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# Judging agricultural policies: a survey

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**Abstract**

This survey provides a structured picture of 40 years of literature which uses welfare economic tools to judge agricultural policy. Challenges and developments of normative agricultural policy analysis are discussed in an easily accessible graphical framework. It is shown how the literature has gone from examining a very small discrete set of simple policies to a much broader (often continuous) set of policies that combine policy instruments simultaneously. The importance of the Pareto criterion, used to explore the limits of how government can affect welfare, is revealed. Moreover, given the importance of the objective of income redistribution in agricultural policy, agricultural economists have often departed from the purely efficiency-oriented tradition in economics. It is shown that they have tried to incorporate equity considerations by either adding these criteria as constraints to the social welfare function, or directly incorporating these criteria in the functional form of the social welfare function.



*JEL classification:* Q18; D61; D63

*Keywords:* Agricultural policy analysis; Review; Welfare economics

## 1. Introduction

Since agricultural economics is mainly an applied science, judging (assessing, comparing, or ranking) agricultural programs has a long tradition (Griliches, 1958; Nerlove, 1958; Wallace, 1962), and nowadays is an essential part of our profession's research and teaching. Whenever researchers try to measure the social costs of a program or compare the efficiencies of alternative programs, they must impose value judgement criteria, and hence, are conducting normative (or welfare economic) analysis. The purposes of this paper are (i) to present a general graphical framework of normative policy analysis with which it is possible to 'unify' the 40 years of literature which uses welfare economic tools to judge agricultural policy; and (ii) to provide a 'big picture' of the developments of that literature which will aid us in providing insight into how normative agricultural policy analysis should be and will be conducted in the future. While some of the ideas presented here are treated in a more general; and hence, analytical way in Bullock et al. (1999), the present study significantly contributes to understanding the developments and challenges of normative agricultural policy analysis in making these ideas more easily accessible by graphical presentation.

In the next section, the reader is invited to view agricultural policy analysis in three different 'spaces':

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'policy instrument space', illustrating government's potential policy choices; the classical 'price–quantity space', in which economists most commonly derive their welfare (surplus) measures; and 'welfare outcome space', which illustrates all potential social states as well as the trade-offs between different social groups' well-being. We argue that when these 'spaces' are kept in mind, it becomes obvious that the researcher conducting normative policy analysis faces three big challenges: (1) choosing a set of policies to be examined; (2) mapping from policy instrument space to welfare outcome space; and (3) applying value judgements that rank the welfare outcomes. Here, we concentrate our discussion on challenges (1) and (3).

After we introduce three policy analysis 'spaces' in Section 2, in Section 3 we discuss how the literature has gone from examining a very small discrete set of simple policies to a much broader (often continuous) set of policies that combine policy instruments simultaneously. Section 4 reveals the importance of the Pareto criterion as a basic value judgement in normative agricultural policy analysis, used to explore the limits of how government can affect welfare. While the Pareto criterion allows judgement of the efficiency of a policy, it does not consider distributive equity. However, as discussed in Section 5, given the importance of the objective of income redistribution in agricultural policy, agricultural economists have often departed from the purely efficiency-oriented tradition in economics. Instead, they have tried to incorporate equity considerations by either adding these criteria as constraints to the social welfare function (SWF), or directly incorporating these criteria in the functional form of the SWF. Finally, in Section 6 we attempt to provide insight into the future of normative agricultural policy analysis.

## 2. Three spaces of normative agricultural policy analysis

Traditional elements of normative analysis of agricultural policy can be illustrated by comparing the effects of two alternative policies: a target price/deficiency payments policy, and a mandatory set-aside (acreage control) policy. As depicted in Fig. 1, the most common method is to use geometric areas behind supply and demand curves, i.e. con-

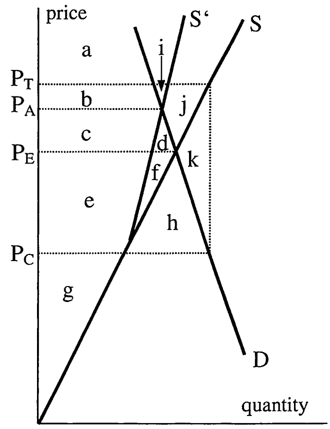


Fig. 1. Effects of target price/deficiency payments and acreage control in price–quantity space.

sumer and producer surplus measures, to calculate the welfare impacts of different policies. In a closed economy without government intervention, where demand is depicted by line $D$ and supply by line $S$, an equilibrium occurs at price $P_E$ implying a consumer welfare level represented by area $a+b+c+d$, and a producer welfare level of $e+f+g$. A target price $P_T$ implies a consumer price of $P_C$, deficiency payments per unit of $P_T - P_C$, consumer welfare represented by area $a+b+c+d+e+f+h$, producer welfare of $b+c+d+e+f+g+i+j$, taxpayer costs of $b+c+d+e+f+h+i+j+k$, and social costs (i.e. the sum of all groups' welfare changes) of $k$.[1] Acreage control pivots the supply curve $S$ upwards to $S'$ from some point where the restriction on land becomes binding. Producers as well as consumers face a price $P_A$ implying consumer welfare of $a+b$, producer welfare of $c+e+g$, and social cost of $d+f$.

Let us call Fig. 1, with 'quantity' and 'price' variables on its axes, an analysis in 'price–quantity space'. To better understand the developments and challenges of normative agricultural policy analysis, we propose to add two more spaces as illustrated in Fig. 2. Assuming that the target price/deficiency payments and acreage control are the only policy instruments available to government, the left-hand panel in Fig. 2 illustrates the 'policy instrument space'. The acreage

[1] The sum of all groups' welfare changes is $-k$, but social costs are $k$, since the term 'costs' already indicates a negative value. The same is true for taxpayer costs.

