

THE INCIDENCE OF AGRICULTURAL POLICY

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Contents

Abstract	1690
Keywords	1690
1. Introduction	1691
2. Single-market models of policy incidence in commodity markets	1693
2.1. The basic model	1693
2.2. Efficient redistribution	1695
2.2.1. Redistribution using an output quota	1696
2.2.2. Redistribution using a subsidy	1698
2.2.3. Comparing quotas and subsidies	1698
2.3. Multiple instruments	1699
2.4. The marginal social opportunity cost of funds	1700
2.4.1. Implications of $\delta > 0$	1701
3. Implications of international trade for incidence	1702
3.1. Market power in trade	1703
3.2. Output quotas for traded goods	1704
3.3. Comparing subsidies on output versus exports	1705
3.4. Price discrimination and pooling schemes	1706
4. Multimarket models	1707
4.1. Aggregation of goods and welfare	1708
4.2. Two factors with fixed factor proportions	1711
4.3. Two factors with variable factor proportions	1714
4.3.1. Equations of the model	1715
4.3.2. Output subsidy	1717
4.3.3. Input subsidy	1718
4.3.4. Quotas on output or an input	1719
4.3.5. Combining instruments	1720
5. Supply controls – some extensions to the analysis	1721

5.1. Quota ownership and transferability	1722
5.2. Quotas and quality	1723
5.3. Output versus input controls and slippage	1724
5.4. Quotas and variability	1726
6. Variability, stabilization, and policy risk	1727
6.1. The stabilization trade-off	1727
6.2. Welfare analysis in variable markets	1728
6.3. Producer and policy responses	1729
6.4. Policy risk	1730
7. Costs of administration and enforcement	1731
7.1. Quotas and cheating	1732
7.2. Deficiency payments and cheating	1734
8. Dynamics of factor and product supply, and policy incidence	1736
8.1. Evolution of supply response	1737
8.2. Implications of dynamic output supply response	1737
8.3. Evolution of factor supply and policy incidence	1739
8.4. Dynamic evolution of markets in response to policy	1740
9. Conclusion	1741
Acknowledgements	1743
References	1743

Abstract

This chapter first discusses what economists mean by “the incidence of agricultural policy” and why we care about it. Then it reviews models of the determinants of the differential incidence of different policies among interest groups such as suppliers of factors of production, consumers, middlemen, taxpayers, and others. Results are represented in terms of Marshallian economic surplus, and surplus transformation curves. After reviewing the results from standard models under restrictive assumptions, certain assumptions are relaxed in order to analyze the effects of imperfect supply controls, variability, cheating and imperfect enforcement of policies, and the dynamics of supply.

Keywords

agricultural policy, welfare analysis, incidence, efficient redistribution

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1. Introduction

Why study policy incidence? One reason is that the economic welfare effects of policies are intrinsically interesting. In addition, the distribution of the resulting benefits and costs is central to understanding why particular policies are chosen; and it is also useful, in some settings, for prescribing policies. Whether we are interested primarily in the causes or in the consequences of policies, it is often appropriate to go beyond the most aggregative summary measures reported in some studies, such as Harberger triangles of deadweight loss, to consider the welfare effects on particular groups in society.

In the analysis of agricultural commodity policies, for instance, it is common to distinguish between the effects on welfare of agricultural producers and the effects on other economic agents. The economic effects of policies are then represented in terms of the costs and benefits to producers as a group and to other groups in society (i.e., the distributional effects), and the net effects on society as a whole (the sum of the effects on producers and others). When we talk about the incidence of agricultural policy, then, we usually mean the distribution of the costs and benefits of the policy among different interest groups, defined in terms of their roles as consumers, taxpayers, or producers (or suppliers of factors of production).

It is conventional in commodity policy analysis to use Marshallian consumer surplus as a measure of consumer welfare change, as an approximation of the more theoretically correct Hicksian welfare measures, implicitly presuming the bias is small, based on arguments from Willig (1976). In addition, it is conventional to explicitly or implicitly invoke Harberger's (1971) "Three Postulates" of applied welfare economics.¹ When these assumptions are valid, the consumer benefits from consumption may be measured as the area beneath the ordinary demand curve, so that net changes in consumer welfare may be measured using Marshallian consumer surplus, and the area beneath the supply curve is a measure of total costs, so that changes in the net welfare of producers may be measured using producer surplus or quasi-rent.²

One of the key points to be made in the pages that follow is that supply conditions, especially elasticities of factor supply but also factor cost shares and elasticities of substitution among factors, are primary determinants of the incidence of policies. Supply analysis is difficult in a range of dimensions, including the inherent dynamics, uncertainty, and the role of expectations. Here, we abstract completely from the truly

¹ These postulates are (a) that the competitive demand price for a given unit measures the value of that unit to the demander, (b) that the competitive supply price for a given unit measures the value of that unit to the supplier, and (c) that when evaluating the net benefits or costs of a given policy action, the costs and benefits should be added without regard to the individual(s) to whom they accrue. Harberger (1971) also discusses the implications of multiple market distortions in general equilibrium for these welfare measures and provides a multiple-distortion deadweight-loss measure.

² In a comprehensive review of empirical approaches to the measurement of welfare, Slesnick (1998) reviewed the literature documenting the shortcomings of Marshallian consumer surplus as a measure of consumer welfare and social welfare.

dynamic and uncertain nature of agricultural supply response and, for the most part, consider comparative-static analysis with a given supply curve. But we do consider the implications of an increasing elasticity of supply, with increasing length of run, for the longer-run incidence of policy – the evolution of the incidence with the evolution of supply response. Notably, one of the first empirical studies of agricultural policy incidence was by Nerlove (1958) in a study titled *The Dynamics of Supply*.

A related issue concerns the degree of aggregation across markets. As we aggregate across commodities, supply becomes less elastic, in particular because the inelasticity of the total supply of land becomes increasingly more relevant as a constraint. For the most part, here, we will be considering policies for individual commodities, commodities for which it is not appropriate to regard the supply of land as absolutely fixed (even if it were appropriate for a nation as a whole, when considering all agricultural commodities together). Only if we are considering changes in a policy that affects all of the commodities together is it reasonable to consider the market for an aggregate agricultural commodity with a fixed supply of land. Even then, a multimarket model, taking appropriate account of the differences among commodities, is likely to be more meaningful, unless the commodities all experience the same policy effects.

Many policies affect agriculture. However, attention here will be limited to policies that are applied directly through farm commodity markets or input markets with a view to raising returns to producers.³ In Section 2, we consider output subsidies and output quotas in the context of a single-market, closed-economy model. Since international trade is important in most agricultural commodity markets, in Section 3 we extend the discussion to consider markets and policies for traded goods. We limit our coverage of those aspects, though, since international trade and trade policy are the subject of another chapter. In Section 4, we consider vertical linkages in multimarket models, which allows us to extend the set of instruments to consider subsidies or quotas on inputs. While we consider small multimarket models, the analysis here is restricted to partial equilibrium models.

In all of these models, for each instrument, we consider the effects on prices and quantities of output (and, where relevant, inputs) and, accordingly, on economic welfare and its distribution among taxpayers, consumers, and producers (and, where relevant, input suppliers). We consider both simple policies and policies involving combinations of instruments, and we compare policies in terms of their transfer efficiency, using conventional stylized models of policies and markets. In addition, we maintain the assumptions that imply that changes in producer and consumer surplus are appropriate measures of welfare change: static supply and demand, perfect knowledge, perfect competition, and perfect and costless enforcement of policies.

In the subsequent sections we consider some extensions to the above models, including some more realistic characterizations of supply controls (Section 5), variability and stabilization issues (Section 6), the role of imperfect enforcement and other costs

³ The same procedures could be used to evaluate transfers to consumers [e.g., Alston et al. (1999)].

of administering policies (Section 7), and some implications of the dynamics of supply response for the incidence of different policies (Section 8). Importantly, however, throughout the chapter we retain the assumption of perfect competition. Finally, Section 9 concludes the chapter.

2. Single-market models of policy incidence in commodity markets

Discussions of the formal analysis of the welfare consequences of agricultural policy often begin with Wallace (1962). Other influential articles in this area, published around the same time, include Nerlove (1958), Parish (1962), Floyd (1965), Johnson (1965), Dardis (1967), and Dardis and Learn (1967). Much of this work can be traced to the University of Chicago.

2.1. *The basic model*

Wallace (1962) compared the effects of two stylized policies in a competitive market for a non-traded commodity: (1) a marketing quota (which he called the “Cochrane proposal”), and (2) a target price and deficiency payments (which he called the “Brannan plan”). These two policies are depicted in Figure 1, where D represents demand, S represents supply, and the initial equilibrium occurs at the price, P_0 , and corresponding quantity, Q_0 . The policies are designed to generate a given price, P_1 , for producers. This is done either by fixing a quota of Q_1 , or by fixing a producer target price at P_1 , allowing the corresponding production of Q_2 to be sold at a consumer price, P_2 , and paying producers a deficiency payment of $P_1 - P_2$ per unit. In this static setting the latter policy is identically equivalent to paying producers a per unit subsidy of $P_1 - P_2$, and for simplicity we refer to it below as a subsidy. Both policies result in the same producer price of P_1 , but the quota reduces the quantity produced and consumed to Q_1 , while the subsidy increases it to Q_2 .

The size and distribution of the welfare effects differ between the two policies, as shown in Table 1 (as is conventional practice, for this analysis it is assumed that quota rents accrue to producers and are included in producer surplus). An important distinction between the two policies is their effects on consumers and taxpayers. The quota policy benefits producers at the expense of consumers, with no effect on taxpayers, while the subsidy policy benefits consumers as well as producers, all at the expense of taxpayers. Producer benefits are greater under the subsidy, since area $A + B + C$ is greater than area $A - (G + K)$. The net social cost or deadweight loss from the quota ($DWL_q = -\Delta NS = \text{area } B + G + K$, where ΔNS is the change in net social welfare) may be greater or smaller than that for the subsidy ($DWL_s = \text{area } E$), depending on the relative sizes of supply and demand elasticities.

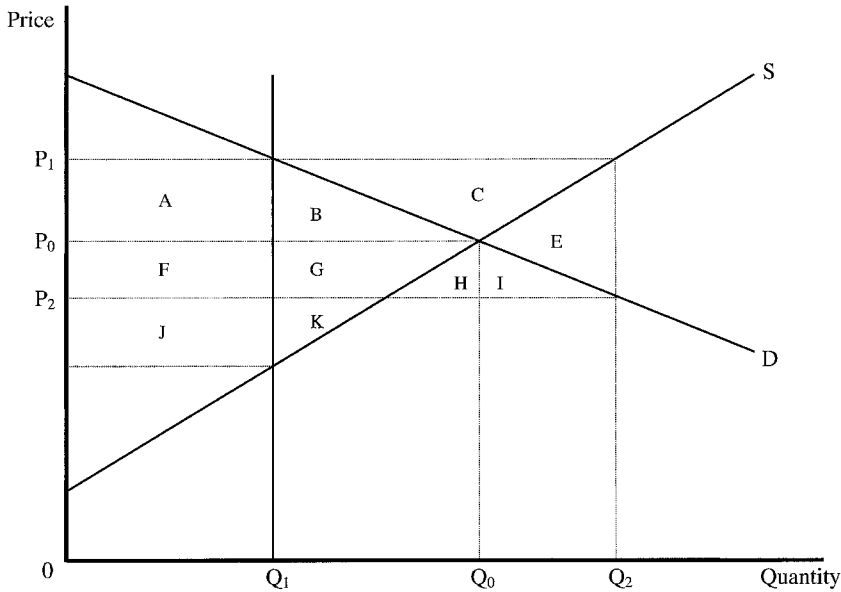


Figure 1. Welfare effects of a quota and a subsidy.

Table 1
Welfare effects of a quota and a subsidy

Changes in	Marketing quota	Production subsidy
Producer Surplus (ΔPS)	$A - (G + K)$	$A + B + C$
Consumer Surplus (ΔCS)	$-(A + B)$	$F + G + H + I$
Taxpayer Surplus (ΔTS)	0	$-(A + B + C + E + F + G + H + I)$
National Surplus ($\Delta NS = -DWL$)	$-(B + G + K)$	$-E$

Note: The entries in this table refer to areas on Figure 1 associated with each policy applied to generate the given increase in the producer price.

