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## Measuring the social costs of suboptimal combinations of policy instruments: A general framework and an example

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### Abstract

Since most agricultural programs employ two or more policy instruments simultaneously, it is notable that little research has attempted to find optimal instrument combinations and no research exists which evaluates the social costs (unrealized benefits) of combining instruments suboptimally. In our paper we report a simple and feasible method to find optimal policy instrument combinations, and we provide the first general, formal approach to measuring the social costs of suboptimal policy instrument combinations. Our approach is illustrated in an analysis for five major U.S. crops (corn, feed grains, wheat, rice, cotton). The simple model we employ for the illustration suggests that except for the feed grains program, the observed programs combined policy instruments quite suboptimally. We conclude that agricultural economics research now can and should begin placing increased emphasis on studying optimal policy instrument combinations. © 1998 Elsevier Science B.V. All rights reserved.

*Keywords:* Social costs; Policy instruments; Suboptimal combinations

### 1. Introduction

Since Wallace (1962), many studies have attempted to use economic welfare measures to find the social costs of agricultural programs. Most of these studies investigate the social costs incurred by suggested or existing programs (e.g. Dardis, 1967; Longworth and Knopke, 1982; Cramer et al., 1990; Albiac and Garcia, 1992; Voon, 1994), or compare the social costs of alternative policy options (Leu et al., 1987; De Gorter and Meilke, 1989; Babcock et al., 1990; Sarwar and Fox, 1992; Kola, 1993). Since most agricultural pro-

grams simultaneously employ two or more policy instruments,<sup>1</sup> it is notable that little research exists which attempts to find optimal (efficient) instrument combinations, and no research exists which tries to evaluate the social costs (unrealized benefits) of combining instruments suboptimally. Some recent papers do discuss the issue of combining instruments optimally. Just (1984), as well as Alston and Hurd (1990),

<sup>1</sup>Examples are manifold, like the combination of target prices, loan rates and acreage controls used in U.S. policy up through 1995, the combination of voluntary set-asides with compensation payments currently used under the EU's new arable regime, or the combination of import quotas and production controls currently used in the Canadian dairy and poultry sector.

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show that in a closed economy with no other markets affected by government intervention in an agricultural market, the optimal combination of target price and production quota is to restrict output at the nonintervention level and use the target price to achieve the desired transfer level. De Gorter et al. (1992) discuss an ‘optimal’ combination of agricultural research and production subsidies, where optimal policies maximize a political preference function. Gardner (1992) calculates the optimal combination of research spending and price supports for the U.S. grains sector. Maier (1993) discusses how the optimal mix of instruments changes with respect to changes in demand elasticities and export shares. Alston et al. (1993) as well as Moschini and Scokoi (1994) discuss theoretically the optimal combination of export subsidies and output subsidies as well as the optimal combination of tariff and direct payments. Bullock (1996) demonstrates for EC wheat policy that the actual welfare outcome was not optimal and calculates an optimal combination of the actual policy instruments. Salhofer (1996) illustrates for the Austrian bread grains market that the costs to consumers and taxpayers could be reduced significantly by implementing currently used instruments optimally. These papers do not try to measure the social costs of suboptimal policy instrument combinations.

In this paper we provide the first general, formal approach to measuring the social costs of a suboptimal combination of policy instruments by adapting Bullock’s (1994) general model of income redistribution to this specific problem. Evaluation of the social costs is based on the commonly accepted Pareto criterion. A side benefit of this research is that we provide a general but simple method to calculate optimal policy instrument combinations. Our method is general in the sense that it may be used on models that assume any number of policy instruments and any number of interest groups. This is in contrast to the papers cited above, which discuss optimal combinations of a few instruments (most often two) and a few interest groups (most often two: ‘producers’ and ‘consumers–taxpayers’).

For purposes of illustration we apply our method to a heuristic model of five major U.S. crops (corn, feed grains, wheat, cotton, and rice) recently developed by Gisser (1993). Our results imply that the social costs of suboptimal instrument combinations might be quite

high. Therefore we argue that future research should place increased emphasis on finding optimal combinations of instruments, rather than simply comparing the social costs of different instruments or programs.

## 2. A formal approach

The question addressed here is clearly one of normative social choice. If one wishes to measure the ‘social costs’ of a policy that is in some sense ‘suboptimal,’ one must somehow quantitatively compare the social state caused by this suboptimal policy with the social state caused by an ‘optimal’ policy. The social state of a society may be characterized by many factors; for example, the amounts of market and nonmarket goods consumed, the pollution level, and income distribution. Economists usually judge a social state by the levels of welfare of the individuals in it (Just et al., 1982; Boadway and Bruce, 1984).<sup>2</sup> So, very generally one can characterize a social state by a vector  $u = (u_1, \dots, u_n)$  consisting of the welfare levels  $u_i$  of all  $n$  individuals  $1, \dots, n$  in this society.