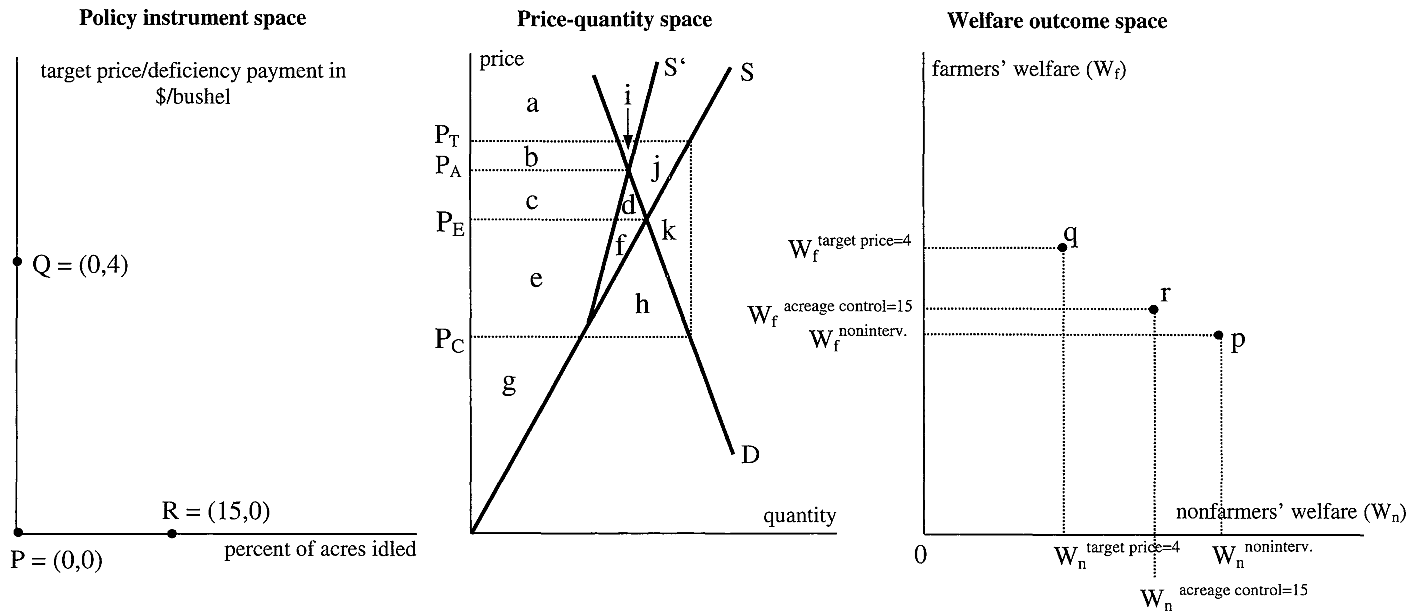


Fig. 2. Three spaces of normative agricultural policy analysis.

control policy instrument variable, stated in terms of percentage of acreage required diverted, is placed on the horizontal axis of the panel, and the target price variable, stated in US$/bushel, is on the vertical axis. Point $P$ illustrates the non-intervention situation where government uses neither the acreage control nor the target price instrument.[2] Point $Q$ depicts a target price of US$ 4/bushel, and point $R$ shows mandatory set-aside of 15%. Any policy available to government can be represented by a point in policy instrument space. Hence, the left-hand panel helps us to better understand government's available instrument choices.

The final goal of normative policy analysis is to obtain a social ordering of alternative policies. A commonly excepted assumption in normative policy analysis is welfarism (Sen, 1979), i.e. that the judgement of the social value of a policy should be based solely on its welfare effects on individuals (or perhaps groups). Hence, the natural space to depict the effects of a policy is the 'welfare space'. The right-hand panel of Fig. 2 illustrates the welfare effects of the policies depicted in the left-hand panel. For illustrative purposes (but in line with the main body of the literature) we assume that society can be divided into two social groups: farmers and non-farmers. The three different policies depicted in the left-hand panel by points $P$, $Q$ and $R$ can be respectively mapped onto points $p$, $q$ and $r$ in the welfare space by utilising the market diagram in the 'price–quantity space' panel. For example, distance $0W_{\mathrm{f}}^{\mathrm{noninterv.}}$ in the right-hand panel corresponds to area $e + f + g$ in the middle panel, distance $0W_{\mathrm{n}}^{\mathrm{noninterv.}}$ to $a + b + c + d$, and so the non-intervention outcome shown at point $p = (0W_{\mathrm{n}}^{\mathrm{noninter.}}, 0W_{\mathrm{f}}^{\mathrm{noninter.}})$ in the right-hand panel corresponds to the non-intervention policy shown at point $P$ in the left-hand panel. Here, we explicitly and intentionally display all three spaces in our analysis. Presenting all three spaces makes obvious three main challenges of normative policy analysis:

(1) choosing a set of policies to be examined;
(2) mapping from policy instrument space to welfare outcome space; and
(3) applying value judgements that rank the welfare outcomes.

In regard to challenge (1), the left-hand panel of Fig. 2 makes clear that the three examined policies depicted are only a very limited selection of the many possible policies that could be exhibited in the entirety of the 'policy space'. In reality government can choose different levels of both instruments and use them separately or combine them. It is technically feasible (though not necessarily politically feasible) for government to set the acreage control variable anywhere between 0 and 100% (see Fig. 3). Similarly, it is technically feasible for government to set the target price variable anywhere from 0 up to some very high level, call it $y'$, above which the economy does not have sufficient resources to pay farmers more for their product. Given these physical limitations on policy instrument choice (and the already mentioned assumption that only two instruments are available to government), the shaded area in the left-hand panel of Fig. 3 represents the set of technically feasible policies. Clearly, the set of technically feasible policies is much larger than simply points $P$, $Q$ and $R$ in Fig. 2.

Because points $P$, $Q$ and $R$ in the left-hand panel of Fig. 2 present a very limited view of government's policy choices, points $p$, $q$ and $r$ in the right-hand panel present also a very limited view of the policy outcomes government can achieve. If one calculated the welfare effects of every point in the shaded area in the left-hand panel of Fig. 3, one would derive the set of all technically feasible welfare outcomes (Bullock, 1995). This set might look like the shaded area in the right-hand panel of Fig. 3. Points $p$, $q$ and $r$ are members of the set of technically feasible policy outcomes, but many other points make up that set, as well. Clearly, an analysis that only considered policies $P$, $Q$ and $R$ by observing outcomes $p$, $q$ and $r$ would be neglecting many feasible policies, which conceptually might lead to policy outcomes that might somehow be deemed 'superior' to outcomes $p$, $q$ and $r$.

The second challenge is how to map points from policy instrument space into the welfare outcome space. As depicted by the middle panel of Fig. 2, one commonly used method is to assume some functional forms and parameter values for demand and supply

[2] Since producers receive the maximum of the target price and the market price, setting the target price to zero effectively precludes government intervention.