The relationship between the deadweight loss measures for the two policies can be seen by approximating the social cost of each policy, using linear approximations of supply and demand. These approximate social cost areas are given by:

$$DWL_q = \frac{1}{2} P_0 Q_0 \tau^2 \eta^2 \left(\frac{\varepsilon + \eta}{\varepsilon \eta} \right); \quad DWL_s = \frac{1}{2} P_0 Q_0 \tau^2 \varepsilon^2 \left(\frac{\varepsilon + \eta}{\varepsilon \eta} \right),$$

where τP_0 is the increase in price, ε is the supply elasticity, and η is the absolute value of the demand elasticity at the initial equilibrium. The social cost of either policy increases with the size of the induced quantity change, and the size of the price wedge associated

with that change. Intuitively, the quantity response to the subsidized price increases as supply becomes more elastic, and a more restrictive quota will be required to reach the target price as demand becomes more elastic. Thus, the social cost of the quota increases with increases in the demand elasticity and with reductions in the supply elasticity, while the converse is true for the subsidy. As summarized by Wallace (1962), $DWL_q \geq DWL_s$ when $\eta \geq \varepsilon$, and vice versa. So, if demand is more elastic than supply (as depicted in Figure 1), the social cost of a quota is greater than that of a subsidy policy, for a given effect on producer price.

A weakness of this analysis is that, in comparing the instruments, it may not be appropriate to hold the producer *price* effect constant. More recent work, which has its roots in articles by Nerlove (1958), Dardis (1967), and Josling (1969), has developed a more useful basis for comparing policies.⁴ Rather than comparing social costs for a given increase in price or gross revenue, policies are compared in terms of their efficiency of redistribution, or transfer efficiency.

2.2. *Efficient redistribution*

Measures of transfer efficiency provide a means for comparing the benefits to producers with the combined costs to consumers and taxpayers, and to society as a whole. Several such measures have their roots in literature described above, but the idea was popularized by Gardner (1983, 1987a, 1987b). Gardner (1983) linked various measures of transfer efficiency to the graphical representation of agricultural policy incidence developed by Josling (1974) and showed how the results depend on elasticities. Using this approach, alternative policies can be compared graphically in terms of their efficiency in meeting a particular goal.

The graphical comparison of policies is facilitated by the use of surplus transformation curves, which are typically attributed to Josling (1974). The surplus transformation curve (STC) for a particular policy instrument typically shows the range of combinations of welfare of producers versus consumers and taxpayers that can be achieved using that instrument.⁵ Several STCs, one for each policy instrument under consideration, may be drawn in a single graph. Then, given some target level of producer benefits or some acceptable cost to consumers and taxpayers, policies may be compared easily in terms of one of several efficiency measures that are defined below. These graphical representations allow us to compare policy consequences, to prescribe more efficient policies, and to understand policy choices.

⁴ Nerlove (1958) expressed welfare losses per net increment to producer surplus as did Dardis (1967), Dardis and Dennisson (1969), and Dardis and Learn (1967). Josling (1969) considered two objectives – increasing farm income and displacing imports – and compared policies in terms of the marginal and average costs per unit of each objective.

⁵ The axes need not be defined this way. Reducing the problem to two dimensions is helpful but not necessary, and for some problems it may be appropriate to aggregate consumers with producers versus taxpayers, or producers with taxpayers versus consumers.

2.2.1. Redistribution using an output quota

The STC for a production quota indicates the combinations of producer and consumer surplus attained when the quota quantity is varied. An example is shown in Figure 2. When the quota is set at the initial equilibrium quantity, Q_0 in Figure 1, the competitive equilibrium is reached, with a distribution of surplus represented by point E in Figure 2. Movement along the STC to the left of point E shows how much producer surplus increases and consumer surplus decreases as the quota quantity is progressively reduced. At point L in Figure 2, if PS_1 and CS_1 are those resulting from the quota quantity Q_1 in Figure 1, then ΔPS and ΔCS in Figure 2 correspond to the areas $A - (G + K)$ and $A + B$, respectively, in Figure 1.

The deadweight loss (DWL) associated with quota quantity Q_1 is also shown in Figure 2. For any value of CS, the total DWL is seen graphically as the vertical distance from the STC to the 45° line through point E , while for any value of PS, the total DWL is seen as the horizontal distance from the STC to the 45° line. Thus, the vertical or horizontal distance from point L to the 45° line corresponds to area $(B + G + K)$, the DWL associated with a quota quantity of Q_1 . As noted above, the DWL associated with a quota increases as the quantity distortion increases, so the DWL is always increasing as one moves further to the left from point E .

DWL is a useful measure for comparing policies when the objective is to increase producer surplus by a certain amount. However, when benefits to producers vary across

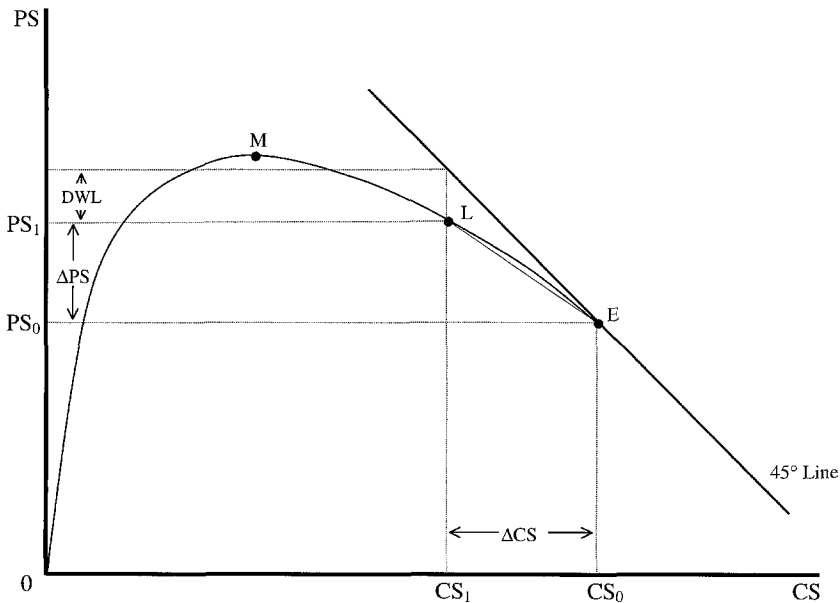


Figure 2. Surplus transformation curve for a production quota.

policies, a measure of average transfer efficiency may be more appropriate (although comparisons are meaningful only if we hold constant either producer benefits or costs to others). One such measure is what Dardis (1967) referred to as the Relative Social Cost (RSC) of a policy, which is defined as the change in total social welfare (i.e., the negative of the DWL) per dollar transferred to producers (i.e., $-DWL/\Delta PS$). RSC is inversely related to the average efficiency measure used by Gardner (1983), the average producer benefit for each dollar foregone by consumers and taxpayers – i.e., $\Delta PS/\Delta (CS + TS)$, which he called “total redistribution”. The primary advantage of Gardner’s measure is that it can be seen graphically as the slope of the line going through point *E* and the relevant point on the STC. Because the STC is concave, Gardner’s average efficiency measure is always decreasing (in absolute value) as we move away from the competitive equilibrium. Furthermore, because of the inverse relationship between average transfer efficiency (ATE) and the RSC of a policy (i.e., $ATE = 1/(RSC - 1)$), the DWL per dollar transferred to producers increases as we move along the STC to the left of point *E*.

A final group of efficiency measures evaluates the marginal efficiency of the transfer to producers. The marginal efficiency of a transfer indicates how much of the next dollar taken from consumers (and taxpayers) will actually be received by producers, and is equal to the absolute value of the slope of the STC at a given point. Similarly, the marginal DWL of a dollar taken from consumers and taxpayers is equal to one minus the marginal efficiency. Finally, the inverse of the marginal efficiency can be interpreted as the marginal cost to consumers and taxpayers of transferring another dollar to producers, and one minus this marginal cost is equal to the absolute value of the marginal RSC of an additional dollar transferred to producers. Because the first of these marginal efficiency measures is most clearly seen in graphs of STCs, it will be the focus of the following discussion.

The marginal efficiency of the first dollar transferred to producers is equal to the slope of the STC at the no-intervention equilibrium, point *E*, which is -1 , reflecting the negligible DWL associated with a small restriction in quota. As the quota is reduced, each incremental dollar of welfare loss to consumers yields a smaller incremental producer surplus gain: the marginal gain in producer surplus diminishes and the STC flattens. This continues until the point is reached where the slope of the STC is zero (its tangent is horizontal), which occurs when the quota quantity equals the output quantity for a monopolist (point *M* in Figure 2). Further reductions in quota will reduce both producer and consumer surplus.

The relationship between marginal transfer efficiency and average efficiency is also of interest. Consider point *L*, where the tangent line is flatter than the line connecting points *L* and *E*. This relationship indicates that average efficiency is greater than marginal efficiency, and that the decreasing marginal efficiency of additional transfers is pulling down the average efficiency. Because the STC is concave, as one moves away from the competitive equilibrium, both marginal and average efficiencies fall with increases in transfers to producers.

2.2.2. *Redistribution using a subsidy*

The STC for a subsidy is derived as above, by evaluating the combinations of producer, consumer, and taxpayer welfare associated with different settings of the subsidy. Unlike the quota policy, however, taxpayers are affected by the implementation of a subsidy. In order to reduce the STC to two dimensions, consumers and taxpayers are typically treated as one group, and consumer and taxpayer surplus are added together. Movement to the left along the STC in this case corresponds to an increase in the per unit subsidy. The shape of the STC for a subsidy differs slightly from that for a quota. While both STCs are concave, the slope of the STC for the subsidy is always negative over the relevant range of $CS + TS$, since producers can always be made better off at the expense of consumers and taxpayers – producer welfare always increases as the subsidy is increased. This is the primary difference between the subsidy and quota, since producer welfare cannot be increased once a quota has reached the monopolist's quantity. Otherwise, the interpretation and graphical representations of the various efficiency measures are the same for the STCs of the two policy instruments.

2.2.3. *Comparing quotas and subsidies*

In comparing the STCs for the two policies, the same types of relationships can be seen as were discussed above in the comparison of the two policies while holding the price effects equal. Here, however, we compare the policies for a given benefit to producers. The position of the STC for a subsidy relative to that of the STC for a quota is determined by the elasticities of supply and demand. When demand is more elastic than supply at the undistorted equilibrium (or when the two elasticities are equal), the STC for the subsidy lies entirely above that for the quota. In this case, for any PS, the subsidy will have a smaller DWL, and will be a more efficient means for transferring income to producers, on both an average and a marginal basis.

Figure 3 shows a more interesting case in terms of policy performance. Here, supply is more elastic than demand at the competitive equilibrium. For a given relatively small transfer to producers, the DWL associated with a subsidy policy is larger than that of a quota, and both marginal and average efficiency measures favor the quota. However, when the transfer to producers is increased, the marginal efficiency of the subsidy eventually exceeds that of the quota. At some higher PS, the two STCs intersect, and the average efficiencies are equal. For transfers beyond that PS amount, the subsidy will have a smaller DWL and more favorable measures of average and marginal efficiency. Furthermore, producer surplus in excess of the monopolist's PS can be attained only by use of a subsidy. The main point, here, is that the relative efficiency of the two policies will depend on the size of the transfer as well as the supply and demand elasticities.

