the bovine growth hormone. While these developments have revealed some concern about the effect of the hormone on the quality of the milk, more important concerns have focused upon the anticipated economic consequences of the widespread adoption of the hormone.

This episode, as it unfolds in the dairy industry, is indicative of an awareness among industry participants that interactions between the two types of policies do exist. Furthermore, participants and observers of the dairy industry believe that, to at least some extent, the two types of policies are jointly determined. They are actively engaged in attempting to influence the portfolio of policies which will be implemented. In the U.S. dairy industry, further research-induced technical advancement is being blocked (or at least slowed

down) while a price-support policy continues to channel income from consumers and taxpayers to producers. This outcome is one in which research and research-induced advances may well appear to be underutilized or underfunded from a pure social-welfare perspective. However, the existence of a price support indicates that the welfare of the two groups is not weighted equally by policymakers. Moreover, since interactions between the two policies necessitate that the two instruments be jointly determined, it follows that the two instruments are complements. What would otherwise appear to be a combination of "underinvestment" in the advancement of technology and "overinvestment" in a price-support intervention can be understood within the framework advocated in this paper.

Footnotes

¹There are many important examples of productive policies in agriculture in addition to research expenditures. Some of the more notable ones include extension, irrigation, rural electrification, and transportation facilities (Stiglitz 1989).

²Mueller states further, "although allocative efficiency and redistributive issues are inevitably intertwined, it is useful analytically to keep them separate, and we shall endeavor to do so wherever possible." Hence, while the public choice literature has made a distinction between the two types of policies, it has intentionally advocated treating them separately.

³Magee, Brock, and Young (1989, p. xv) claim 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 in providing productive policies as well. Further, such a framework does not allow for governments to account for the interaction effects between the two policies when they determine them jointly.

⁴The results of this analysis are qualitatively similar to the outcome which obtains when either a production subsidy or a target price program are substituted for the price support instrument. This point is demonstrated in Nielson, Rausser, and de Gorter (1990).

⁵The CCC has made positive net purchases each year since 1955. However, market prices often are above Class II support prices during a year since CCC purchases are seasonal. The Class II support price P_{II} was found to be 99.9 percent of the market price on average for the time period, 1955-1988. Hence, we ignore the distinction between P_{II} and the market price for manufacturing products in this study.

⁶For a detailed review of the mechanics of the U. S. dairy program, see Ippolito and Masson (1978).

⁷Imports of manufacturing milk products in the United States are very low and stable throughout the historical time period under investigation. Hence, they are ignored throughout the analysis, without consequence for our results.

⁸Nielson, Rausser, and de Gorter (1990) have a detailed presentation of the economic model and the methodology underlying this econometric specification of the supply model.

⁹The estimated elasticities are taken from Sullivan, Wainio, and Roningen (1989). The weighted average total demand for milk for the time period, 1955-1988, is -0.418.

¹⁰A complete documentation of the model simulation inputs and outputs are available from the authors upon request.

¹¹More recently, Fox (1985) finds that optimal expenditure levels for public research were on the order of four times recent actual expenditure in U.S. agriculture. Hence, the results of this paper are entirely consistent with recent studies.

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