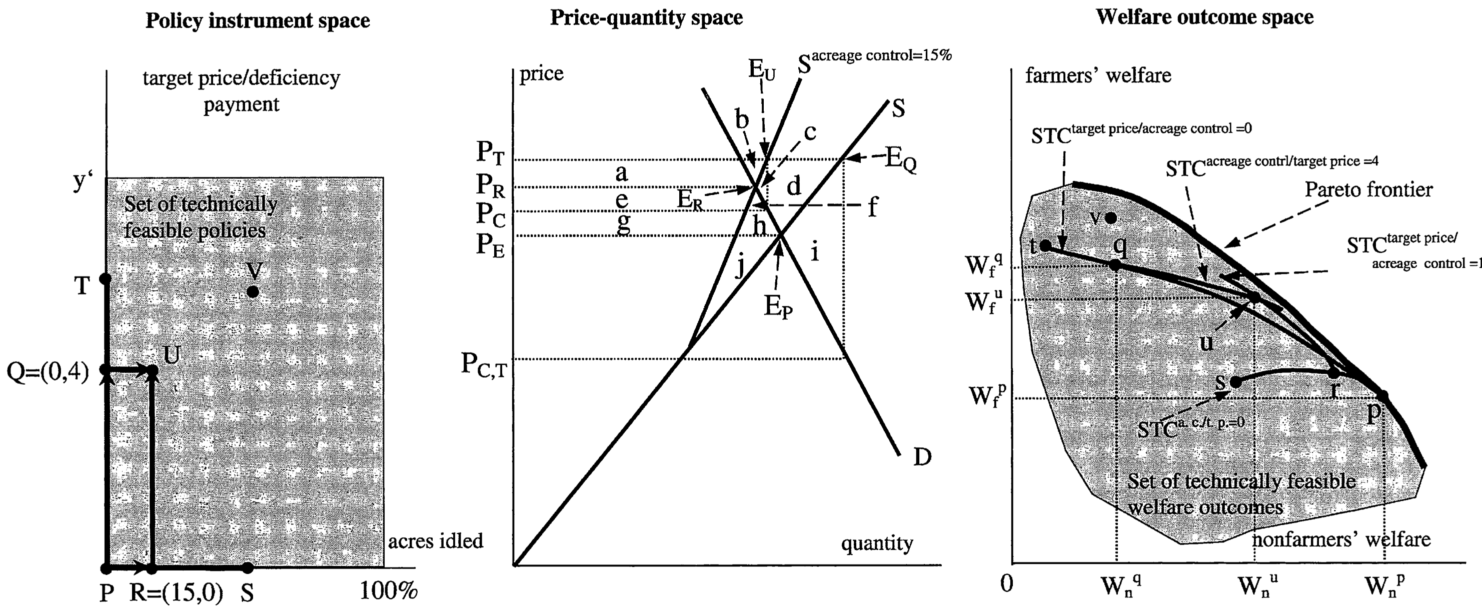


Fig. 3. Set of technically feasible policies and welfare outcomes.

curves and derive Marshallian welfare measures.[3] More generally and systematically, to derive welfare measures it is necessary

(i) to develop an appropriate model of the sector of the economy studied,
(ii) to obtain appropriate estimates of the model's parameters, and
(iii) to obtain appropriate welfare measures.

Numerous advances have been made in all of these three areas over the last 40 years. Examples of efforts to address (i) are advances made in non-co-operative game theory (see Sexton, 1994a,b for a survey). Examples of efforts in (ii) are Deaton and Muellbauer's (1980) method of estimating demand systems rather than single equations, and Christensen et al.'s (1971) more flexible descriptions of production technology. Examples of efforts to improve welfare estimation techniques (iii) have taken into account multi-market effects (Just and Hueth, 1979; Just et al., 1982; Thurman and Wohlgenant, 1989; Bullock, 1993; Thurman, 1993; Brännlund and Kriström, 1996), non-competitive market structure (Just et al., 1979; Wong, 1989; McCorriston and Sheldon, 1994; Peterson and Connor, 1995), and the presence of risk and uncertainty (Just et al., 1977; Konandreas and Schmitz, 1978; Wright, 1979; Helms, 1985; Larson, 1988; Fraser, 1992). These days, much applied welfare analysis is conducted using Computable General Equilibrium models (see Hertel and Tsigas, 1991; Hertel, 1998; Weyerbrock, 1998; Blake et al., 1999; Philippidis and Hubbard, 2001; van Tongren et al., 2001; Warr, 2001). One advantage of CGE models is that since they are built by assuming consumer preference relations directly, expenditure functions are 'built in', and equivalent variation can be measured directly. Of course, the reliability of any measure of equivalent variation due to a policy change depends on the appropriateness of the underlying assumptions about consumer preferences.

Even if the policy analyst is able to observe all feasible policy choices and to map them into the welfare outcome space, Fig. 3 makes clear a third main challenge of normative policy analysis, which is to decide how to properly rank policy choices and outcomes. For example, part of this challenge might be to whether the welfare outcome $q$ is socially more desirable than the welfare outcome $r$. Clearly, to rank policies and policy outcomes one must apply value judgements. Agricultural policy analysts have employed various value judgement criteria to derive rankings of alternative policies. Presenting the welfare space enables us to compare these alternative welfaristic value judgements straightforwardly.

In what follows we concentrate on the first and third challenges of normative policy analysis listed above. In Section 3 we will discuss how agricultural economists over the past 40 years have explored the set of technically feasible welfare outcomes by filling in the set of examined policies in policy instrument space. Sections 4 and 5 will systematise the approaches used by agricultural economists to rank alternative policies by examining welfare outcome space.

## 3. Expanding the set of examined policies

### 3.1. Analysing a few simple policies

Wallace (1962) as well as other early contributors to normative agricultural policy analysis including Nerlove (1958), Johnson (1965), Dardis (1967a,b), and French-Davis (1968) pioneered the literature by introducing welfare economic tools to examine discrete sets of simple, single policy instruments. Hence, they compared the welfare effects of only a very few of the many feasible policies available to government, and the policies they examined only employed one instrument at a time, with all other instruments being set at their 'non-intervention' levels. In the left-hand panel of Fig. 3, such 'simple' policies are represented by points such as $P$, $Q$, $R$, $S$ and $T$ on the vertical and horizontal axes.

Starting with Josling (1969), Dardis and Dennison (1969), and Hushak (1971), agricultural economists

[3] Though there exist techniques to obtain exact welfare measures such as compensating and equivalent variations (see, for example, Chipman and Moore, 1980; McKenzie, 1983; Cornes, 1992; Martin and Alston, 1994; Slesnick, 1998), using the approximative Marshallian surpluses is still the most common procedure among agricultural economists, as discussed in Alston and Larson (1993). Therefore, and because of their familiar graphical representations as areas between demand and supply curves and price–quantity axes, we also use Marshallian surpluses to illustrate the second challenge of mapping from policy instrument space into welfare outcome space.

also examined the welfare effects of combined agricultural policies; and hence, points off the axes of the policy instrument space, such as $U$ and $V$ in Fig. 3.

### 3.2. Analysing continuous sets of policies

Josling (1974) first recognised that by continuously changing the level of the instrument of a simple policy, a curve could be mapped in welfare space to provide a broader picture of government's opportunities and constraints when using a single policy instrument. Gardner (1983) expanded Josling's analysis, and actually derived such continuous sets of welfare outcomes calling them surplus transformation curves (STCs). Hence, instead of looking at only a few points in policy instrument space, Gardner examined the effects of continuous sets of simple policies like the thick line segments between $P$ and $S$ or between $P$ and $T$ in the left-hand panel of Fig. 3. Calculating the welfare effects of the continuous set of policies between $P$ and $S$ one derives a continuous set in policy outcome space, $\mathrm{STC}^{\text{acreage control/target price=0}}$ between $p$ and $s$. Similarly, calculating the welfare effects of the continuous set of policies between $P$ and $T$ one derives $\mathrm{STC}^{\text{target price/acreage control=0}}$ between $p$ and $t$. Hence, using the Josling–Gardner framework we get a more complete picture of how government is able to affect the welfare levels of the social groups analysed.