Government is able to influence individuals’ welfare levels and hence the social state by using policy instruments. For example, the introduction of a floor price policy for wheat may increase the welfare of individuals producing wheat and decrease the welfare of individuals buying wheat. Let  $x = (x_1, \dots, x_m)$  be a vector describing levels of policy instruments  $1, \dots, m$  which government is observed using. For example,  $x_1$  might be an acreage retirement requirement,  $x_2$  might be a deficiency payment per unit of output,  $x_3$  might be an environmental regulation, etc. Each of these policy instrument variables can take on different specific values, and we denote a specific policy instrument value with a superscript; for example,  $x_1^A$  is an acreage retirement requirement of 20 percent,  $x_2^A$  is deficiency payments of \$0.15 per kilogram,  $x_3^A$  is a fertilizer restriction of 50 kg per hectare, etc. A specific government *policy* is described by a vector of the values of all utilized policy instruments, for example,  $x^A = (x_1^A, x_2^A, \dots, x_m^A)$ .

<sup>2</sup>This of course does not mean that ‘noneconomic’ factors like environmental benefits are not considered in the characterization of a social state. Rather, they are taken into account according to their contributions to individuals’ welfare.

Though government has various policy instruments with which to influence individuals' welfare, it may be that not every policy is technically feasible. It makes little sense, for instance, to think about deficiency payments greater than the gross domestic product or an acreage retirement of more than 100 percent. Therefore, let  $X$  be the set of all policies that can be implemented given the limited resources in an economy, and call it the set of technically feasible policies, where  $x \in X$  for any technically feasible policy  $x$ .<sup>3</sup> In addition, government's abilities to influence individuals' welfare are limited by the realities of the economic markets. For example, the distribution of a tax's burden (i.e. the tax incidence) between producer and consumer depends on the properties of supply and demand, and the market structure, rather than on whom the levy is nominally placed. In economic models limits imposed by economic market realities are implicit in the model parameters (typically, e. g. supply and demand elasticities or the elasticities of substitution in a production function). Ultimately these parameters reflect human behavior and the technological relationship between scarce resources and production. Let  $\mathbf{b} = (b_1, \dots, b_z)$  be such a vector describing levels of exogenous market parameters 1, ...,  $z$ . Each of these market parameters can take on different specific values, and we denote a specific market parameter value with a superscript, for example,  $b_1^1$  is a demand elasticity of  $-0.5$ ,  $b_2^1$  is the supply elasticity of  $2.3$ ,  $b_3^1$  is the market share of an oligopolist of  $50$  percent.

Individuals' welfare levels can be modeled as depending on exogenous market conditions  $\mathbf{b}$  and government policy  $\mathbf{x}$ :<sup>4</sup>

$$\mathbf{u} = (h_1(\mathbf{x}, \mathbf{b}), \dots, h_n(\mathbf{x}, \mathbf{b})) = \mathbf{h}(\mathbf{x}, \mathbf{b}) \quad (1)$$

<sup>3</sup>Note that a technically feasible policy need not be politically feasible.

<sup>4</sup>As a reviewer correctly pointed out, some or all of the market parameters, like supply and demand elasticities, might not be exogenous to government policy, at least in the long run. If this is the case then  $\mathbf{b}$  depends on  $\mathbf{x}$  and  $\mathbf{u} = \mathbf{h}(\mathbf{x}, \mathbf{b}(\mathbf{x})) = \mathbf{g}(\mathbf{x})$ . If some of the elements of  $\mathbf{b}$  depend on  $\mathbf{x}$  and some do not, then  $\mathbf{b} = (\mathbf{b}_1(\mathbf{x}), \mathbf{b}_2)$ , and hence  $\mathbf{u} = \mathbf{h}(\mathbf{x}, \mathbf{b}_1(\mathbf{x}), \mathbf{b}_2) = \mathbf{f}(\mathbf{x}, \mathbf{b})$ . Therefore, our assumption that individuals' welfare levels are dependent on market parameters and government policy is generally applicable whether or not market parameters are exogenous or depend on policy.

Let us assume that the actual (observed) market conditions can be described by  $\mathbf{b}^1 = (b_1^1 \dots b_z^1)$ . In applied work these market parameters are often derived with econometric procedures. Then the set of technically feasible social states (or 'policy outcomes') is described by

$$F(\mathbf{b}^1) = \{\mathbf{u} | \mathbf{u} = \mathbf{h}(\mathbf{x}, \mathbf{b}^1), \mathbf{x} \in X\} \quad (2)$$

which is  $\min\{m, n\}$ -dimensional submanifold in  $R^n$  (Bullock, 1994).  $F(\mathbf{b}^1)$  contains all policy outcomes that government could achieve by combining the actually used instruments at all technically possible levels given limited resources, technology, and human behavior.

Given that the actual policy is described by  $\mathbf{x}^A \in X$ , the actual policy outcome  $\mathbf{u}^A$  is described by

$$\begin{aligned} \mathbf{u}^A &= (u_1^A, \dots, u_n^A) \\ &= (h_1(\mathbf{x}^A, \mathbf{b}^1), \dots, h_n(\mathbf{x}^A, \mathbf{b}^1)) = \mathbf{h}(\mathbf{x}^A, \mathbf{b}^1) \end{aligned} \quad (3)$$

which is a point in  $F(\mathbf{b}^1) \subseteq R^n$ .