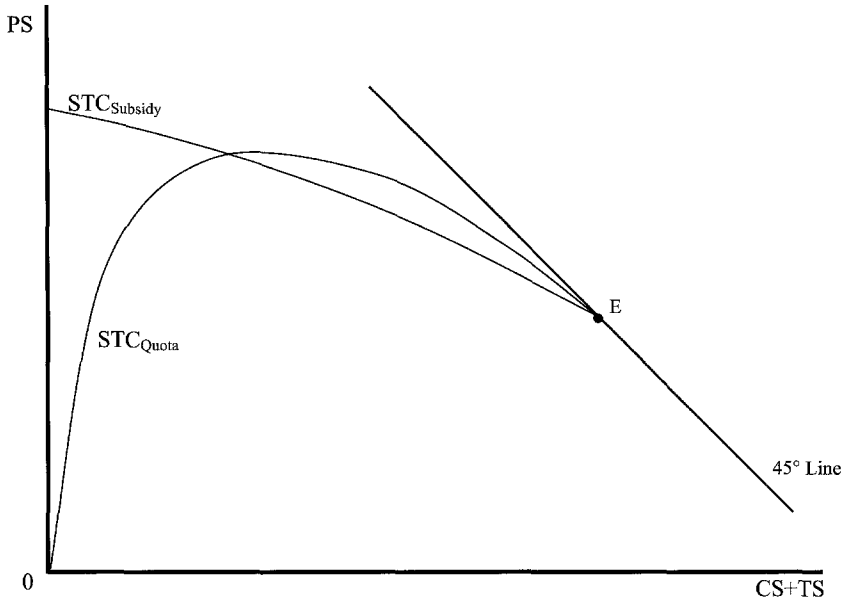


Figure 3. Surplus transformation curves: quota versus subsidy.

2.3. Multiple instruments

Alston and Hurd (1990) extended Gardner's (1983) analysis to show what happens when the policies are not mutually exclusive and may be combined efficiently. If a quota set equal to the competitive quantity were combined with a subsidy, transfers from taxpayers to producers could be made without any distortions in production or consumption because the quota would prevent supply response to the subsidy. Thus, the efficient STC for this problem is the 45° line in Figure 3 since, by combining the two instruments, the equivalent of a lump-sum transfer is achieved.

The idea that combining instruments can increase transfer efficiency has been formalized and extended in several recent articles, going beyond two interest groups and two policies. One issue is the number of policy instruments required to achieve a Pareto-efficient outcome, given a particular number of interest groups. Bullock (1994, 1995) has analyzed this issue. Bullock and Salhofer (1998a) provided theoretical and empirical results on measuring the costs of suboptimal combinations of policy instruments, and Bullock and Salhofer (1998b) showed that under the usual assumptions, in general, the addition of another instrument cannot reduce transfer efficiency. A number of recent studies have measured the transfer efficiency of different simple and combined policies, including Kola (1993), Salhofer (1996, 1997), and Alston and Gray (1998). In earlier work, Just (1984), Innes and Rausser (1989), and Gisser (1993) considered the welfare

implications of combined policies, but did not measure transfer efficiency. Bullock, Salhofer and Kola (1999) present a synthesis and review of these and related studies.

2.4. *The marginal social opportunity cost of funds*

The analysis above rests on the conventional assumption that a dollar of government spending involves a loss of taxpayer surplus of one dollar. In developing the STC for a subsidy, Gardner (1983) considered the effects when the social opportunity cost of one dollar of government spending is greater than one dollar, owing to the distortions involved in general taxation measures. Thus the marginal taxpayer cost of a subsidy expenditure can be represented as $1 + \delta$ times that amount, where δ is the marginal excess burden or deadweight loss involved in generating the revenue to finance the subsidy. This excess burden includes the deadweight losses from distortions in the markets from which the tax revenue is raised (primarily, the labor market) along with taxpayer costs of compliance, and costs to the treasury, including revenue collection costs and other costs of administration and enforcement of the tax policy.

Most studies of the deadweight costs of general taxation refer only to the distortions in the labor market associated with income taxes. One issue in the literature has been the appropriate value for the relevant labor supply elasticity, which may depend on assumptions about what is to be done with the tax revenue. The response of the quantity of labor supplied to the imposition of a tax can be partitioned into substitution and income effects which work in opposite directions so that the uncompensated labor supply curve, including both effects, is less elastic than the compensated supply curve, including only the substitution effect. If all tax revenues were effectively returned to taxpayers – through either a lump-sum payment or the provision of public good – then the income effect would be eliminated. When the income effect is eliminated, the tax-induced distortion in quantity and the deadweight costs of taxation are larger.

An extensive literature documents measures of the deadweight losses from income taxation and discusses the interpretation of the estimates. Relatively recently, Fullerton (1991) reconciled a wide range of previous estimates of the marginal social cost of public funds in the United States in terms of their treatment of the income effect. He suggested values for the marginal cost of public funds ranging from \$1.07, when the income effect is included, to \$1.25 when the income effect has been eliminated. Campbell and Bond (1997) reported corresponding estimates for Australia of \$1.19 and \$1.24;⁶ similar estimates were obtained by Diewert and Lawrence (1995) for New Zealand. A value for δ in the range of 10 to 25 percent seems plausible. In the context of benefit-cost analysis of the provision of public goods, Campbell and Bond (1997) and Campbell (1997) argue for using the larger value. They note that measures of the benefits from projects funded with taxes generally do not include income effects, and so neither should the measures of the costs.

⁶ Findlay and Jones (1982) and Freebairn (1995) provide a wider range of estimates for Australia that may be more comparable to the range from Fullerton (1991) and the other U.S. studies.

2.4.1. Implications of $\delta > 0$

To show the effects of $\delta > 0$, Figure 4 replicates the curves in Figure 3. If a dollar of subsidy payments reduces taxpayer surplus by $1 + \delta$ dollars, the STC for a subsidy alone is shifted down from b to b' , while the STC for a quota is unaffected. This increases the likelihood that an all-or-nothing choice between production controls and subsidies will favor production controls. The reasoning is straightforward. For very small transfers, the distortion associated with a quota is infinitesimal and the marginal transfer efficiency of a quota is almost one. However, a one dollar lump-sum payment now costs the economy $1 + \delta$ dollars, owing to the excess burden of taxation. This deadweight cost of taxation, in addition to the deadweight loss in the commodity market caused by the subsidy, means that the slope of the STC for the subsidy must be less than $-1/(1 + \delta)$, even for very small transfers.

Consider, again, a subsidy combined with a quota fixed at the competitive quantity. The surplus transformation curve for this policy is no longer the line, c , with slope -1 , but, rather, the line, d , with slope $-1/(1 + \delta)$. This line, d , is also the STC for a lump-sum transfer, as described above. However, when $\delta > 0$, the policy of combining a quota of Q_0 and a subsidy is no longer efficient. As shown by Alston and Hurd (1990), a superior option would be to combine a subsidy with a production quota set at the quantity corresponding to point F , where the slope of the STC for production controls equals $-1/(1 + \delta)$, and the marginal deadweight cost from further reductions

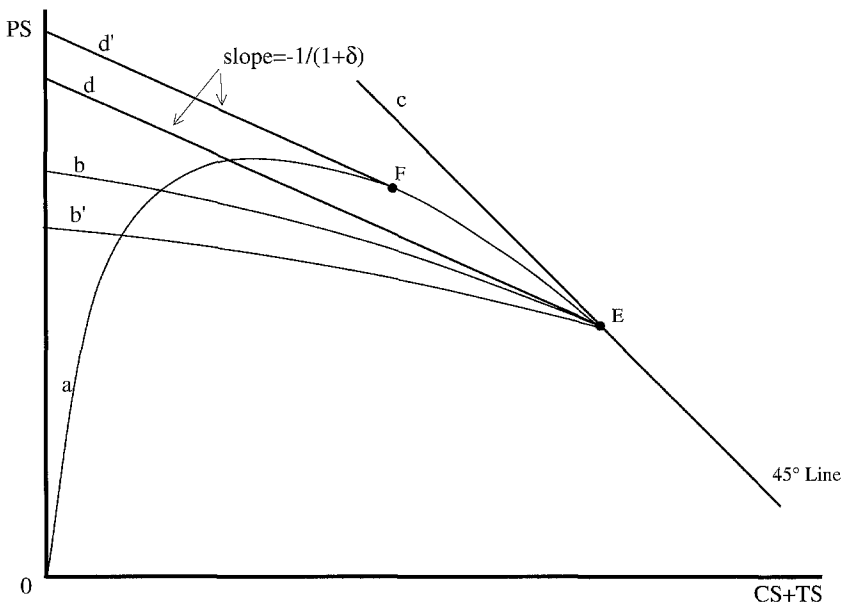


Figure 4. Surplus transformation curves and marginal social opportunity cost.

in quantity equals the marginal deadweight cost of taxation. This option is shown by d' which is parallel to d , but above it. Thus, the curve EFd' shows the efficient STC for this problem, and it may be efficient to specialize in production controls or to use a mix of policies, depending on the size of the transfer to producers, and the values of δ and the other parameters. For small transfers (i.e., points to the right of F), a quota alone is superior, but for larger transfers (i.e., points to the left of F), a quota combined with a subsidy is superior.⁷

3. Implications of international trade for incidence

While the above models can be applied to any commodity, most agricultural commodities are traded internationally, and if we fail to account explicitly for international markets the aggregate welfare measures may not be accurate or relevant as a measure of national welfare. In addition, analysts could use inappropriately small values for elasticities if they failed to recognize that the total supply to the market includes relatively elastically supplied imports, or that the total demand includes relatively elastic demand for exports. Elasticities matter for both the total welfare effects and the international as well as domestic distribution of the effects.

The introduction of international trade changes both the relevant elasticities and the computation of domestic, as compared with global, benefits and costs. It also increases the number of potential policy instruments, since instruments may distinguish among different groups of consumers, or producers, or both. Further, international trade expands geometrically the possibilities for combinations of policies. For instance, U.S. grain policies in recent years combined supply controls with target prices and deficiency payments as well as export subsidies, food aid, and government stocks policies. Since most commodities are actually or potentially tradeable, policies that may appear to be primarily domestic are often made possible only through concomitant trade barriers – e.g., domestic milk market policies are often sustained by an embargo against imports.

We cannot deal effectively here with the full range of the many different and interesting trade-oriented or trade-distorting policies used in agricultural commodity markets. However, the extension of the analysis of quotas and subsidies to the case of traded goods is straightforward and interesting, especially in case of a large-country exporter. This leads naturally to a consideration of export subsidies and price-discrimination, revenue-pooling schemes, in comparison both with one another and with the alternative of a simple output subsidy.

⁷ Chambers (1995) extended the analysis of Alston and Hurd (1990) and Gardner (1983) to general equilibrium, and found that partial equilibrium measures tend to overstate the welfare effects of stereotypical commodity policies when general equilibrium feedback is important, as may happen in less-developed countries.

3.1. Market power in trade

Large-country trading nations, by definition, can influence the world market price by changing their quantities traded. Hence, as nations they have market power in the international market and can improve net domestic welfare by exploiting their monopoly power in export markets or their monopsony power in import markets. In order to obtain the greatest possible national benefits from production and consumption, a large-country importer might tax imports with an “optimal tariff” while a large-country exporter might charge an “optimal export tax”.

To see how this works, consider Figure 5 in which panel a represents the domestic market (with domestic supply, S , and domestic demand, D) and panel b represents the export market (with supply of exports, ES , and demand for exports, ED). The export supply curve is given by the horizontal difference between domestic demand and supply – i.e., at any price, the quantity on ES is equal to the quantity on S minus the quantity on D (similarly, ED is derived, implicitly, as the difference between demand and supply in the rest of the world). With free trade, the equilibrium is given by the intersection of ED and ES , resulting in a price of P_0 , so that the quantity produced domestically is Q_0 , the quantity consumed domestically is C_0 , and the quantity exported is E_0 , equal to $Q_0 - C_0$. From the home country’s point of view, welfare is maximized when the marginal revenue from sales on the export market (MR in panel b of Figure 5) is equal to the marginal (opportunity) cost of exports, measured by ES . This outcome is achieved when the quantity exported is equal to E_1 , which could be achieved by imposing either

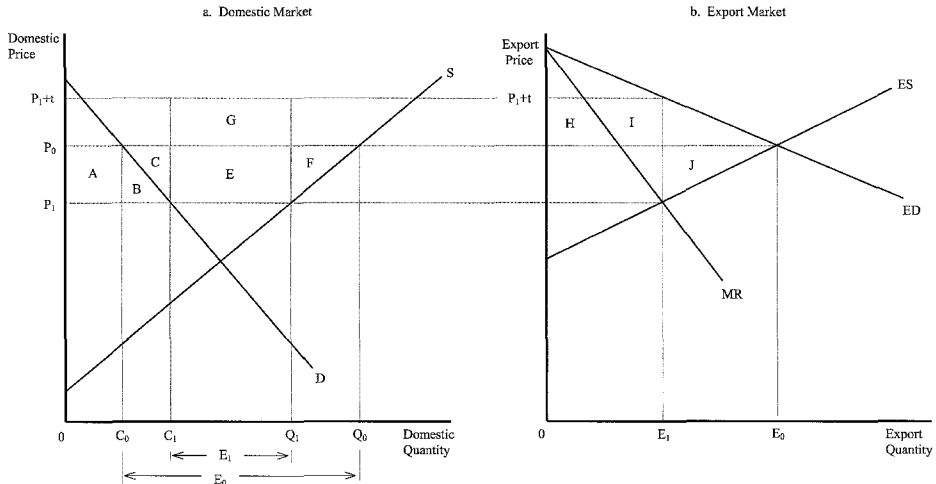


Figure 5. Optimal export tax for a large country.

an export quota equal to E_1 or an export tax equal to t per unit (and at the optimum, t would be equal to the reciprocal of the elasticity of export demand).⁸

With the export tax, the equilibrium price paid by foreigners increases to $P_1 + t$, but the domestic price falls to P_1 , so that the quantity produced domestically is Q_1 , the quantity consumed domestically is C_1 , and the quantity exported is E_1 , equal to $Q_1 - C_1$. The welfare effects can be seen in panel a. Domestic consumer surplus increases by area $A + B$, domestic producer surplus falls by area $A + B + C + E + F$, but taxpayers gain revenue of $tE_1 = \text{area } G + E$. Thus, the net effect on domestic welfare is a gain equal to area $G - (C + F)$ (equal to area $H + I - J$ in panel b), and this amount is positive and maximized when t is set "optimally". An export quota set at E_1 would have the same effects on producers, consumers, and domestic welfare; the only difference would be that area $G + E$ would be quota rent (going to those given the licenses to export) rather than tax revenue.