Examples of studies using this framework to examine the welfare effects of single policy instruments are Thomson and Harvey (1981), Gardner (1985, 1987), Just (1985), Antle (1991), Williams and Wright (1993, pp. 378–383), Isosaari (1993), Maier (1993a, pp. 126–143, pp. 216–225), Wright (1993), and Giannakas and Fulton (2000a).[4]

In the late 1980s and early 1990s, several researchers extended Gardner's (1983) approach to show how multiple STCs can be combined to study the welfare effects of combined policies (i.e. policies which employ more than one policy instrument) (Innes and Rausser, 1989; Alston and Hurd, 1990; Gardner, 1991, 1992; Bullock, 1992; de Gorter et al., 1993). Other studies using STCs for combined policies include Kola (1993), Salhofer (1993), Garcia and Lothe (1996), and Alston and James (2002). Their procedure is illustrated in Fig. 3. Let us assume government combines a target price of US\$ 4 with an acreage control policy of 15%. This combined policy is depicted by point $U$ in policy instrument space. Obviously, there are many possible paths from point $P$ to point $U$. Two examples are $P \to Q \to U$ and $P \to R \to U$. The path $P \to Q \to U$ first increases the target price from US\$ 0 to US\$ 4, and afterwards increases the acreage control from 0 to 15% while keeping the target price constant at US\$ 4. Moving along the vertical axis from $P$ to $Q$ in policy instrument space gradually increases the producer price in price–quantity space from $P_{\mathrm{E}}$ to $P_{\mathrm{T}}$ while decreasing the consumer price from $P_{\mathrm{E}}$ to $P_{\mathrm{C,T}}$. The (producer) price–quantity equilibrium moves from $E_{\mathrm{P}}$ to $E_{\mathrm{Q}}$. This implies a redistribution of welfare from non-farmers to farmers along $\mathrm{STC}^{\text{target price/acreage control=0}}$ in welfare outcome space. At a target price of US\$ 4, farmers' welfare (producer surplus) increases by area $a+b+c+d+e+f+g+h$ in price–quantity space, or distance $W_{\mathrm{f}}^{q}-W_{\mathrm{f}}^{p}$ in welfare outcome space. Non-farmers' welfare (consumer surplus minus taxpayer costs) decreases by $a+b+c+d+e+f+g+h+i$ in price–quantity space, which is distance $W_{\mathrm{n}}^{p}-W_{\mathrm{n}}^{q}$ in welfare outcome space.

In the second step the target price is kept constant at US\$ 4 while the acreage control is increased from 0 to 15%. This is illustrated by a horizontal movement from $Q$ to $U$ in policy instrument space. Increasing acreage control rotates the supply curve in the price–quantity space to the left, increasing the consumer price from $P_{\mathrm{C,T}}$ to $P_{\mathrm{C}}$. The (producer) price–quantity equilibrium moves from $E_{\mathrm{Q}}$ to $E_{\mathrm{U}}$. This implies a redistribution of welfare from farmers to non-farmers along $\mathrm{STC}^{\text{acreage control/target price=4}}$. Changing the acreage control from 0 to 15% (given a target price of US\$ 4) decreases farmers' welfare by area $c+d+f+h+j$ in price–quantity space, or distance $W_{\mathrm{f}}^{q}-W_{\mathrm{f}}^{u}$ in welfare outcome space. It increases non-farmers' welfare (consumer surplus minus taxpayer costs) by $d+i$ in price–quantity space, or distance $W_{\mathrm{n}}^{u}-W_{\mathrm{n}}^{q}$ in welfare outcome space. The overall welfare effect of going from $P$ to $U$ is an increase in farmers' welfare of $a+b+e+g-j$, which is $W_{\mathrm{f}}^{u}-W_{\mathrm{f}}^{p}$, and a change in the welfare of non-farmers of $-(a+b+c+e+f+g+h)$, which is $W_{\mathrm{n}}^{u}-W_{\mathrm{n}}^{p}$.

A different path from $P$ to $U$ first increases the acreage control from 0 to 15%, i.e. a movement from

[4] Norton et al. (1992), and Beach and Fernandez-Cornejo (1994) adopt the STC framework to illustrate the trade-off between efficiency and equity in the context of research policy.

$P$ to $R$. This shifts/rotates the supply curve in Fig. 3 to the left from $S$ to $S^{\text{acreage control}=15}$, and implies a new equilibrium $E_{\mathrm{R}}$ at price $P_{\mathrm{R}}$. This implies a redistribution of welfare from non-farmers to farmers along $\mathrm{STC}^{\text{acreage control/target price}=0}$ in welfare outcome space. At an acreage control of 15%, farmers' welfare changes by $e + g - j$, non-farmers' welfare by $-(e + f + g + h)$, and the new welfare distribution is given by point $r$ in the right-hand panel. The second step is to increase the target price, i.e. to move vertically from $R$ to $U$ in policy instrument space. This increases the producer price from $P_{\mathrm{R}}$ to $P_{\mathrm{T}}$ and decreases the consumer price from $P_{\mathrm{R}}$ to $P_{\mathrm{C}}$. Welfare is redistributed from non-farmers to farmers along $\mathrm{STC}^{\text{target price/acreage control}=15}$. Increasing the target price to US\$ 4 changes farmers' welfare by $a + b$ and non-farmers' welfare by $-(a + b + c)$. The total welfare effect to farmers of going from $P$ to $U$ is again $a + b + e + g - j$, which is $W_{\mathrm{f}}^{u} - W_{\mathrm{f}}^{p}$. Non-farmers' welfare change is $-(a + b + c + e + f + g + h)$ which is $W_{\mathrm{n}}^{u} - W_{\mathrm{n}}^{p}$.[5]

Using the procedure discussed above, one can map any line segment from policy instrument space into welfare space; and hence, get a more complete view of the trade-offs of alternative policies. Following the logic of the development of the literature, it becomes clear that, conceptually at least, we could map the whole set of technically feasible policies from the policy instrument space into the welfare outcome space to derive the whole set of technically feasible policy outcomes. Having identified all of government's possibilities to affect the welfare of groups and society, the goal is to judge and rank alternative welfare outcomes. To do this one must apply value judgement criteria.

## 4. Finding Pareto efficient policies

A value judgement criterion commonly accepted among economists is the Pareto criterion. According to this criterion, a policy $A$ is preferred (or Pareto superior) to a policy $B$, if $A$ makes at least one person (or in this context group) better off than he or she is under $B$, while no one (group) is made worse off.[6] A policy is said to be Pareto efficient (or Pareto optimal) if no technically feasible policy implies a Pareto superior welfare outcome. Clearly, the 'north-east' boundary of the set of technically feasible welfare outcomes in Fig. 3 represents the set of Pareto efficient policies, commonly called the Pareto frontier.