Fig. 1 illustrates this general approach for the simple case of two policy instruments (acreage control and deficiency payments) and two individuals (farmer and nonfarmer). Fig. 1(a) represents the policy instrument space with  $x_1$  being the level of acreage controls and  $x_2$  being the level of deficiency payments. Fig. 1(b) represents the policy outcome space with  $u_1$  being the welfare level of the farming individual and  $u_2$  being the welfare level of the nonfarming individual. If  $x_1 = 0$  government does not use the acreage control instrument and no land is idled. If  $x_1 = 0.5$  half of the land is idled, and if  $x_1 = 1$  all land is taken out of production. The range between zero and one is technically feasible. If  $x_2 = 0$  government does not use deficiency payments, if  $x_2 = 1$  the farming individual receives deficiency payments of one dollar per unit, and if  $x_2 = x_2^x$  the farming individual receives deficiency payments of  $x_2^x$ , the highest payments technically feasible. The range between zero and  $x_2^x$  is technically feasible. Therefore the set of technically feasible policies  $X$  is given by the shaded area. Now let us assume  $\mathbf{x}^A = (x_1^A, x_2^A) = (0.5, 1)$  in Fig. 1(a) is the actual policy. Policy  $\mathbf{x}^A$  in the policy instruments space implies that the actual policy outcome is point  $\mathbf{u}^A$  in the policy outcome space. Policy  $\mathbf{x}^A$  is mapped from policy instruments space into point  $\mathbf{u}^A$  in the policy outcome space by  $\mathbf{u}^A = \mathbf{h}(\mathbf{x}^A, \mathbf{b}^1)$ . The shaded area in

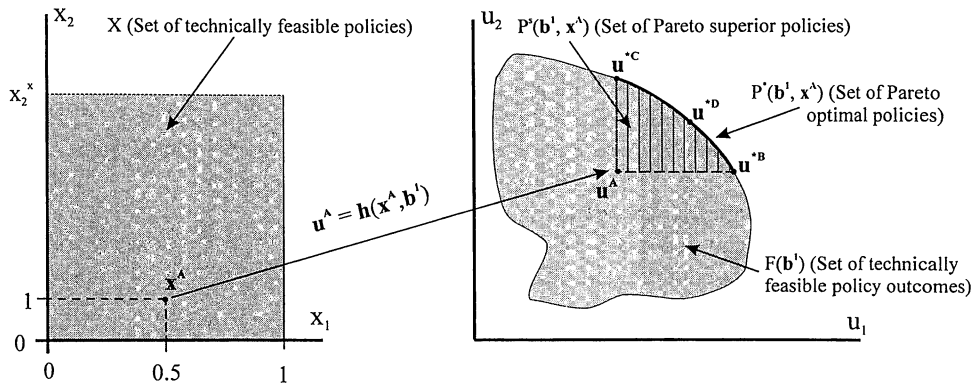


Fig. 1. Policy instrument space and policy outcome space.

Fig. 1(b) illustrates all the policy outcomes implied by all technically feasible policies in Fig. 1(a).<sup>5</sup>

To prove whether the actual policy  $x^A$  (i.e. the combination of policy instruments) is socially optimal or instead implies unrealized benefits from combining instruments suboptimally, it is necessary to define what is socially desirable. To decide if a policy (or its implied policy outcome), is socially preferable to another policy, one must establish social value judgment criteria. A very weak and hence commonly accepted social value judgment criterion in economics is the Pareto principle, which states that a policy  $x^B$  is preferred (or Pareto superior) to a policy  $x^A$  if  $x^B$  makes at least one individual better off than he or she is under  $x^A$ , while no one is made worse off. That is, under the Pareto principle for  $(x^A, x^B \in X, x^B \succ x^A \Leftrightarrow h_i(x^B, b) \geq h_i(x^A, b), i = 1, \dots, n)$ , with at least one strict inequality, where we use ‘ $\succ$ ’ to mean ‘socially preferred to.’ A policy is said to be Pareto optimal if there is no technically feasible policy Pareto superior to it. Given its general acceptance we utilize the Pareto principle as a criterion to judge alternative policies in this study.

Let  $X^S(b^1, x^A) \subseteq X$  be the set of policies Pareto superior to the actual policy  $x^A$ , given that the market conditions are  $b^1$ . Then the set of policy outcomes obtained from Pareto superior policy instrument combinations is described by

$$P^S(b^1, x^A) = \{u | u = h(x, b^1), x \in X^S(b^1, x^A)\} \quad (4)$$

<sup>5</sup>Note that the set of technically feasible policy outcomes in Fig. 1(b) is not actually computed but rather its form is assumed here for illustrative purposes.

In Fig. 1(b) the policy outcomes Pareto superior to the actual social state lie to the northeast of  $u^A$  and hence make up the dotted area between  $u^A, u^{*B}$ , and  $u^{*C}$ . For all points in this area the welfare of both individuals is at least as high as at  $u^A$  and the welfare of at least one of the two individuals is greater than under the actual policy. Now, let  $X^*(b^1, x^A)$  be the set of Pareto optimal policies in  $X^S(b^1, x^A)$  with  $X^*(b^1, x^A) \subseteq X^S(b^1, x^A)$ , then the set of policy outcomes obtained from Pareto optimal policy instrument combinations is described by

$$P^*(b^1, x^A) = \{u | u = h(x, b^1), x \in X^*(b^1, x^A)\} \quad (5)$$

In Fig. 1(b) the set of Pareto optimal policy outcomes is the thick-lined northeast boundary of the set of Pareto superior policy outcomes. For all points on this thick line between  $u^{*B}$  and  $u^{*C}$  it is not possible to increase the welfare of one of the two individuals without harming the other individual.