Corresponding results apply for an importable good, for which there is an optimal tariff, which equates the marginal cost of imports and the domestic consumer and producer prices (with the tariff rate equal to the reciprocal of the elasticity of supply of imports), and an equivalent optimal import quota. Terms of trade effects also arise through the operation of any other instruments that affect traded quantities in a large-country trader, including quotas and subsidies applied to total production.

3.2. Output quotas for traded goods

An output quota alone cannot be a useful policy for transferring income to producers in a small open economy. When we see an output quota applied by an importing or exporting country that is a price taker in the world market, it is always in conjunction with some other trade-restricting policy. In these cases, trade restrictions prevent international arbitrage from undermining the quota's intended effects: to raise producer returns by restricting supply and thereby raising domestic consumer prices. For instance, milk quotas are generally accompanied by barriers against imports and, when these quotas apply at a sub-national level, barriers to interprovincial or interstate trade.

In a large-country case, where the country can influence the world price, a production quota still does not make much sense for an importer that aims to assist producers. A restriction of domestic output may drive up the domestic and world price for the commodity, but it would be a very inefficient policy, since producers in the rest of the world would benefit without having to restrict their production. In this case, producers could be protected instead by an import quota or a tariff, possibly with an increase rather than a decrease in domestic welfare, since the policy would work to the disadvantage of the rest of the world. Import barriers have been extensively applied as part of the

⁸ The algebra and diagrams for "optimal" import tariffs and export taxes and related discussion can be found in Corden (1997). Other distortions in the economy may change the optimum trade taxes, as will allowing for $\delta > 0$, which, in this case, implies that the marginal social value of trade tax revenue is greater than one.

protective umbrella for domestic agricultural producers in most countries that protect agriculture, whether they have market power in trade or not.

For a large-country exporter, an output quota offers similar benefits to an export quota (or export tax), but is less efficient since the output quota distorts domestic consumption. A case in point is the farm program for U.S. tobacco, which has been analyzed in these terms by Johnson (1965), Johnson and Norton (1983), Johnson (1984), Sumner and Alston (1984), and Alston and Sumner (1988). These authors all concluded that the U.S. tobacco quota had generated net benefits to the U.S. economy – the U.S. benefits from monopolistic exploitation of the markets in the rest of the world outweighed the losses from distortions in U.S. production and consumption. While not as efficient as an export tax, which is ruled out by the U.S. Constitution, the output quota had achieved many of the same benefits. Clearly, in such setting, a quota is a more efficient means of transferring income to producers than any form of output or export subsidy, which must entail deadweight losses – especially when $\delta > 0$.

3.3. Comparing subsidies on output versus exports

Following Gardner (1983), Alston and Hurd (1990) compared a range of instruments in terms of their costs of achieving a given benefit to producers in the case of a small-country importer or exporter. The results parallel those for the closed economy case. They showed that the introduction of $\delta > 0$ changes the comparison between policies that involve different amounts of government spending as well as between those that involve spending and those that do not, overturning some conventional wisdom that is based on an implicit assumption that $\delta = 0$.

A conventional view is that trade-distorting policies cannot be preferred to a production subsidy as a means of supporting domestic producer income. However, Alston and Hurd (1990) showed that, in the case of a small-country importer, a tariff combined with a quota and an output subsidy might be more efficient than an output subsidy alone, depending on the relative slopes of supply and demand. Moreover, the rankings of policies may change completely when $\delta > 0$. Certainly some tax on trade will be superior to free trade when δ is positive, even in this small-country case. Indeed, an import tariff could yield net social benefits when a dollar of tariff revenue is worth $1 + \delta$ dollars of taxpayer surplus.

It is not possible to rank all policies unambiguously from theory alone. As in the case of a closed economy, the ranking of policies in an open economy depends on the size of the transfer, elasticities of supply and demand, the marginal value of government revenue, as well as the share of production that is traded. Alston, Carter and Smith (1993) compared subsidies on output and exports for both large- and small-country cases. As they showed, the comparison of an export subsidy and an output subsidy for a given producer benefit depends on the difference between the cost of distortions in domestic consumption under the export subsidy and the deadweight losses from additional taxation to fund the additional outlays for the output subsidy. The social cost of consumption distortions is infinitesimal for small transfers, but grows geometrically

with rising subsidies. A result that is surprising to some is that, for large values of δ or relatively small transfers, an export subsidy could be more efficient than a subsidy on all output.⁹ As well as changing the efficiency ranking of policy instruments, different values of δ change the measure of the taxpayer costs and the net social costs.

3.4. Price discrimination and pooling schemes

A common policy has been to establish statutory authorities (such as marketing boards or state trading enterprises) that are empowered to price discriminate among markets. Some discriminate between fresh and processing uses of a commodity (e.g., various milk marketing authorities) and others between different geopolitical markets (e.g., domestic versus export markets). Among the best-known examples are the Australian and Canadian wheat boards. These types of policies have been studied extensively in general terms [e.g., Alston and Freebairn (1988)] as well as in particular instances [e.g., Parish (1963), Ippolito and Masson (1978), Longworth and Knopke (1982), Sieper (1982)]. A key feature of such schemes is that they are self-financing – i.e., no taxpayer expenditure is required. Rather, different segments of the total market are separated and charged different discriminatory prices, the resulting revenue is pooled, and producers receive and respond to a unit price equal to the average revenue thus obtained.

The simplest case, with a perfectly elastic export demand and a downward-sloping domestic demand, is shown in Figure 6. In this case, the domestic price is set above the export price, since domestic demand is less elastic than export demand, and the producer price (P_p) is equal to a share-weighted average of the domestic price (P_d) and the export price (P_e). The pooled price line is defined such that the pooled revenue for any quantity to producers exactly exhausts the revenue earned from the domestic and export markets. At the equilibrium, this means that total revenue (area $B + C + E + F + G$) equals the revenue from the domestic market (area $A + B + F$) plus revenue from the export market (area G). Hence, area $A = \text{area } C + E$.

Alston and Freebairn (1988) extended the analysis to a large-country exporter. Alston, Carter and Smith (1993), following Sieper (1982) and others, argued that such a policy of regulated pricing and revenue pooling could be regarded as the equivalent of either (a) an output subsidy of $P_p - P_e$ per unit financed by a domestic consumption tax of $P_d - P_e$ per unit, or (b) an export subsidy of $P_p - P_e$ per unit financed by a domestic consumption tax of $P_d - P_p$ per unit. In this sense, price-discriminatory, revenue-pooling schemes can be considered as export subsidy programs financed by a tax on a particular group (consumers of the subsidized commodity), rather than on society as a whole. [Alston, Carter and Smith (1995) and Gardner (1995) elaborate on whether this perspective is reasonable.]

⁹ As discussed by Alston, Carter and Smith (1993), other studies have justified export subsidies as a second-best correction for some other distortion in the economy – e.g., Itoh and Kiyono (1987), Feenstra (1986), and Abbott, Paarlberg and Sharples (1987).

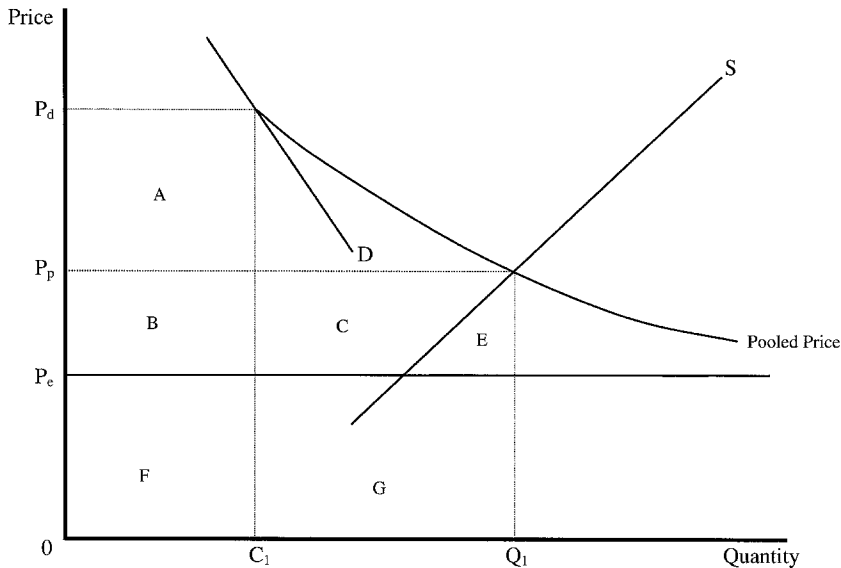


Figure 6. Price discrimination and revenue pooling.

The conclusions drawn from the simplest case – price discrimination and revenue pooling in a small country – apply also to a more general setting with multiple separate markets and market power in trade. For example, Alston and Gray (1998) compared an export subsidy against price discrimination and revenue pooling by a state trader having sole export powers (exemplified by the Canadian Wheat Board, CWB) as alternative ways of achieving a given benefit to producers. They showed that the effective export subsidy per unit must be greater under the policy of a state trader discriminating against the domestic market (since production would be the same under both policies but the domestic price would be lower and domestic consumption greater under the export subsidy). They also found that transfer efficiency was likely to have been greater under the actual CWB policies in 1994 than if an equivalent export subsidy had been used.

4. Multimarket models

The conventional supply and demand model, while powerful, has some limitations. In particular, participants in the commodity market are characterized as either producers or consumers, and their welfare is aggregated accordingly. Even when we disaggregate horizontally, between domestic and foreign producers and consumers, we have still aggregated vertically across various suppliers of factors of production and final consumers.

Our choice of which market to analyze implicitly defines how welfare measures are aggregated. For instance, if we study policy incidence in a retail market, benefits

accruing to middlemen are combined with those accruing to all other input suppliers in “producer” surplus; if we study incidence in the market for the farm product, however, benefits to middlemen are part of “consumer surplus”. Vertical disaggregation of markets and the resulting welfare measures is important if we are to accurately describe, prescribe, and explain policy choices when the goal of policy is to transfer benefits to specific resource owners or interest groups (such as landowners or agribusiness firms). To disaggregate these measures of policy incidence into more useful subaggregates requires a more elaborate model of supply and demand.