In the agricultural economics literature of the past 15 years or so, the importance of the Pareto frontier as a limit to how government can affect welfare has been considered by several researchers in independent work. Just (1984, p. 58, p. 130) and Alston and Hurd (1990) first derived a Pareto frontier for a very special case of two instruments: (i) a production quota and a (ii) target price/deficiency payments. As copied in the middle panel of Fig. 4, they showed that a Pareto efficient combination of these two instruments is to fix the quota at the non-intervention output level and set the target price level according to the desired level of welfare transfer to farmers.[7] For example, if the desired welfare transfer is $P_{\mathrm{E}}P_{\mathrm{T}}ab$, one has to set the target price at $P_{\mathrm{T}}$. Hence, in this case the set of Pareto efficient policies is point $P$ plus the line segment $QR$. This set of Pareto efficient policies maps to the Pareto frontier, which in this case is a straight 45° line from the non-intervention point $p$ to point $r$ in welfare outcome space.[8] Because, the Pareto efficient combination of these two policy instruments is relatively straight forward in a sense that one instrument is fixed at a certain level while only the other instrument is varied, Just (1984) and Alston and Hurd (1990) were able to

[5] While in this simple, single market example both paths imply the same final surplus changes, this does not hold in general. It is well known that in the case of multiple price changes or simultaneous price–income changes, Marshallian surplus measures may face a path-dependency problem (Silberberg, 1972). However, this is a problem of the exact measurement of welfare. Whatever path we take from $P$ to $U$ in policy instrument space, the welfare distribution from $p$ to $u$ in welfare outcome space will be the same if the welfare changes are calculated correctly.

[6] Defining the Pareto criterion for groups rather than individuals of course requires some strong assumptions about the preferences and endowments of the individuals condensed within a group, but is nevertheless common practice in applied work.

[7] Assuming that government can raise revenue without distorting other markets, setting the quota in the agricultural market at the non-intervention production level enables government to raise the target price above the non-intervention price level without attracting additional resources into the agricultural sector. It is this attraction of resources from other sectors in which they were more efficiently used that creates social cost.

[8] The Pareto frontier in this particular case is a 45° line because there is no social cost to welfare redistribution—every dollar taken from non-farmers provides a full dollar to farmers, as discussed in the previous footnote.

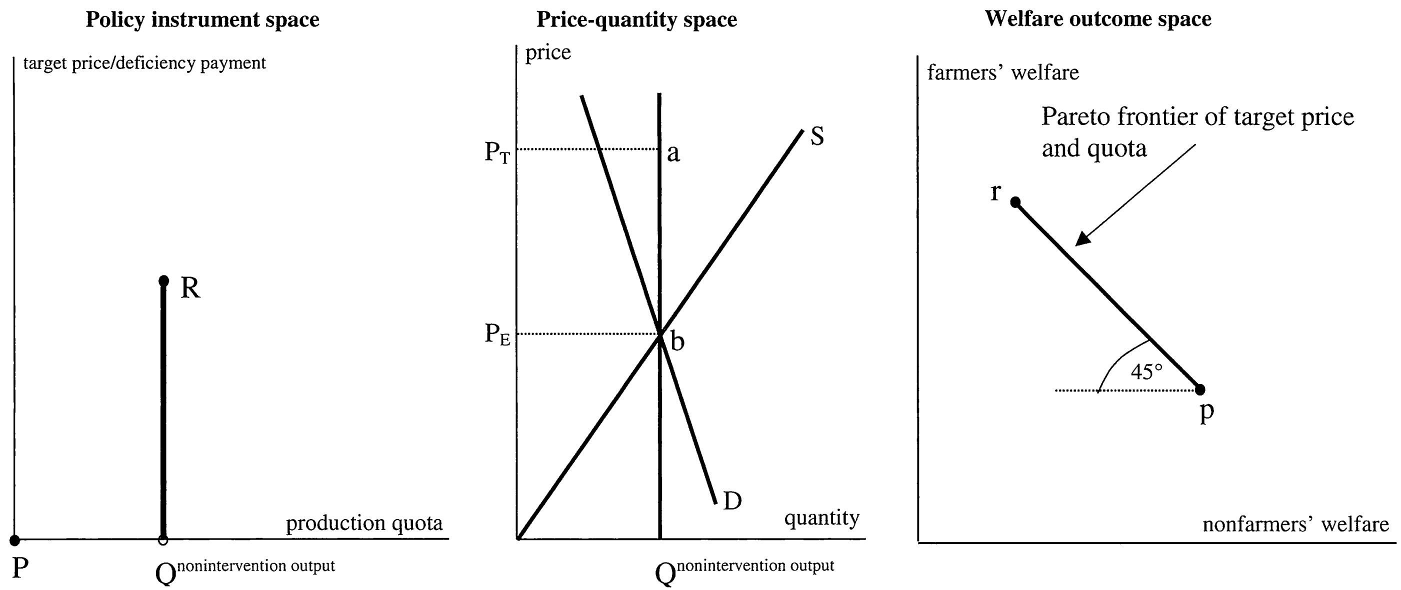


Fig. 4. Optional combination of target price/deficiency payments and production control.

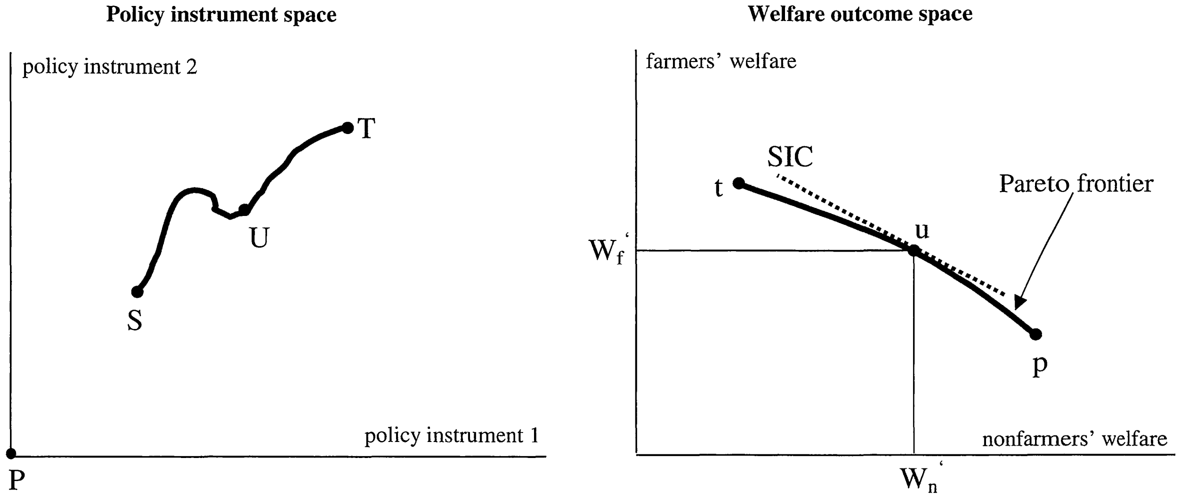


Fig. 5. Optimal combination of two policy instruments.

derive this Pareto frontier based on graphical analysis only. However, in most other cases the set of Pareto efficient policies is not a straight line parallel to one of the axes in policy instrument space, but perhaps may look more like point *P* plus curve *ST* in the left-hand panel of Fig. 5, which implies a non-linear Pareto frontier such as *pt* in the right-hand panel. In such a case, the points on the Pareto frontier can only be derived with some mathematical optimisation procedure.[9]

To derive Pareto efficient policy instrument combinations and/or Pareto frontiers, researchers have utilised two different approaches: (i) to find the highest possible welfare of one group while holding the other group's welfare constant; and (ii) to find the highest possible value of a (weighted) SWF.