Now according to the Pareto criterion all points in  $P^*(b^1, x^A)$  are socially optimal. However, here we argue that the two points ( $u^{*B}$  and  $u^{*C}$ ) have a considerable theoretical advantage when measuring the social costs of suboptimal combinations (SCSC) of policy instruments. At  $u^{*B}$  and  $u^{*C}$  the welfare level of only one of the two individuals has changed while in all other socially optimal points between  $u^{*B}$  and  $u^{*C}$ , for example,  $u^{*D}$ , the welfare level of both individuals has changed. Hence, if we compare the optimal points  $u^{*B}$  and  $u^{*C}$  to the actual welfare outcome  $u^A$  we can measure the SCSC in terms of potential welfare gains of one individual. This circumvents the well-known problem of how to aggregate the welfare of different

individuals (Boadway and Bruce, 1984). Given this, we suggest measuring the SCSC as the change in welfare between the actual policy outcome  $u^A$  and the optimal policy outcome  $u^{*B}$ , that is, distance  $u^A u^{*B}$ , or as the change in welfare between the actual policy outcome  $u^A$  and the optimal policy outcome  $u^{*C}$ , that is, distance  $u^A u^{*C}$ . Here, distance  $u^A u^{*B}$  can be interpreted as the potential welfare gains of the farming individual and distance  $u^A u^{*C}$  as the potential welfare gains of the nonfarming individual.

More generally, the social costs of a suboptimal combinations of policy instruments are measured as the distance in welfare between a Pareto optimal policy outcome  $u^*$  and the actual policy outcome  $u^A$ , where  $(u^* = u_1^A, \dots, u_{i-1}^A, u_i^*, u_{i+1}^A, \dots, u_n^A)$  is a situation in which the welfare of only one individual is maximized, while all other individuals are kept at their actual welfare levels. Therefore, the social costs of a suboptimal combination of policy instruments in terms of potential welfare gains of individual  $i$  can be measured by

$$SCSC_i(b^1) = \|u^* - u^A\| = u_i^* - u_i^A = h_i(x^*, b^1) - h_i(x^A, b^1) \tag{6}$$

where  $x^*$  solves the constrained maximization problem

$$\max_{x \in X} \{h_i(x, b^1) : h_j(x, b^1) = u_j^A\} \text{ for } j = 1, \dots, i - 1, i + 1, \dots, n \tag{7}$$

and given that there exists a  $u_i$  satisfying  $(u_1^A, \dots, u_{i-1}^A, u_i, u_{i+1}^A, \dots, u_n^A) \in P^*(b^1, x^A)$ . (We discuss this assumption in the Appendix A).  $SCSC_i$  measures the social costs of suboptimal combinations of policy instruments in terms of potential welfare gains of individual  $i$ .

An additional benefit of our approach to measuring the SCSC is that by solving the maximization problem (7) it is possible to discover a policy  $x^* = (x_1^*, x_2^*, \dots, x_m^*)$  which uses Pareto optimal levels of policy instruments. While so far in the literature such an optimal combination of policy instruments is discussed for a few specific policy instruments (most often two instruments) and a few specific interest groups (most often two interest groups are represented: ‘producers’ and ‘consumers–taxpayers’) (Just, 1984; Alston and Hurd, 1990; De Gorter et al., 1992; Alston et al., 1993; Moschini and Sckokai, 1994; Bullock, 1996; Salhofer,

1996) our general method may be used on models that assume any member of policy instruments and any number of interest groups.

### 3. Illustrative example

We will now illustrate this general procedure by applying it to a heuristic partial equilibrium model recently developed by Gisser (1993) of five major U.S. crops (corn, feed grains, wheat, rice, and cotton).<sup>6</sup> In this model production of an agricultural commodity is described by a CES-production function:

$$Q = Z(\alpha A^{-\rho} + \beta B^{-\rho})^{-1/\rho} \tag{8}$$

where  $Q$  denotes the quantity of an agricultural product,  $Z$  a shift parameter,  $B$  the land used for production,  $A$  encompasses all other inputs, and  $\alpha, \beta$ , and  $\rho$  are production function parameters. Since land is considered fixed, either by government or by nature, and the input price of the variable factor ( $P_a$ ) is assumed to be constant throughout the analysis, the production function can be immediately inverted to obtain a derived conditional demand function for input  $A$ . The fixed factor is assumed to be owned by the firm. Total variable costs of production equal the cost of the purchased factor,  $C = P_a A$ . The first derivative of the cost function with respect to  $Q$  gives us the marginal cost function or the short run supply function:

$$P = \alpha^{1/\rho} P_a Z^\rho (Q^{-\rho} Z^\rho - \beta B^{-\rho})^{-(1+\rho)/\rho} Q^{-(1+\rho)} \tag{9}$$

where  $P$  denotes the supply price.<sup>7</sup>

Total (domestic plus the rest-of-world excess) demand is described by the constant elasticity demand function:

$$Q = HP_d^\eta \tag{10}$$

<sup>6</sup>The model is a standard neoclassical model in the tradition of Floyd (1965). Gisser’s (1993) model is based on the time period 1984–1988. In our view, Gisser’s model is too simple and stylistic to be used in serious empirical work. Our purpose in employing this model is to take advantage of its simplicity to illustrate our method, and not to provide serious measurement of the suboptimality of U.S. agricultural policy instrument combinations.