At one extreme, we can envision a totally disaggregated general equilibrium model, in which consumption expenditures are endogenous and depend on factor payments as well as endowment incomes. At the other extreme, we have the single commodity market model, as discussed above. In between lie many intermediate cases with different degrees of elaboration of the vertical structure and factor markets, and the horizontal structure in terms of different commodities and spatial aggregates. Modeling several linked markets allows us to take account of cross-market effects, which may be important for accurately measuring the incidence in the market for the commodity in question, as well as for studying the spillover effects into the related commodity markets.¹⁰

In what follows we consider small, essentially partial equilibrium, multimarket settings, to see the implications of the vertical structure for incidence among factors. Similar models can also be used to consider the incidence of policy in a multi-output setting – where, when commodities interact in either production or consumption, policies applied in the market for one commodity can have implications for producers and consumers of related commodities. This type of multimarket structure was modeled by Buse (1958) and more recently by Piggott (1992) in terms of the equilibrium prices and quantities. Just, Hueth and Schmitz (1982), Thurman (1991, 1993), Bullock (1993), and Brännlund and Kriström (1996) discuss welfare measures and their interpretations in this type of setting. An early study in this vein was by Hushak (1971).

4.1. Aggregation of goods and welfare

Welfare aggregations for vertically and horizontally linked markets are summarized graphically in Figure 7. Here, land, labor, and other (purchased) farm inputs are used to produce a farm product, and the farm product is used with other (marketing) inputs to produce a retail product. Each of these farming and marketing inputs earns a quasi-rent or producer surplus that can be measured from its supply function, and consumer surplus can be measured from the retail demand function. The interpretation of the area of producer surplus (and, indeed, the associated consumer surplus) in terms of the

¹⁰ Such intercommodity interactions are involved in sector-wide (but nevertheless *partial* equilibrium) models of the agricultural sector, such as the USDA’s SWOPSIM model, as well as in *general equilibrium* models [such as Higgs (1986)], and are reflected in the results when those models are used to measure the welfare effects of policy.

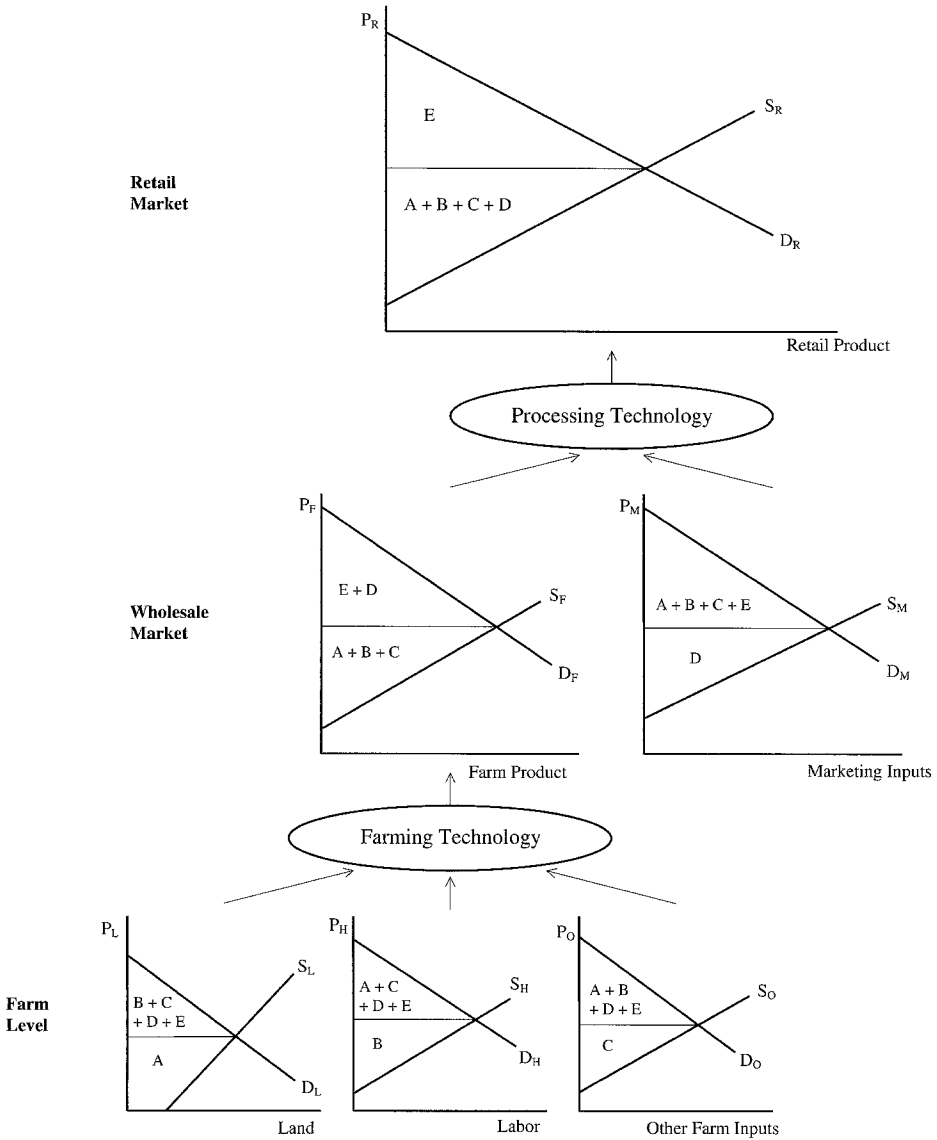


Figure 7. Distribution of welfare in a multimarket model.

underlying surpluses accruing to factors of production and consumers depends on which market is being studied.

The welfare measures defined in each market are related in precise and interesting ways, as proven by Just and Hueth (1979). Provided that all inputs are necessary, and

that a positive shutdown price exists for output, the total surplus (the sum of consumer and producer surplus) is equal to area $A + B + C + D + E$ in every market. This means that we can measure the total economic surplus in any of the markets and get the correct answer. However, the interpretations differ among the markets. In the retail market, the consumer surplus accrues to purchasers of the final product and the producer surplus includes the surpluses accruing to all the inputs. Area D accrues to suppliers of marketing inputs, and area $A + B + C$, the sum of the surpluses across inputs used to produce the farm product (area A to landowners, area B to farm labor, and area C to suppliers of purchased farming inputs), accrues to the farm product supplier.

The supply of the farm product at wholesale is derived from the underlying supply functions for inputs used in farming and the farming technology. The demands for the farm product and marketing inputs are derived demands, each depending on retail demand, the processing technology, and the supply of the other. Accordingly, consumer surplus in the farm product market includes retail consumer surplus and the producer surplus accruing to marketing input suppliers, while consumer surplus in the market for marketing inputs includes retail consumer surplus and farm product producer surplus. The demands for all of the inputs used in farming are derived demands, each depending on the demand for the farm product (which is itself a derived demand) and the supplies of the other inputs used in farming. Consumer surplus in each of the farm input markets includes the consumer surplus in the market for the farm product and the quasi-rents accruing to the other farm inputs.¹¹

Similar relationships among the surplus measures can be seen in all vertically and horizontally linked markets, so long as the issue is not confounded by price feedback effects (i.e., so long as any endogenous prices of one input are not arguments of supply for another input). In any given market, "consumer" surplus includes the consumer surplus of the market directly above it in the production process (i.e., the market for which it is an input) as well as the quasi-rent accruing to suppliers of other inputs used at the same stage of production. The area of producer surplus in any market includes the quasi-rent accruing to suppliers of all inputs used to produce the product supplied to that market (e.g., farm product and marketing inputs for retail; land, labor, and other inputs for farm product).

A policy that is introduced in the market for any of the factors, or the output, affects the factor suppliers by inducing a shift in the demand for their factor. Hence, for example, whether suppliers of land to the industry in question benefit from a subsidy on purchased inputs (such as, say, a fertilizer subsidy) depends on whether the derived

¹¹ In some settings, general-equilibrium type feedback of price effects into supply and demand equations means that one cannot disentangle the total surplus in such a fashion [for instance, see Thurman (1991, 1993)]. In the meat industry, if supplies of hogs and chickens are related (i.e., if they compete for and both influence the price of feed grains) and the demands are related for pork and poultry, then we have multiple sources of general equilibrium feedback and the producer and consumer surplus areas do not have welfare significance. Here, since all of the underlying factor supply functions and the final demand function are independent of one another, no such problems arise.

demand for land is induced to rise or fall. This depends in turn on a complex set of induced changes in the demands and thus prices of all the other factors, and the cross-elasticities of demand for land with respect to those prices.¹² Thus, as shown in Figure 8, a fertilizer subsidy could lead to an increase in demand for land, but reduced demand for farm labor, an increased supply of the farm product, an increased demand for marketing inputs, and an increased retail supply. In this hypothetical case, landowners, fertilizer suppliers, middlemen, and consumers all gain, but suppliers of labor (i.e., farmers) lose. Producer surplus measured in the market for the agricultural product increases, but within that aggregate, there is a hidden loss to suppliers of farm labor.

In this section we develop some more formal models of policy incidence in multimarket models, to establish the determinants of the types of results illustrated in Figure 8. The distribution of producer surplus among the factors of production is most readily seen in the most basic example, which is presented first, that of two inputs used in fixed proportions to produce a single output. We then relax the assumption of fixed factor proportions.

4.2. *Two factors with fixed factor proportions*

Figure 9 shows the markets for a retail product (panel a), and the marketing inputs (panel b) and farm product (panel c) used to produce it. Since we have fixed proportions between the farm product (F) and the marketing inputs (M) in the production of the retail product (R), we can choose appropriate quantity units (so that one unit of output is produced using one unit of each of the inputs), and arrange the panels vertically as shown, so that the quantities of the inputs and output change together in lock step.¹³

Given the demand for the retail product (D_R), the technology of production (the fixed factor proportions), and the supply functions for marketing inputs (S_M) and the farm product (S_F), we can derive demand functions for each of the two inputs (D_M and D_F) and the supply function for the retail product (S_R). For any given quantity of output, the willingness to pay for the corresponding quantity of one input is equal to the price per unit of the retail product minus the marginal cost of the other input. Thus, the demand for each input is simply the vertical difference between the retail product demand and the supply of the other input. Similarly, the marginal cost at retail is equal to the sum of the marginal costs of the two inputs per unit of output, so that the retail supply function is simply the vertical sum of the two factor supply functions. These derived supply

¹² In the limiting case, when all the other factor prices are exogenous (i.e., the supplies are all perfectly elastic), the issue reduces to whether land and purchased inputs are substitutes or complements; otherwise it is more complicated (although it is essentially the same idea) to establish whether an increase in supply of one factor leads to an increase in demand for another, holding constant the supply functions of the other factors. This can be thought of as a “total” cross-price elasticity of factor demand in the terminology of Buse (1958); also, see Piggott (1992).

¹³ Friedman (1976) describes a model of the production of knives using blades and handles in fixed proportions, which was first used by Marshall (1949, pp. 383–384).