Utilising approach (i), Alston et al. (1993) showed that points on the Pareto frontier can be derived by maximising the welfare of non-farmers given some predetermined welfare level of farmers. (Equivalently, one could minimise the cost to non-farmers given some determined welfare transfer to farmers.) As the authors note (footnote 7, p. 1002), their approach may be thought of as a procedure for defining an "efficient surplus transformation curve" (a Pareto frontier) for a given set of available policy instruments. This method can be explained with reference to Fig. 5. First, the welfare of farmers is fixed at some level $W_f'$ while looking for the combination of policy instruments that ensures a welfare for non-farmers which lies as far as possible to the right. The maximised non-farmers' welfare level is shown as $W_n'$, and the point $u = (W_n', W_f')$ is on the Pareto frontier. By changing the fixed value of farmers' welfare in the maximisation problem's constraint from $W_f'$ to other levels, the entire Pareto frontier *pt* as well as the set of Pareto efficient policy instrument combinations *P* plus *ST* can be calculated and traced out.[10]

[9] In each of Figs. 3–5, we present the non-intervention point *p* as being Pareto efficient, and therefore as leading to a welfare point *P* on the Pareto frontier. As long as the conditions of the First Fundamental Theorem of Welfare Economics are met, non-intervention will be Pareto efficient in equilibrium. But of course, in the real world, these conditions are not necessarily met, and non-intervention may not be Pareto efficient. Examples in which the conditions in the First Theorem are not met include declining average cost industries (as in Romer's (1991) New Growth Theory), externalities such as agricultural R&D that affect total factor productivity, and technological spillovers from other sectors, such as with information technology (Newbery and Stiglitz, 1981).

[10] Bullock (1994, 1996) noted how the envelope theorem implies that the Pareto frontier envelopes all Josling–Gardner STCs, and how at points along the Pareto frontier all STCs are tangent to a common hyperplane. From this finding one can deduce that an optimal combination of *m* instruments is always at least as desirable as a policy using only a subset of those *m* instruments. This result is stated in Rausser and de Gorter (1991) and Maier (1993b), proved for two specific instruments in Just (1984) and Gardner (1988), and proved for the general case of *m* instruments in Bullock and Salhofer (1998b).

Bullock (1991, 1996) developed a technique for finding Pareto efficient policies and policy outcomes for the general $m$-policy instrument, $n$-social group model. Bullock (1991) proved formally that a policy is Pareto efficient if and only if it solves simultaneously $n$ constrained maximisation problems. As proved by Bullock et al. (1999), Bullock's (1991, 1996) method of solving $n$ constrained maximisation problems simultaneously is equivalent to the simpler method proposed by Alston et al. (1993) of solving a single constrained maximisation problem only if the solution to their problem is unique, and therefore corresponds to a well-behaved set of feasible welfare outcomes.

Gallagher (1988); Maier (1993b); Salhofer (1993, 1997); Moschini and Sckokai (1994); Bullock and Salhofer (1998a); Swinnen and de Gorter (1998); Giannakas and Fulton (2000b) use techniques similar to Alston et al. (1993) and Bullock's (1991, 1996) to derive theoretical or empirical optimal combinations of two or more policy instruments; and hence, points on Pareto frontiers. Bullock (1994, 1996), Bullock and Salhofer (1995), Salhofer (1996) actually draw empirically derived Pareto frontiers by repeatedly solving optimisation problems as described in Alston et al. (1993) or Bullock (1991, 1996) for various optimisation constraints.

An alternative method used to derive Pareto efficient policies is to maximise a weighted utilitarian (i.e. linear) social welfare function (SWF).[11] Given some weights to farmers and non-farmers, a Pareto efficient policy outcome such as $u$ (and the corresponding Pareto efficient policy $U$) in Fig. 5 are derived where the marginal rate of substitution (the slope of the corresponding social indifference curve (SIC)) equals the marginal rate of transformation (the slope of the set of feasible welfare outcomes).

Gardner (1987, pp. 231–233; 1991; 1992) numerically solved the implied optimisation procedure by calculating a great number of instrument combinations to find the one with the highest possible value to the SWF.

Gardner (1988, 1995), Innes and Rausser (1989), Innes (1990a), McCorriston and Sheldon (1991), de Gorter et al. (1993), Guyomard and Mahé (1994), Alston and Spriggs (1998), Swinnen and de Gorter (1998), Alston et al. (1999) and Giannakas and Fulton (2000a) derive theoretical or empirical points on Pareto frontiers of two or more instruments by actually solving an optimisation problem. So far, no whole Pareto frontier and/or set of Pareto efficient policies has been calculated utilising this technique. However, Yaron and Ratner (1990) discussed in the context of a water allocation problem how one can obtain the whole Pareto frontier by parametrically varying the weights of the SWF.

## 5. Considering distributive equity

While the Pareto criterion allows judgement of the efficiency of a policy, it does not consider distributive equity. All points on the Pareto frontier are efficient; and hence, Pareto incomparable to each other (and to many other points within the set of feasible welfare outcomes). To find the 'most efficient' policy (or to be able to rank certain Pareto incomparable points within the set of feasible welfare outcomes) one has to apply value judgements about distributive equity.

A complete ranking of all feasible welfare outcomes is provided by a Bergson–Samuelson SWF, which in our simple two social group case is $W = W(W_{\rm n}, W_{\rm f})$. Every SWF implicitly contains value judgements (in addition to the Pareto criterion, as long as it is non-decreasing in its arguments) about distributive equity.