<sup>7</sup>Eq. (9) is a conditional supply function since  $Q$  on the right hand side of Eq. (9) changes if market parameters and  $B$  change. To derive unconditional quantities  $Q$ , given  $P, B$  and market parameters, we solve Eqs. (8) and (9) simultaneously.

Table 1  
Market parameters of five major crops

	Elasticity of demand ( $\eta^1$ ) (1)	Export share ( $E^1$ ) (2)	Input price of factor A ( $P_a^1$ ) (3)	Target Price ( $P^A$ ) (4)	Market value of output (\$) (5)
Corn	-0.75	0.224	0.9774	1.281	15,796
Feed grains	-1.96	0.159	0.8897	1.166	3,283
Wheat	-3.00	0.568	1.0117	1.326	6,746
Rice	-2.20	0.501	1.2948	1.697	907
Cotton	-0.50	0.412	0.9774	1.281	3,559

Source: Gisser (1993).

where  $\eta$ ,  $H$  and  $P_d$  are the price elasticity of demand, a shift parameter, and the world market as well as the domestic demand price. Domestic demand is given by:

$$Q_d = (1 - E)HP_d^\eta \quad (11)$$

where  $Q_d$  is the domestic quantity demanded, and  $E$  denotes exports as a proportion of total demand.

Eqs. (8)–(11) describe an agricultural commodity market. Market parameters are  $b = (\alpha, \beta, \rho, Z, H, P_a, \eta, E)$ . We are able to describe the five agricultural commodity markets under investigation by applying the specific market parameters  $b^1 = (\alpha^1, \beta^1, \rho^1, Z^1, H^1, P_a^1, \eta^1, E^1)$  to Eqs. (8)–(11). According to Gisser (1993) the production parameters  $(\alpha^1, \beta^1, \rho^1)$  are assumed to take on the values (0.763, 0.237, 5.0976) for every commodity.  $Z^1$ , and  $H^1$  are set to one, and  $\eta^1$ ,  $E^1$ ,  $P_a^1$ , are reported in columns (1) through (3) in Table 1 for all commodities. For example, in the case of corn  $b_c^1 = (\alpha^1, \beta^1, \rho^1, Z^1, H^1, P_{ac}^1, \eta_c^1, E_c^1) = (0.763, 0.237, 5.0976, 1, 1, 0.9774, -0.75, 0.224)$ .

The model of Eqs. (8)–(11) is represented graphically in Fig. 2 where  $S_0$  and  $D_d$  denote domestic supply and demand curves. Curve  $D$  is the domestic plus rest-of-world excess demand. At a given price, the horizontal difference between  $D$  and  $D_d$  divided by the distance between the vertical axis and  $D$  is therefore the export share  $E$ . In a free market, without government intervention,  $P = P_d$ , and equilibrium would be determined at point  $G$ , where supply intersects demand and equilibrium price ( $P_e$ ) and quantity ( $Q_e$ ) are realized.

For simplicity we investigate the combination of two major instruments of U.S. agricultural policy

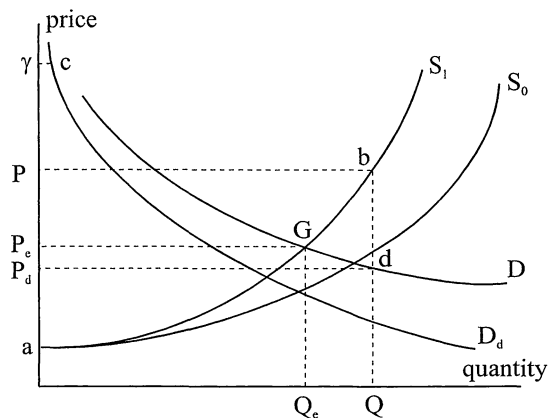


Fig. 2. U.S. agricultural policy.

(target price and acreage control).<sup>8</sup> In order to receive the target price  $P$  farmers have to idle land as required by the acreage reduction program. Due to this constraint on the production factor land, production costs rise and the supply curve pivots from  $S_0$  to  $S_1$ . The combined use of these two instruments leads to an output of  $Q$  and a world market price of  $P_d$ . The target price ( $P$ ) and the acres of land used for production ( $B$ ) are policy instruments in the model (8) through (11), and therefore  $x = (B, P)$  in this empirical example. Following Gisser (1993) the model is parameterized by setting the actual values of  $B$ ,  $A$ ,  $Q$ , and  $P_d$  to one. Since in the case of corn the target price  $P$  is 28.1 percent higher than the market price  $P_d$  the actual instrument vector for corn is described by  $x_c^A =$

<sup>8</sup>For the purposes of our heuristic example, we ignore the loan rate program, the Export Enhancement Program, and many other details of U.S. agricultural policy.