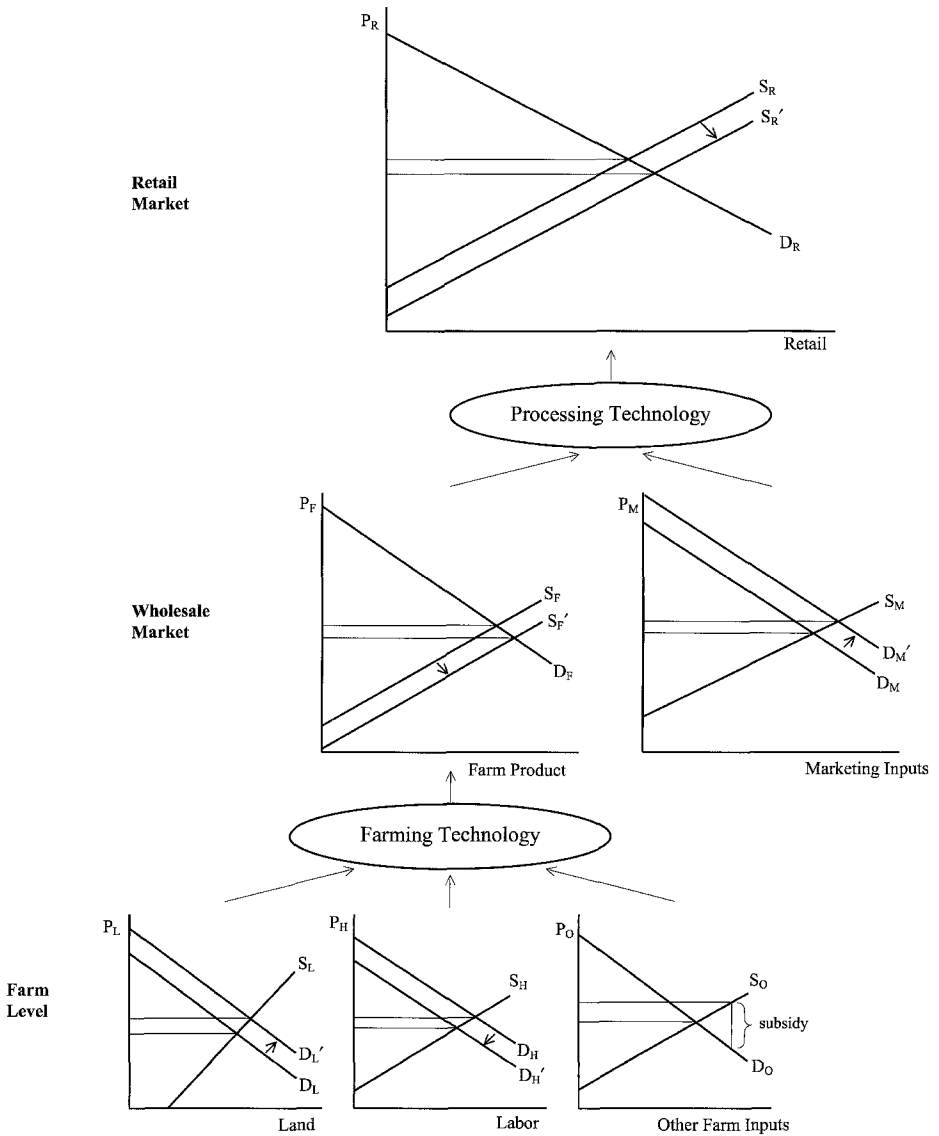


Figure 8. Hypothetical incidence of a subsidy on purchased inputs in a multimarket model.

and demand relationships show how the elasticities of the three underlying functions, and the factor shares, determine the elasticities of output supply and derived demand. Increasing the elasticity of supply of either input increases the elasticity of supply of output and the elasticity of demand for the other input, and increasing the elasticity of demand for output increases the elasticities of demand for both inputs.

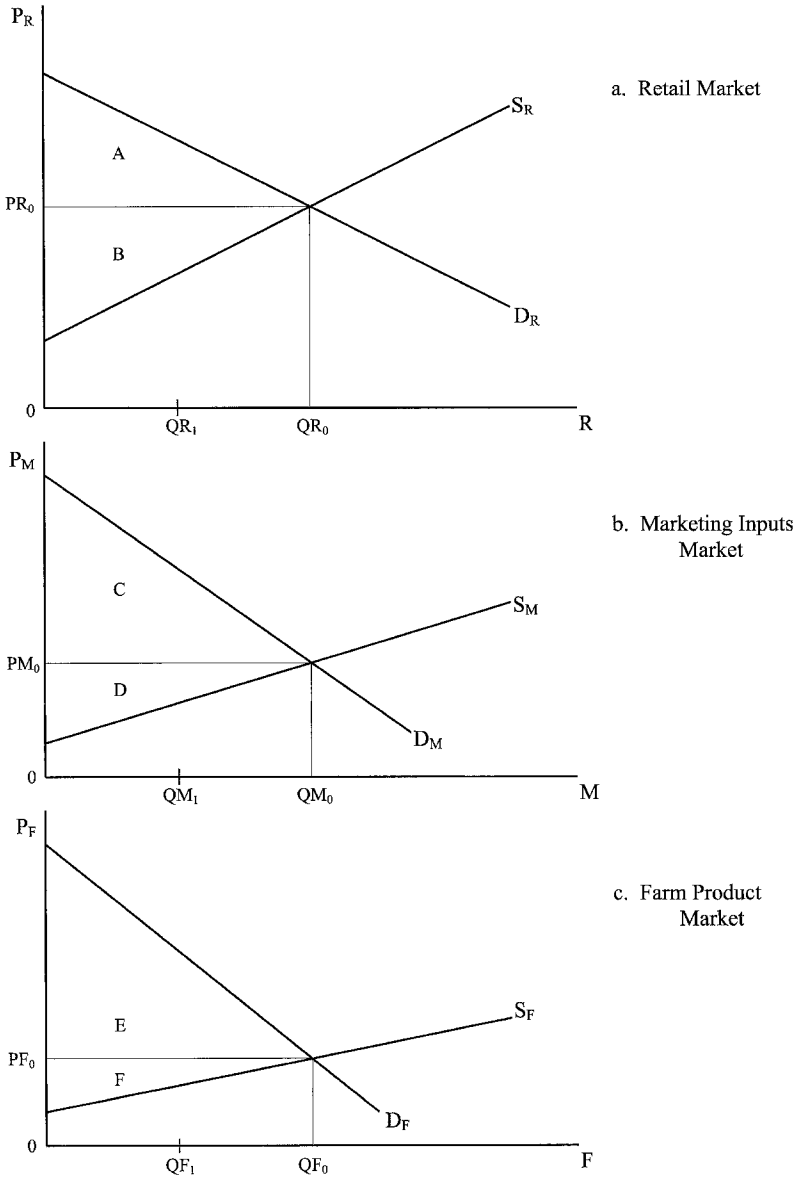


Figure 9. Surplus distribution in a model with two factors used in fixed proportions.

Equilibrium in the retail market is given by the intersection of D_R and S_R , with a quantity of QR_0 and a price of PR_0 . Corresponding to this are equilibria in the other markets with quantities and prices of marketing inputs, QM_0 and PM_0 , and of the

Table 2
Surplus distribution in a model with two factors used in fixed proportions

Market	Producer surplus (PS)	Consumer surplus (CS)	Total (net) surplus (NS)
Retail	$B = D + F$	A	$A + B = A + D + F$
Marketing input	D	$C = A + F$	$C + D = A + D + F$
Farm product	F	$E = A + D$	$E + F = A + D + F$

Note: The entries in this table refer to areas in Figure 9.

farm product, QF_0 and PF_0 . As above, our measures of producer, consumer, and total economic surplus (PS, CS, and NS) depend on which market we look at. Table 2 lists the surplus measures for each market, and shows how they relate to one another, in accordance with the above discussion of vertical markets.

The two-factor, fixed-proportions model can be used to consider the incidence of policies applied in the different markets; for instance, a subsidy or quota in the farm or retail markets. It can easily be seen in the model in Figure 9 that the incidence does not depend on whether a per unit subsidy or quota applies to output or an input when we have fixed factor proportions; only the elasticities of factor supply and retail demand, and factor shares matter. The assumption of fixed factor proportions means a quota, QR_1 , in the output market is identically equivalent to the same quota in either input market (QF_1 or QM_1). Similarly, a per unit subsidy on either input would have the exact same price, quantity, and welfare effects as would result if the same per unit subsidy were applied to the output market. Nevertheless, if we choose to study incidence in only one market, we must choose that market with a view to isolating the welfare effects of particular interest. The equivalence of the effects of a policy (quota or subsidy), regardless of whether it applies to an input or output, is a direct consequence of the assumption of fixed factor proportions. In the next section we relax this assumption, and see that the incidence of a policy depends on where it is implemented.

4.3. Two factors with variable factor proportions

Variable factor proportions in production is more realistic and adds some interesting dimensions to the analysis. In this section, we use a market displacement model to consider policy incidence in an output market and two input markets. We can define the output as either a farm product or a retail product. In the first case, the relevant inputs would be land and other farming inputs, whereas, in the second case, inputs would include the farm product and marketing inputs. If we were interested in the effects of a policy on landowners, we must choose the first structure. Similarly, if we were interested in the effects of a policy on middlemen (e.g., processors), we would choose the latter structure.

Two-factor, one-output models of agricultural commodity markets have been of two types. Some have assumed a relatively simple (and restrictive) explicit functional

form for the production function, such as the Cobb-Douglas or constant-elasticity-of-substitution (CES) form, or the Leontief fixed-proportions form shown above). Gisser (1993) provides a recent example using a CES model. Others have taken a local linear approximation to a general function, and modeled displacements from an initial equilibrium. Floyd (1965) exemplifies this approach, although he used explicit constant elasticity models for factor supply and final demand rather than leaving those functions in general form. Muth (1964) provides a more complete set of solutions for essentially the same model – without imposing any specific functional forms. This approximation approach is in some senses more general than using explicit functional forms (since it admits more general forms of production technology). It is also usually easier, especially when we extend the analysis to allow for more than two factors or more than one output (although cases may be found where specific functional forms are easier to solve or have other advantages in more accurately representing particular policies).

4.3.1. *Equations of the model*

In all of these two-factor models, the basic structure includes a final demand, two factor supply equations, a production function (or a cost function) to represent the technology for production of a homogeneous product, Q , using two factors of production, X_1 and X_2 , and equations imposing competitive market clearing.¹⁴ Thus, we can model the market equilibrium of a competitive industry in terms of the following six equations:

$$Q = D(P, A) \tag{1a}$$

$$C = c(W_1, W_2)Q \tag{1b}$$

$$X_1 = c_1(W_1, W_2)Q \tag{1c}$$

$$X_2 = c_2(W_1, W_2)Q \tag{1d}$$

$$X_1 = g_1(W_1, B_1) \tag{1e}$$

$$X_2 = g_1(W_2, B_2) \tag{1f}$$

The first equation expresses quantity of the product demanded, Q , as a function of its price, P , and an exogenous demand shifter, A . The second equation shows the industry total cost function, which is assumed to be characterized by constant returns to scale. Thus, unit costs, $c(W_1, W_2) = C/Q$, depend on the two factor prices, and, under competition, factor payments exhaust the total product [i.e., $P = c(W_1, W_2)$]. The third and fourth equations are derived by the application of Shephard's lemma to the cost function, and are Hicksian (output constant) demands for the two factors of

¹⁴ In his version of this model, Muth (1964), like Floyd (1965), characterized the technology using a production function instead of a cost function. A cost function is easier to apply, especially for more than two factors [e.g., see Wohlgenant (1982), and Alston, Norton and Pardey (1995)].

production so that $c_i = \partial c(\cdot) / \partial W_i$. The fifth equation expresses the quantity of X_1 supplied as a function of its own price and an exogenous supply shifter, B_1 ; the sixth equation is the supply of X_2 . The endogenous variables are the prices and quantities of the output and inputs (i.e., P , W_1 , W_2 , Q , X_1 , X_2), and the exogenous shifters are A , B_1 , and B_2 .¹⁵

Totally differentiating equations (1a–f) and expressing the results in relative change terms (i.e., $dX/X = \text{dln } X$) yields equations in terms of relative changes and elasticities:¹⁶

$$\text{dln } Q = -\eta \text{dln } P + \alpha \quad (1a')$$

$$\text{dln } P = k_1 \text{dln } W_1 + k_2 \text{dln } W_2 \quad (1b')$$

$$\text{dln } X_1 = -k_2 \sigma \text{dln } W_1 + k_2 \sigma \text{dln } W_2 + \text{dln } Q \quad (1c')$$

$$\text{dln } X_2 = k_1 \sigma \text{dln } W_1 - k_1 \sigma \text{dln } W_2 + \text{dln } Q \quad (1d')$$

$$\text{dln } X_1 = \varepsilon_1 \text{dln } W_1 + \beta_1 \quad (1e')$$

$$\text{dln } X_2 = \varepsilon_2 \text{dln } W_2 + \beta_2 \quad (1f')$$

In these equations, α , β_1 , and β_2 express the effects of shift variables on demand and supply as general shifts in the quantity direction, in relative change terms. As before, η is the absolute value of the own-price elasticity of output demand, ε_i is the elasticity of supply of factor i , k_i is the cost share of factor i , and σ is the elasticity of substitution between the two factors.¹⁷ This system could be solved either by repeated substitution or by using matrix algebra methods.¹⁸ The solution consists of linear equations expressing relative changes in endogenous prices and quantities as functions of the parameters and the exogenous shifters.

We can use this general model to represent specific price policies that operate through either input or output markets.¹⁹ The shift variables take particular forms to represent the price and quantity effects of a subsidy on an output or an input; they take different values, combined with extreme elasticity assumptions, to represent a quota on an output or an input. For simplicity we will drop one of the input supply shifters by setting $\beta_2 = 0$. The results are summarized in Table 3 and explained below.