In applied normative economic analysis the most common specific functional form of a SWF and hence the most common value judgement criterion used to derive a complete ranking of welfare outcomes and/or the socially optimal policy is a 'utilitarian' or 'Benthamite' SWF. In our illustrative example of two social groups the utilitarian SWF is $W = W_{\rm n} + W_{\rm f}$. A policy $A$ is socially preferred to a policy $B$ if its welfare outcome lies on a higher social indifference curve (SIC, a contour of the SWF), which in the case of a utilitarian SWF are 45° lines. The optimal policy lies on the highest obtainable SIC. Equivalent to using a utilitarian SWF, the same ranking may be derived by the lowest social cost (or deadweight loss) $\mathrm{SC} = -(\Delta W_{\rm f} + \Delta W_{\rm fn})$ criterion. Both criterion are either based on the assumption that increasing the

[11] In the context of Walrasian equilibrium theory, Varian (1992) provides a proof that maximising a social welfare function leads to Pareto efficiency, and that Pareto efficient allocations maximise a linear social welfare function for some choice of welfare weights, given concavity assumptions about individuals' utility functions.

welfare of a wealthy person by one unit is of equal social value to increasing the welfare of a poor person by one unit, or that any desired welfare distribution can be achieved by costless lump-sum transfers.

Though the Benthamite SWF and the SC criteria are commonly used in agricultural economics (e.g. Otsuka and Hayami, 1985; Lichtenberg and Zilberman, 1986; Leu et al., 1987; Murphy et al., 1993), they have also been criticised by many noted agricultural economists over a long period (e.g. Nerlove, 1958, p. 223; Josling, 1974, p. 242; Rausser, 1982; Gardner, 1983; Just, 1984, pp. 17–19). The quintessence of this critique is that given that lump-sum transfers are not possible in reality and that the main objective of many agricultural policies is to redistribute welfare to farmers, one has to take this objective into account when judging a policy. Given this, agricultural economists have often departed from the traditional utilitarian value judgement criterion, and have tried to incorporate equity considerations into their normative analysis. While at a glance it may seem that many different methods have been used to consider distributive equity, we are able to categorise them into three different formulations of the objective function:

(i) a utilitarian SWF with a predetermined welfare level for farmers or non-farmers;
(ii) a utilitarian SWF with a predetermined welfare ratio between farmers and non-farmers (or, equivalently, a Leontief-type SWF); and
(iii) a weighted linear SWF.

### *5.1. A utilitarian SWF with a predetermined welfare level for one of the two social groups*

According to this approach a policy $A$ is preferred to a policy $B$ if it leads to a higher social welfare level, given some predetermined welfare level for one of the two social groups. Within this approach two subdivisions corresponding to two different views of government (society) objectives can be identified. In accordance with Hueth (2000) we will call them: (i) the income-support objective; and (ii) the income-transfer objective.

According to the income-support objective, government's objective is to ensure, at least cost, a predetermined level of welfare for farmers. Practically, researchers following this approach have either maximised the welfare of non-farmers given some predetermined welfare level of farmers or minimised the cost to non-farmers given some predetermined transfer to farmers. Examples of studies using this view of the government objective are Josling (1974), Gallagher (1988), de Gorter and Meilke (1989), Alston and Hurd (1990), Alston et al. (1993), Gisser (1993), Maier (1993b), Salhofer (1996, 1997), Blandford and Dewbre (1994), Moschini and Sckokai (1994), Bullock and Salhofer (1995, 1998a), OECD (1995), Alston and Gray (1998), Swinnen and de Gorter (1998) and Giannakas and Fulton (2000b).

Fig. 6 illustrates the income-support objective criterion. Suppose that the actually observed welfare outcome is $r = (W_n', W_f')$. Suppose further that the actually observed welfare level of farmers is the socially desired (exogenously given) one. According to this value judgement criterion, welfare outcome $s$ is socially preferable to $r$ and the optimal welfare outcome is $t$.

Next, assume the government's agricultural policy objective is to transfer as much welfare to farmers as possible given some predetermined (socially acceptable) cost. This is the income-transfer objective criterion. Practically, it is to maximise farmers' welfare given some welfare level of non-farmers. This was first discussed in Josling (1974) and applied in Bullock and Salhofer (1995, 1998a). Fig. 6 also illustrates this income-transfer objective criterion. Suppose again that the actually observed welfare outcome is $r = (W_n', W_f')$ and that the actual observed welfare level of non-farmers is the socially desired (exogenously given) one. According to this value judgement criterion welfare outcome $u$ is socially preferable to $r$ and welfare outcome $v$ is optimal.

### *5.2. A utilitarian SWF with a predetermined welfare ratio between farmers and non-farmers*

According to this approach, a policy $A$ is preferred to a policy $B$ if it leads to a higher social welfare given some predetermined welfare ratio between farmers and non-farmers. Josling (1974) as well as Gardner (1983, pp. 228–229) recommended and Just (1984) applied this value judgement criterion. Assuming again that the actually observed welfare ratio between farmers and non-farmers is the socially desired one, welfare outcome $w$ in Fig. 6 is optimal.

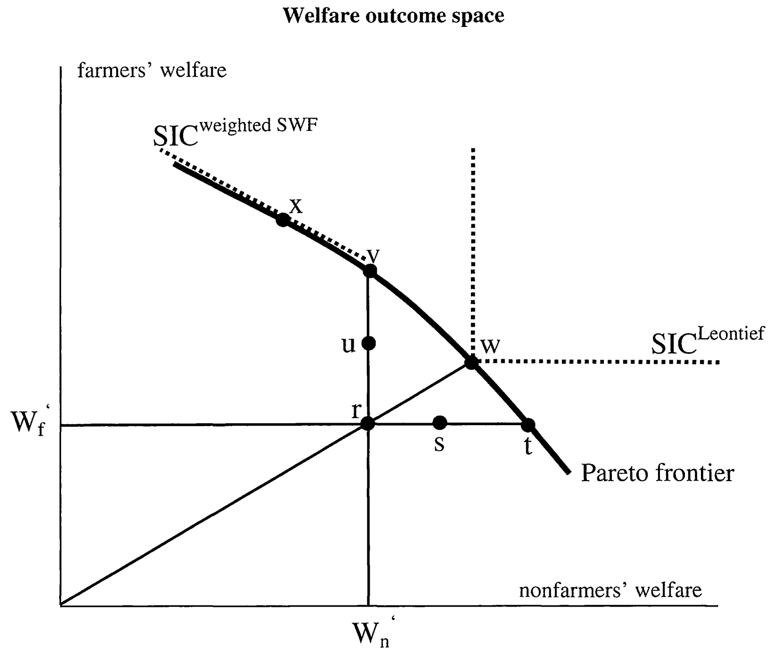


Fig. 6. How agricultural economists considered distributive equity.

Just (1984) showed that this value judgement criterion can also be represented by a SWF with right-angled social indifference curves (SICs). Such a SWF can be expressed by a Leontief-type SWF $W = \min(\phi_f W_f, \phi_n W_n)$, where $\phi_f$ and $\phi_n$ are the weights attributed to farmers and non-farmers, respectively. Hence, the welfare distribution ratio is given by $\phi_f/\phi_n = 1$. If $\phi_f/\phi_n = 1$, this value judgement criterion is equal to the Rawlsian maximum criterion (Tuomala, 1990).