$(B_c^A, P_c^A) = (1, 1.281)$  (Table 1, column 4). Instrument vectors for all other crops are defined in the same way.

The market intervention described affects a large number of individuals, and a determination of the welfare effects on each individual is impractical both computationally and from the standpoint of data availability (Just et al., 1982, p. 147). So in applied welfare economics individuals are usually aggregated into market groups such as ‘producers,’ ‘consumers,’ ‘tax-payers’ etc. For illustrative purposes here we divide the society into two groups, farmers and nonfarmers. The welfare of farmers is measured by producer quasi-rents ( $PS$ ) which are given by revenues minus costs:

$$PS = PQ - P_a A, \quad (12)$$

or area  $aPb$  in Fig. 2.

Welfare of nonfarmers is measured by consumers surplus ( $CS$ ) minus taxpayer’s costs ( $T$ ).  $CS$  is calculated by

$$CS = \frac{(1-E)H}{\eta+1} (\gamma^{\eta+1} - P_d^{\eta+1}) \quad (13)$$

where  $\gamma$  denotes some arbitrary number with  $\gamma > P_d$ , since the constant elasticity demand curve does not meet the price axis.<sup>9</sup>  $CS$  is illustrated by area  $P_d\gamma cd$  in Fig. 2. Taxpayers’ costs are given by the difference between target price and market price times quantity supplied:

$$T = (P - P^d)Q \quad (14)$$

equal to area  $P_dPbd$  in Fig. 2.

The policy outcome for the two groups of individuals is described by the vector of welfare levels  $\mathbf{u} = (PS, CT) = (h_{PS}(\mathbf{x}, \mathbf{b}), h_{CT}(\mathbf{x}, \mathbf{b}))$ , where

$$CT = CS - T \quad (15)$$

The actual policy outcome for each commodity can be calculated by employing the specific market parameters  $\mathbf{b}^1$ , and the actual value of the variable  $\mathbf{x}$  in Eqs. (8)–(15). For example, in the case of corn the actual policy outcome is given by

$$\begin{aligned} \mathbf{u}^A &= (PS^A, CT^A) = (h_{PS}(\mathbf{x}_c^A, \mathbf{b}_c^1), h_{CT}(\mathbf{x}_c^A, \mathbf{b}_c^1)) \\ &= (4796, 33721) \end{aligned} \quad (16)$$

<sup>9</sup>Note that since we are interested in the difference in welfare levels rather than in the absolute welfare levels, the actual value of  $\alpha$  is not crucial to our analysis.

which can be calculated by using values  $\mathbf{b}_c^1$  and  $\mathbf{x}_c^A$  in Eqs. (8)–(15). The welfare of farmers is calculated to be US \$4,796 million, whereas nonfarmers’ welfare is US \$33,721 million.<sup>10</sup> The actual policy outcomes for all other crops are calculated similarly and appear in Table 2, columns 1 and 2.<sup>11</sup>

According to Eq. (7) we can calculate and optimal instrument combination by solving

$$\max_{\mathbf{x}_c} h_{PS}(\mathbf{x}_c, \mathbf{b}_c^1) \text{ s.t. } h_{CT}(\mathbf{x}_c, \mathbf{b}_c^1) = 33721 \quad (17)$$

where  $h_{PS}()$  and  $h_{CT}()$  are given by Eqs. (8)–(15). Eq. (17) calculates the maximum welfare available to corn farmers leaving nonfarmers at their actual level. We solved such a maximization problem using GAMS software (Brooke et al., 1988). The maximum welfare corn farmers can reach, given that the welfare of nonfarmers is the actual level of US \$33,721 million, is US \$5,139 million (column 3 in Table 2). The social costs of the suboptimal combinations of the policy instruments are US \$5,139–US \$4,796= US \$343 million in terms of potential welfare gains of farmers (column 5 in Table 2). Similarly, the maximum welfare nonfarmers can reach, given that the welfare of corn farmers remains at the actual level, is calculated by

$$\max_{\mathbf{x}_c} h_{CT}(\mathbf{x}_c, \mathbf{b}_c^1) \text{ s.t. } h_{PS}(\mathbf{x}_c, \mathbf{b}_c^1) = 4796, \quad (18)$$

and is US \$34,110 million (column 4, Table 2). Hence the social costs of suboptimal combinations of policy instruments are US \$389 million in terms of non-farmer welfare (column 6, Table 2). Table 2 also reports that the costs of suboptimal policy instrument combinations are also considerably high for all other crops, except feed grains. The total social costs of suboptimal instrument combinations for all five crops are calculated to be US \$1,733 million in terms of potential welfare gains of farmers and US \$1,911 million in terms of potential welfare gains of nonfarmers.

<sup>10</sup>Setting  $Q$  and  $P_d$  to unity implies that the market value of output ( $P_d Q$ ) of each commodity is unity, too. Therefore, to get the reported dollar values of farmers’ and nonfarmers’ welfare we have to multiply the results of (16), (17), and (18) by the market value of the output. Average annual market values of output for each commodity are taken from Gisser (1993) and reported in Table 1, column 5.

<sup>11</sup>Note that the welfare levels of farmers and nonfarmers are calculated separately for each crop.