¹⁵ Muth (1964) also included shifters to represent neutral and biased technical changes, but these are omitted since technical change is not the focus of this analysis.

¹⁶ This derivation uses the fact that the Hicksian factor demand elasticities can be represented in terms of the elasticity of substitution and the factor shares as follows: $\eta_{11}^H = -k_2 \sigma$, $\eta_{12}^H = k_2 \sigma$, $\eta_{21}^H = k_1 \sigma$, $\eta_{22}^H = -k_1 \sigma$.

¹⁷ The elasticity of substitution is defined mathematically for the case of constant returns to scale as $\sigma = \sigma_{12} = \sigma_{21} = c_{12}c/c_1c_2$ where c_{12} is the second cross-partial derivative of the cost function, $c(W_1, W_2)$, and c_1 and c_2 are its first derivatives. For perfect substitutes, $\sigma = \infty$, while for fixed factor proportions, $\sigma = 0$.

¹⁸ See Alston, Norton and Pardey (1995, pp. 258–260) for details.

¹⁹ Gardner (1975) used an essentially identical model to analyze marketing margins, and Gardner (1987b) used related methods to analyze various agricultural policies.

Table 3
Price and quantity effects of subsidies or quotas on output or an input in a two-factor model

	Output subsidy (τ_Q)	Input subsidy (τ_1)	Output quota (δ_Q)	Input quota (δ_1)
$\text{dln } Q$	$\frac{\eta[\varepsilon_1\varepsilon_2 + \sigma(k_1\varepsilon_1 + k_2\varepsilon_2)]}{D} \tau_Q$	$\frac{k_1\varepsilon_1\eta(\sigma + \varepsilon_2)}{D} \tau_1$	$-\delta_Q$	$-\frac{k_1\eta(\sigma + \varepsilon_2)}{D''} \delta_1$
$\text{dln } P$	$\frac{\eta(\sigma + k_2\varepsilon_1 + k_1\varepsilon_2)}{D} \tau_Q$	$-\frac{k_1\varepsilon_1(\sigma + \varepsilon_2)}{D} \tau_1$	δ_Q/η	$\frac{k_1(\sigma + \varepsilon_2)}{D''} \delta_1$
$\text{dln } X_1$	$\frac{\eta\varepsilon_1(\sigma + \varepsilon_2)}{D} \tau_Q$	$\frac{[(k_2\sigma + k_1\eta)\varepsilon_2 + \eta\sigma]\varepsilon_1}{D} \tau_1$	$-\frac{\varepsilon_1(\sigma + \varepsilon_2)}{D'} \delta_Q$	$-\delta_1$
$\text{dln } X_2$	$\frac{\eta\varepsilon_2(\sigma + \varepsilon_1)}{D} \tau_Q$	$-\frac{k_1(\sigma - \eta)\varepsilon_1\varepsilon_2}{D} \tau_1$	$-\frac{\varepsilon_2(\sigma + \varepsilon_1)}{D'} \delta_Q$	$\frac{k_1(\sigma - \eta)\varepsilon_2}{D''} \delta_1$
$\text{dln } W_1$	$\frac{\eta(\sigma + \varepsilon_2)}{D} \tau_Q$	$-\frac{(k_1\sigma + k_2\eta + \varepsilon_2)\varepsilon_1}{D} \tau_1$	$-\frac{(\sigma + \varepsilon_2)}{D'} \delta_Q$	$\frac{(k_1\sigma + k_2\eta + \varepsilon_2)}{D''} \delta_1$
$\text{dln } W_2$	$\frac{\eta(\sigma + \varepsilon_1)}{D} \tau_Q$	$-\frac{k_1(\sigma - \eta)\varepsilon_1}{D} \tau_1$	$-\frac{(\sigma + \varepsilon_1)}{D'} \delta_Q$	$\frac{k_1(\sigma - \eta)}{D''} \delta_1$

$D = \sigma(k_1\varepsilon_1 + k_2\varepsilon_2 + \eta) + \eta(k_2\varepsilon_1 + k_1\varepsilon_2) + \varepsilon_1\varepsilon_2 > 0$, $D' = \sigma(k_1\varepsilon_1 + k_2\varepsilon_2) + \varepsilon_1\varepsilon_2 > 0$, and $D'' = \sigma\eta + \varepsilon_2(k_1\eta + k_2\sigma) > 0$.

4.3.2. Output subsidy

An output subsidy at a rate $100\tau_Q$ percent can be represented as an upwards shift of demand. Thus, setting $\tau_Q = 0.1$ gives the effects of a 10 percent output subsidy. In the model, the demand shifter, α , operates in the quantity direction, so we set $\alpha = \eta\tau_Q$ to represent an output subsidy of τ_Q . The relative changes in quantities and prices as a result of an output subsidy are given in the first column of Table 3. The subsidy results in an increase in both the quantity and *producer* price of output, while the change in *consumer* price is a decrease: $\text{dln } P - \tau_Q$. At the same time, with the increase in production, the demands for both factors of production have increased, reflected in increases in both the quantity and price of each factor.

Given the price and quantity changes in Table 3, we can estimate the changes in consumer and producer welfare in any of the three markets, provided that both inputs are necessary and that a positive shut-down price exists in the output market. For simplicity, we can approximate the changes in consumer (or producer) surplus using the percentage change in the relevant price, multiplied by the initial value of consumption (or production). These approximations measure the rectangle of surplus (given by the price change on the initial quantity) but leave out the triangle associated with the policy-induced change in quantity. For small changes in prices, the rectangle is very large relative to the triangle, and the approximation error is small.

The benefits to consumers are approximately equal to the relative change in the consumer price multiplied by the value of initial consumption – i.e., $\Delta CS \approx -(\text{dln } P - \tau_Q)PQ = (\text{dln } Q/\eta)PQ = \text{dln } Q(PQ/\eta)$. Similarly, the benefits to producers can be

approximated by $\Delta PS \approx (\ln P)PQ = \ln Q(PQ/\varepsilon)$.²⁰ This amount is equal to the sum of the increases in producer surplus for the two factor suppliers. The benefit from an output subsidy to suppliers of input i is approximately equal to the relative change in supplier price multiplied by the initial value of that input – i.e., $\Delta PS_i \approx (\ln W_i)W_i X_i = \ln X_i(W_i X_i/\varepsilon_i) = \ln X_i(k_i PQ/\varepsilon_i)$. In other words, benefits to consumers, producers, and input suppliers are approximately proportional to the increases in their respective quantities consumed and supplied.

The benefits to suppliers of input 1 relative to suppliers of input 2, $\Delta PS_1/\Delta PS_2$, can be approximated as $k_1(\sigma + \varepsilon_2)/k_2(\sigma + \varepsilon_1)$. Clearly, a greater share of the benefits goes to a factor as it becomes more important (accounting for a larger share of costs) or less elastically supplied. Let input 1 be land and consider the extreme case where $\varepsilon_1 = 0$ (i.e., the supply of land is fixed), and consider the benefits to landowners relative to other input suppliers: $k_1(\sigma + \varepsilon_2)/k_2\sigma$. If all the benefits of an output subsidy went to landowners, as is often claimed, this ratio would be ∞ . However, this can occur only in one of two extreme cases: either the price of input 2 is fixed and there is no producer surplus for its suppliers ($\varepsilon_2 = \infty$), or factor proportions are fixed ($\sigma = 0$).

The conditions under which all of the benefits from an output subsidy accrue to landowners are extreme, but may be appropriate at some levels of aggregation. However, it is often not adequately recognized that both factor supply conditions and policies differ importantly between agriculture in aggregate and particular agricultural industries. For instance, in his analysis of policies for individual commodities, Gisser (1993) assumed a fixed supply of land for each individual crop while all other inputs were perfectly elastically supplied. These assumptions are clearly inappropriate for individual commodities, and guarantee that all of the benefits would go to landowners. Such assumptions are more reasonable for agriculture as a whole. For instance, Rosine and Helmberger (1974) assumed a fixed supply of land and a perfectly elastic supply of other inputs except labor (which had a large supply elasticity of 2.6), and concluded that 92 percent of the benefits from U.S. farm programs went to landowners, and the other 8 percent went to suppliers of labor. The problem with this analysis is that Rosine and Helmberger (1974) modeled agriculture as a single industry, as though a single uniform policy applied to every commodity. The assumptions made in either study may be appropriate in some context or at some level of aggregation, but Gisser (1993) failed to match his parameters to his commodity aggregates, and Rosine and Helmberger (1974) could not match their policy instrument to theirs.

4.3.3. Input subsidy

To represent an input subsidy of τ_1 per unit on input 1, we set $\alpha = 0$ and $\beta_1 = \varepsilon_1 \tau_1$. The corresponding relative changes in prices and quantities are shown in the second column in Table 3. Because the subsidy reduces the price output suppliers must pay for the

²⁰ ε is the elasticity of output supply: $\varepsilon = \{\varepsilon_1 \varepsilon_2 + \sigma(k_1 \varepsilon_1 + k_2 \varepsilon_2)\}/\{\sigma + k_1 \varepsilon_2 + k_2 \varepsilon_1\}$.

input, the marginal cost of output production is reduced and the output supply function shifts down. In turn, this shift implies an increase in output quantity, a decrease in the output price, and an increase in consumer welfare. A subsidy on X_1 unambiguously increases the quantity of X_1 demanded, by lowering the price paid by output producers ($\text{dln } W_1 < 0$). The change in price received by suppliers of X_1 , including the subsidy, is $\text{dln } W_1 + \tau_1 > 0$, giving rise to benefits to suppliers of X_1 .

The effects on the X_2 market are ambiguous, hinging on whether the inputs are substitutes or complements in production. If the two inputs are gross complements (i.e., $\sigma < \eta$), the lower price of X_1 results in an increase in demand for X_2 , and the quantity, price, and producer surplus for suppliers of X_2 all increase. If the two inputs are gross substitutes (i.e., $\sigma > \eta$), however, a lower price of X_1 causes a reduction in demand for X_2 , and consequent reductions in price, quantity, and producer surplus in the X_2 market. Thus, an input subsidy aimed at transferring income to suppliers of X_1 could either confer benefits or impose costs on suppliers of X_2 .

The output and input subsidies can be compared in terms of their effectiveness at achieving particular effects for a given subsidy expenditure since, for equal subsidy expenditures, $\tau_Q P Q = \tau_1 W_1 X_1$, so that $\tau_Q = k_1 \tau_1$. From the equation for $\text{dln } Q$, the output effect of a τ_Q subsidy on output is greater than the effect of spending the same amount as a τ_1 subsidy on input 1 if $\varepsilon_2 > \varepsilon_1$ (so long as $\sigma > 0$ and $\varepsilon_1 > 0$).²¹ Hence, for the same taxpayer cost, consumers will benefit more from a subsidy on output than from a subsidy on X_1 only if X_1 is relatively inelastically supplied. On the other hand, making the same substitution (such that $\tau_Q = k_1 \tau_1$) in the equation for $\text{dln } X_1$, suppliers of X_1 necessarily benefit more from a subsidy on X_1 than from an output subsidy with the same taxpayer cost, unless we have fixed factor proportions ($\sigma = 0$). In this case, X_1 suppliers are indifferent between the two subsidies. Finally, using the equation for $\text{dln } X_2$, suppliers of X_2 will always prefer a subsidy on output over a subsidy on the other input (again, unless $\sigma = 0$, in which case suppliers of X_2 are indifferent between the two policies).

4.3.4. *Quotas on output or an input*

The same model can be used to explore the implications of quantitative restrictions on inputs or on output, as done by Floyd (1965), for example. The effects of introducing a quota on output can be analyzed using the solutions above, by making the effective demand perfectly inelastic (by setting $\eta = 0$ in the solutions) and defining the displacement as a quantity reduction using $\alpha = -\delta_Q$ (where δ_Q is the proportional reduction in quantity from the competitive solution) so that (1a') becomes $\text{dln } Q = -\delta_Q$. The effects on price and consumer surplus are obtained using $\text{dln } P = -\text{dln } Q/\eta$, where

²¹ Parish and McLaren (1982, p. 12) report an equivalent result, although they were identifying the least-cost way of achieving a given effect on output, an output subsidy or an input subsidy. They considered a case where one of the inputs was supplied by a decreasing-cost industry.