### *5.3. A weighted linear SWF*

According to the weighted linear SWF approach, a policy $A$ is preferred to a policy $B$ if it leads to a higher social welfare level, defined as $W = \phi_f W_f + \phi_n W_n$, where typically $\phi_f > \phi_n$.[12] Just (1984), Paarlberg (1984), Gardner (1985, 1988, 1991, 1992, 1995), Innes and Rausser (1989), Innes (1990a,b), Chambers (1992), de Gorter et al. (1993), Alston and Spriggs (1998), Swinnen and de Gorter (1998), Alston et al. (1999) and Giannakas and Fulton (2000a) judged policies using this value judgement criterion.

In Fig. 6, this value judgement criterion is illustrated by linear SICs with slopes less than 45°. According to this value judgement criterion the optimal welfare outcome would be in point $x$.

### *5.4. A combination of a weighted and a Leontief SWF*

In a recent study, Romero (2001) suggested a more general form of a SWF that includes the Benthamite, the weighted and the Leontief SWF as a special case. According to this value judgement criterion a policy $A$ is preferred to a policy $B$ if it leads to a higher social welfare level, defined as $W = \min(1 - \lambda)(\phi_f W_f, \phi_n W_n) + \lambda(\phi_f W_f + \phi_n W_n)$, where $\phi_f$ and $\phi_n$ are the weights attributed to farmers and non-farmers, respectively, and $\lambda$ is a control parameter. If $\lambda = 1$, we have a linear weighted SWF;

[12] Here we must distinguish between a social welfare function, which is a normative construct, and a 'political preference function', which is a positive construct. Many in the agricultural economics literature have reported attempts to measure empirically the revealed 'political weights' of interest groups in the public decision making process. Conceptually, the notion of distributive equity need not play a role in the determination of such political weights. Rather, these weights might reflect the rent-seeking abilities of interest groups (see Bullock (1994) for a critique of this literature).

moreover if $\phi_f = \phi_n$, we have a classic Benthamite SWF. If $\lambda = 0$, we have a Leontief SWF; moreover if $\phi_f = \phi_n$, we have a Rawlsian SWF.

## 6. Outlook

Researchers conducting normative policy analysis face three important challenges:

(1) choosing a set of policies to be examined;
(2) mapping from policy instrument space to welfare outcome space; and
(3) applying value judgements that rank the welfare outcomes.

As demonstrated above, substantial developments have taken place in regard to the first challenge. The literature's gradual expansion of the set of examined policies has led to a corresponding gradual expansion of the examined feasible set of welfare outcomes, from welfare outcomes of a few specific policies, to Josling–Gardner surplus transformation curves, to Pareto frontiers. Given recent advances in computer hardware and software it is no longer a problem in empirical work to calculate the welfare effects of a great number of alternative combinations of several instruments or to calculate Pareto efficient combinations of more than two instruments (e.g. Salhofer, 1997). For the (very commonly used) simple case of two social groups (farmers and non-farmers) presented here, a graphical illustration of a feasible welfare outcome set or a Pareto curve is possible and useful. However, now it is important also to consider how to obtain and present meaningful welfare measures and outcomes for the case of more than two social groups. Or to put it differently, now that we are able to create a great amount of information very cheaply, it is time to think about how to make use of it.

Another way in which advances in computational power are already in use and will be used even more in the future is in regard to challenge (2). In mapping from policy instrument space to welfare outcome space researchers have to deal with many uncertainties, including in functional forms, parameter values, and market structure. Given this, the welfare outcome implied by each policy (as well as an STC or Pareto frontier) is only known with some degree of uncertainty (von Cramon-Taubadel, 1997). Computer-intensive methods have been introduced in the agricultural economics literature to obtain a fuller picture of the statistical properties of welfare measurements based either on bootstrapping (Efron, 1979; Freedman and Peters, 1984; Dorfman et al., 1990; Kling and Sexton, 1990), Monte Carlo simulations (Krinsky and Robb, 1986, 1990, 1991; Adamowicz et al., 1989, 1991) or Bayesian inference (Zhao et al., 2000).[13] Recent applications of these methods in the field of agricultural policy analysis include Tremblay and Tremblay (1995), von Cramon-Taubadel (1997), Jeong et al. (1999), Jeong et al. (2003) (bootstrapping), Alston et al. (1998, 2000) (Monte Carlo simulation), Davis and Espinoza (1998, 2000), Griffiths and Zhao (2000), Zhao et al. (2000), Salhofer et al. (2001) and Sinabell et al. (1999) (Bayesian inference).

In regard to the third identified challenge of normative agricultural policy analysis, the most important development is that in many cases agricultural economists have departed from the traditional utilitarian value judgement criterion of minimising social costs, and have tried to incorporate equity considerations. However, given the applied nature of agricultural policy research, those equity considerations have been incorporated in very simple ways, either by a weighted linear SWF or by placing constraints on the minimising social cost criterion. Interesting starting points for refining this line of research are Romero's (2000) more general SWF, and Chavas' (1994) article on fairness.

Another development in meeting the third challenge is that several recent welfare analyses have employed a wider disaggregation of social groups. Prior to this development, it was common to evaluate the effects of agricultural policy by dividing society into two (farmers and non-farmers) or three groups (farmers, consumers, taxpayers). Thus, these studies aggregated the entire agricultural industry into one group, and potentially missed important aspects of inter-agricultural politics. Examples of studies disaggregating the agricultural sector vertically, e.g. by

[13] See Bullock et al. (1999), Abler (2001) and Salhofer (2001) for a broader discussion of sampling procedures. The traditional approach to get statistical welfare measures are linear approximations based on Taylor series expansion (Kealy and Bishop, 1986; Bockstael and Strand, 1986).

distinguishing between agricultural production and processing, are Mullen et al. (1989), Maier (1993a), Alston et al. (1997) and Jeong et al. (2003). Examples of horizontal disaggregation, e.g. by distinguishing between different product qualities, are Zhao et al. (2001, 2002). However, only rarely have studies disaggregated farmers by natural production conditions (such as between European Union favoured versus disfavoured areas), or by economic production conditions (small versus large farms). Nor has it been common to disaggregate farmers by income class, though this seems of obvious importance for analysing equity issues. Exceptional examples of this type of study are Chambers (1985) and Hueth (2000).

Finally, though income redistribution is still the most important practical goal of agricultural policy, we also observe increasing importance of other objectives, for example environmental quality. In general, as long as one accepts the basic value judgement criterion of welfarism, the theoretical normative analyses of traditional agricultural policies and environmental and resource policies rest on the same foundations. From a normative point of view both should be introduced if they improve the social state, where the measure of such improvement is a function of the welfare of all individuals. The effects of any such policies are usually best discussed in reference to welfare outcome space (Antle, 1991; Gardner, 1991). Unfortunately, since environmental quality is a public good not usually traded in markets, mapping environmental policy into welfare outcome space is often a much trickier than is mapping commodity policy into welfare outcome space. Nevertheless, the theoretical advantages of discussing the effects of policy by examining welfare outcome space hold for the study of environmental policy just as well as they hold for the study of commodity policy.

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