Table 2  
Actual policy outcome, optimal policy outcome, and social costs of suboptimal instrument combination

	Actual policy outcome		Optimal policy outcome		Social costs of suboptimal combination in term of	
	Farmers mill. US\$ (1)	Nonfarmers mill. US\$ (2)	Farmers mill. US\$ (3)	Nonfarmers mill. US\$ (4)	Farmers mill. US\$ (5)	Nonfarmers mill. US\$ (6)
Corn	4,796	33,721	5,139	34,110	343	389
Feed grains	907	2,016	923	2,034	16	18
Wheat	2,120	-757	2,345	-505	225	252
Rice	365	-279	527	-103	162	176
Cotton	1,081	8,050	2,067	9,126	986	1,076
Total	9,268	42,751	11,001	44,662	1,733	1,911

Instrument vectors  $x^* = (B^*, P^*)$  which solve maximization problems (17) or (18) reveal Pareto optimal policy instrument combinations. Table 3 illustrates the changes in policy instrument levels induced by a change from the actual policy to a Pareto optimal policy. For example, in Table 3 it is reported that to obtain a Pareto optimal policy and realize potential welfare gains of US \$343 million for corn farmers, the target price would need to be increased by 9% and acreage would need to be decreased by 23% relative to actual instrument levels. Similarly, to realize the potential welfare gains of nonfarmers of US\$389 million, the target price would need to be increased by 7% and acreage decreased by 22% relative to actual instrument levels. Table 3 reveals that for some commodities, for example, rice and cotton, the needed policy changes are quite extreme. For example, an optimal cotton policy would be to raise the target price by 92% and lower acreage by 64% relative to actual instrument levels. Such extreme results may come about because of the simplicity of the model.

#### 4. Discussion

Many studies have measured and/or ranked the social costs of agricultural programs. Less research has attempted to find optimal combinations of policy instruments. So far, no research has tried to answer the question of how costly suboptimal combinations of policy instruments are. In this paper we provide a general, formal approach to the question of how to value the social costs of suboptimal combinations of policy instruments. Social costs usually measure the difference in social well-being between two alternative social states. Here social costs are defined as the difference in well-being between actual social state and the best social state technically feasible by combining the actually used policy instruments optimally. To define an optimal social state it is necessary to develop a social value judgment criterion. The value judgment criterion used here to derive an optimal social state and to measure social costs is the very weak (and hence commonly accepted) Pareto criterion. By expressing

Table 3  
Changes in instrument levels induced by optimal policies

	Optimal policy for farmers		Optimal policy for nonfarmers	
	Change in target price % (1)	Change in acreage control % (2)	Change in target price % (3)	Change in acreage control % (4)
Corn	9	-23	7	-22
Feed grains	-3	19	-4	20
Wheat	25	-48	20	-47
Rice	92	-73	53	-71
Cotton	92	-64	35	-61

the social costs of suboptimal combinations of policy instruments in terms of the potential welfare gains of one of the affected individuals it is possible to circumvent the problem aggregating welfare across individuals. Therefore, the theoretical definition of the social costs used here is much less controversial than in most other applied research, where social optimality and social costs are based either on the utilitarian criterion that society is completely indifferent to the degree of welfare inequality in the society, or on the assumption that lump sum transfers are possible.

Of course, in applied work aggregation of individuals' welfare into the welfare levels of groups of individuals is inevitable. However, to aggregate individuals of similar characteristics, for example, corn farmers, may be less problematical than aggregating the welfare of all individuals in society. This seems to be true especially if the policy under investigation has the redistributionary goal of transferring income from one group to another, as in the case of most agricultural policies. The applied researcher faces the challenge of dividing society into pertinent groups in a reasonable way.

Using the commonly accepted Pareto criterion instead of a social welfare function results in not only one measure of social costs, but rather in as many measures as there are pertinent groups. However, this should not be seen as a weakness of our approach but rather as a strength, since it allows the possibility of providing information about upper bounds of how much each of the various groups can gain from the changing of the actual policy to various optimal policies.

These results obtained from applying our methods will only be as good as the econometric model to which they are applied. Furthermore (as with methods used in most applied welfare studies), a limitation of our methods is that they are not 'statistical' in the sense that we have not provided a means of obtaining confidence intervals around the measurements of social costs of suboptimal policy instrument combinations. Thus, it would be important in applied research to either provide adequate sensitivity analysis of the results, or perhaps to use bootstrapping methods to examine the statistical properties of the social cost measures used (Kling and Sexton, 1990).

We employed a heuristic agricultural model recently used by Gisser (1993) to illustrate our approach empirically rather than to draw serious empirical conclusions. The effects of acreage control have been modeled crudely, some aspects of the investigated agricultural policy (loan rate program, Export Enhancement Program,...) have not been considered, horizontal and vertical market linkages have been ignored, and the welfare effects on pertinent interest groups, such as farm input suppliers, have not been considered. For more definitive conclusions to be drawn about the actual efficiency of U.S. agricultural policy, or any policy, agricultural research can and should now place increased emphasis on applying our methods to more serious empirical models.

Whether we should expect to observe that actual policies are Pareto optimal is currently under debate in the political literature. In his seminal article on political pressure groups, Becker (1983) derives a theoretical result which Gardner (1983) labels 'the efficient redistribution hypothesis.' Gardner (1987) attempts to test the efficient redistribution hypothesis, and Bullock (1995) critiques Gardner's approach and provides an alternative statistical test of the efficient redistribution hypothesis. It is well known that solutions to many simple noncooperative games, such as Prisoner's Dilemma, are not Pareto optimal. But in a cooperative game framework, we might think that no interest group would oppose a policy change that would make all groups better off, and therefore we might expect to find Pareto optimal policies in political-economic equilibria. Whether we should expect actual policies to be Pareto optimal may therefore depend on the type of 'game' being played by interest groups in the political arena.

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**Appendix A**

Clearly, if there exists no  $u_i$  satisfying  $(u_1^A, \dots, u_{i-1}^A, u_i, u_{i+1}^A, \dots, u_n^A) \in P^*(b^1, x^A)$  the solution to (7) will not be a Pareto optimal policy outcome, and hence our method will not lead to a correct measure of the SCSC. To illustrate an example of how the solution to (7) may not result in a Pareto optimal policy outcome, assume that the set of technically feasible policy outcomes takes the form in Fig. A. Then the set of Pareto superior policy outcomes  $P^s(b^1, x^A)$  is again the dotted area, and the set of Pareto optimal policy outcomes  $P^*(b^1, x^A)$  is the thick line. Policy outcomes obtained by solving (7) are  $u^{*B}$  and  $u^C$ . While  $u^{*B} = (u_1^A, \dots, u_{i-1}^A, u_i^{*B}, u_{i+1}^A, \dots, u_n^A)$  is a point in the set of Pareto optimal policy outcomes,  $(u^C = (u_1^A, \dots, u_{i-1}^A, u_i^C, u_{i+1}^A, \dots, u_n^A))$  is not. Hence distance  $u^A u^{*B}$  shows our measure of the social costs of suboptimal combinations of policy instruments which  $u^A u^C$  does not.

To test if the solution to (7) is a Pareto optimal policy outcome, one has to test if the following  $n-1$  conditions are satisfied (see Bullock, 1996):

$$\begin{aligned} & \max_{x \in X} \{h_j(x, b^1) : h_i(x, b^1) = u_i^* \text{ and } h_k(x, b^1) \\ & = u_k^A \forall k \neq i, j\} = u_j^A \text{ for } j = 1, \dots, i-1, \\ & \quad i+1, \dots, n, \end{aligned}$$

In the two-dimensional case in Figure A,  $u^{*B} = (u_1^{*B}, u_2^A)$  results from the solution to  $\max_{x \in X} \{h_1(x, b^1) : h_2(x, b^1) = u_2^A\}$ . To know that  $u^{*B}$  is Pareto optimal it is sufficient to show that  $\max_{x \in X} \{h_2(x, b^1) : h_2(x, b^1) = u_1^{*B} = u_2^A\}$ , since this is the case SCSC<sub>1</sub>

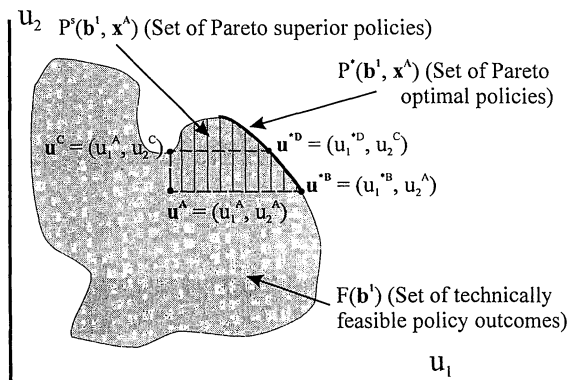


Fig. A. U.S. agricultural policy.

provides a valid measure. Similarly,  $u^C = (u_1^A, u_2^C)$  results from the solution to  $\max_{x \in X} \{h_2(x, b^1) : h_1(x, b^1) = u_1^A\}$ , and we need to test whether  $\max_{x \in X} \{h_1(x, b^1) : h_2(x, b^1) = u_2^C\} = u_1^A$ . But since  $\max_{x \in X} \{h_1(x, b^1) : h_2(x, b^1) = u_2^C\} = u_1^{*D}$  and  $u_1^{*D} \neq u_1^A$ , SCSC<sub>2</sub>, will not provide a valid measure of the social costs of the suboptimal combinations of policy instruments.

In our empirical example we calculated the maximum welfare corn farmers can obtain, given that the welfare of nonfarmers remains at the actual level of US\$33,721 million, by finding that  $PS^* = \max_{x_c} \{h_{PS}(x_c, b_c^1) \text{ s.t. } h_{CT}(x_c, b_c^1) = 33271\} = \text{US } \$5,139$  million. Hence, to be sure that  $PS^*$  was Pareto optimal, we used GAMS software to confirm that  $\max_{x_c} \{h_{CT}(x_c, b_c^1) \text{ s.t. } h_{PS}(x_c, b_c^1) = 5139\} = 33,721$ . We used similar methods to confirm that our measure of SCSC was valid for the case of maximizing the welfare of nonfarmers subject to the constraint that corn farmers' welfare be maintained at its actual level.

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