η is the actual demand elasticity (in absolute value terms). Similarly, the effects of introducing a quota on one input, X_1 , can be analyzed by making the effective supply of that factor perfectly inelastic ($\varepsilon_1 = 0$) and defining the displacement as a quantity shift by $\beta_1 = -\delta_1$ (where δ_1 is the proportional reduction from the competitive solution) so that (1d') becomes $\text{dln } X_1 = -\delta_1$. The last two columns in Table 3 show the effects of a quota that reduces output by a fraction δ_Q , and a quota that reduces the quantity of X_1 by a fraction δ_1 , respectively.

An output quota raises the consumer price and reduces the demand for both inputs, harming consumers and suppliers of both inputs. These effects are offset partially by the quota rents accruing to quota owners: only quota owners benefit, and their benefits are smaller than the costs imposed on consumers and input suppliers. The consumer share of the cost of the output quota depends on the elasticity of demand relative to the elasticity of output supply. The distribution of the cost between input suppliers can be seen in terms of the ratio, $\Delta\text{PS}_1/\Delta\text{PS}_2$, which is approximately equal to $k_1(\sigma + \varepsilon_2)/k_2(\sigma + \varepsilon_1)$. This is identical to the ratio of the benefits to the input suppliers from an output subsidy, only now the effects are negative: suppliers of an input bear more of the cost of an output quota, the less elastic is the supply of the input or the bigger is its share of costs.

An input quota also raises the output price, resulting in losses to consumers. Assuming that they own the quota, suppliers of input 1 gain from a quota on X_1 (in the relevant range of quota quantities, their losses as suppliers of X_1 from the reduction in quantity are more than offset by their gains in quota rent).²² Suppliers of the other input, X_2 , may gain or lose, depending on whether the two inputs are gross substitutes ($\sigma > \eta$), in which case they gain, or gross complements ($\sigma < \eta$), in which case they lose. These results are opposite those for a subsidy on X_1 : when the two inputs are gross substitutes, suppliers of X_2 lose as a result of a subsidy on X_1 but gain when the quantity of X_1 is restricted by a quota. Thus, for example, landowners are likely to favor acreage allotments over output quotas, and they may be supported in this view by suppliers of other inputs that are close substitutes for land.

4.3.5. Combining instruments

As discussed above, single instruments are likely to be less efficient than multiple instruments combined. In the single-market model, we saw that an output quota at the competitive quantity, combined with an output subsidy, would be equivalent to a lump-sum transfer to producers (more precisely, to whoever owns the quotas). We also saw that it would be more efficient to set the quota below the competitive quantity if the social opportunity cost of government spending were $1 + \delta$ dollars per dollar of spending. The same ideas apply in the same ways in the context of the two-factor model,

²² The effects on W_1 in the case of an input quota are obtained assuming suppliers of X_1 own the quota and the quota rents are included in W_1 . The price of X_1 excluding the quota rent, V_1 , can be deduced using $\text{dln } V_1 = -\text{dln } X_1/\varepsilon_1$, where ε_1 is the actual supply elasticity. These two effects can be combined to determine the size of the quota rent.

with a less-aggregated view of producer surplus. That is, if the objective of a policy were to transfer income to suppliers of X_1 , an efficient policy would be to combine an input quota on X_1 (set so its marginal cost per dollar of benefit to the input suppliers is $1 + \delta$) with a subsidy on X_1 .

The effects of combining an output subsidy with an input quota, a common policy in the United States, can be seen by combining the elements in the first and last columns of Table 3. The elements in the first column have to be adjusted to reflect the fixed supply of land, by setting $\varepsilon_1 = 0$, before they are added to the elements in the last column. In a typical representation, the effects on output and producer prices are likely to be in the same direction as with an output subsidy alone (i.e., both quantity and producer price increase), but the magnitudes of changes are reduced by the input quota. Of course, an input quota could be set such that output is less than the competitive quantity, more than offsetting the effects of the subsidy on quantity produced. Thus the effect on consumption and the consumer price is ambiguous, depending on parameter values and the size of the transfer. The effect of the combined policy on the rental price for land is unambiguously positive. If the two inputs were gross substitutes ($\sigma > \eta$), then the input quota on land and the output subsidy both would act to increase the demand for X_2 , causing its price and quantity to rise with benefits to the suppliers. If land and X_2 were gross complements, however, X_2 and W_2 may rise or fall.

Understanding some subtler policy choices may require a finer disaggregation into a larger number of groups that have distinct interests. Some [e.g., Babcock, Carter and Schmitz (1990)] have suggested that agribusiness interests (including both suppliers of inputs purchased by farmers and suppliers of inputs combined with farm products in processing) are politically influential, and thus there is merit in considering the incidence of policy alternatives on agribusiness in attempting to understand policy choices. To do this requires a less aggregative model.²³

5. Supply controls – some extensions to the analysis

Thus far, the welfare effects of policies have been analyzed under a number of assumptions. We now begin to consider how the results may change when some of these assumptions are relaxed, and more realistic policy and market characteristics are introduced. First, in the present section (Section 5), we consider the implications for the analysis of quotas when we allow for limits on transferability, endogenous quality, quotas on inputs (as a proxy for output), and quotas under variability. Then, in subsequent sections we consider some further extensions to models for a more general set of policies, including other aspects of variability (Section 6), enforcement costs (Section 7), and dynamic responses (Section 8).

²³ For instance, Alston, Carter and Wohlgenant (1989) extended the two-factor model to a three-factor model of a competitive agricultural commodity market, which they used to derive and illustrate the conditions under which agribusiness firms (i.e., middlemen or farm input suppliers) may gain or lose from different types of farm policies.

5.1. Quota ownership and transferability

In the analysis above, it was assumed that quota was given to producers, so that quota rents may be included in producer surplus. This assumption may be accurate for a new quota scheme, since quota is usually allocated to producers based on past production so that initially, quota owners are also producers. When the quota is freely transferable by lease or sale, as is often assumed, the interests of quota owners and producers become increasingly disparate over time. This arises because the original quota recipients receive a windfall gain of the quota rents accruing over the life of the policy (or the equivalent value by selling the quota), regardless of whether they continue to produce or continue to own the quota. On the other hand, producers who purchase or lease quota incur quota rents as a cost of production. As a result, in many instances, it is appropriate to treat quota rents separately from quasi-rents accruing to the suppliers of other inputs.

The distinction between producers and quota owners adds one complication to the standard analysis of a quota. Another is introduced when restrictions on the transferability of quota are imposed. There are usually limits on who may buy or lease quota, whether they are allowed to lease or must buy the asset, and how much quota an individual may own or use. In addition, there are often rules that make transfers inefficient (e.g., regulated rental or purchase prices, restrictions on when transfers may occur or the size of transactions, or a requirement that all transfers must be made through a regulatory agency). If any of the restrictions are binding, then quota will not be allocated to the most efficient producers, costs will not be minimized, and the unrestricted marginal cost curve is no longer relevant. Higher production costs arising from restrictions on quota ownership or use may mean a reduction in producer quasi-rents, a reduction in quota rents, or both, but unambiguously reduce both the sum of quasi-rents and quota rents, and net social welfare.²⁴ Barichello and Cunningham-Dunlop (1987) documented comprehensively the nature of the restrictions on quota ownership and transfer in Canadian agriculture and the sources of efficiency loss that they entailed.

The efficiency loss resulting from restrictions on quota transfer has been the subject of several empirical studies, but has been more often ignored in both theoretical and empirical analysis of quotas in agriculture. Alston (1986) estimated that limits on transferability of hen quota increased the costs of producing eggs in Victoria, Australia, by approximately 20 percent. Rucker, Thurman and Sumner (1995) evaluated the implications of restrictions on inter-county transfers of U.S. flue-cured tobacco quota. They found that a move to free transferability would increase quota rents by 3.5 percent, but would also entail a 2.1 percent loss of producer surplus accruing to growers. Bureau et al. (1997) found that cross-border transferability of sugar quota in the European Union would result in a very substantial redistribution of production with important effects on net welfare and quota rents – even *within* country transferability would confer

²⁴ In addition, going beyond the static analysis, Lerner and Stanbury (1985) suggested that restrictions on who may own quota increase the risk associated with owning quota, since such restrictions mean quota is held in relatively undiversified portfolios, and this cost of risk is leveled against the quota rents.

considerable benefits. A number of studies have considered the implications of transferable quotas for milk. The issue of milk quota transferability in New South Wales was modeled by Neutze (1961), Parish (1963), Lloyd (1971), and more recently measured by Lembit et al. (1988), Tozer (1993), and Drynan et al. (1994). Milk quotas were introduced in the European Community in 1984 and have been much analyzed since, beginning with Burrell (1989). Recent studies measuring the benefits of transferable quotas include Guyomard et al. (1996) for French milk, and Boots, Oude-Lansink and Peerlings (1997) for Dutch milk.

Despite the deadweight costs associated with limits on transferability, imperfectly transferable quotas continue to be the norm. Sieper (1982, p. 65) suggested that the law of restricted quota transferability “may be as well established as the law of demand” and hence, such restrictions should not be assumed away lightly when analyzing quota policies.

5.2. *Quotas and quality*

The typical policy analysis assumes that the commodity of interest is homogeneous. However, commodities are rarely homogeneous, and output controls can lead to distortions in the mix of qualities produced. That the United States produces and exports high-quality flue-cured tobacco, while importing low-quality tobacco, is thought to be – at least in part – a response to the tobacco marketing quotas. Such quality responses to quantity controls can be seen in terms of the Alchian and Allen (1964) theorem and Barzel’s (1976) alternative approach to taxation.

The Alchian and Allen theorem concerns the effects of per unit costs on the relative consumption of high-quality and low-quality goods. The original example concerned “good” and “bad” grapes grown in California. From an individual consumer’s perspective, prices are fixed, and the price of each quality of grapes for a consumer in, say, New York increases by the transportation cost. Thus, good grapes become relatively cheaper for a consumer in New York, and hence, a New Yorker will consume a larger proportion of good grapes compared with a person in California who has identical preferences and means. An analogous result holds for producers, as described by Borchering and Silberberg (1978) in their analysis of why Washington apple growers “ship the good apples out”. The Alchian and Allen theorem holds for individual consumers and producers under certain conditions, and applies for any per unit cost that meets criteria described by Umbeck (1980). Such costs include per unit taxes and quota rents, the only difference being that the tax rate is exogenous while quota rent is endogenously determined by the interactions of supply and demand, given the quota quantity.

Barzel (1976) addressed a similar phenomenon at the market level in his alternative approach to taxation. Barzel noted that every commodity is more or less a bundle of characteristics. If a per unit tax is imposed, the tax statute will use a subset of characteristics to define the commodity, assuming that an exhaustive description is either impossible or very costly. As a result, the per unit tax is actually taxing the defining characteristics. In maximizing their profits subject to the tax, producers may

alter the characteristics included in their units of production. Barzel (1976) showed that the quantity of the defining characteristics (specified in the tax statute) will decrease, and the other characteristics will increase on a per unit basis.

Just as the specification of a per unit tax will use some characteristics to define a "unit", so will the specification of a production quota. In general, a quota will be specified in terms of the commodity's physical characteristics, e.g., weight. Quota rents act as a per unit tax, so that Barzel's model can be applied and used to predict that, although the physical quantity of a commodity is restricted by the quota, other characteristics of the commodity, which implicitly define its quality, will increase. Thus, a quota will lead to an increase in quality.

To estimate the welfare effects of quality responses to an output quota, James (2000) specified a model of two qualities of the same commodity, and imposed a quota to be allocated between the two markets. The average quality, measured as the proportion of production and consumption in the high-quality market, increased as the quota quantity was reduced. The increase in quality increased the producer benefits (exclusive of quota rent) and decreased the consumer losses from a given quota quantity, relative to the case where quality was held constant. However, the quota rent generated by a given quota quantity was smaller than that generated in the constant-quality case, reducing the efficiency of the policy as a means of transferring income to producers. When producers alter the quality of their production in response to a quota policy, the actual transfer achieved from a given quota is smaller and a more restrictive quota must be imposed in order to achieve the desired transfer, relative to the case where quality remains unchanged.

5.3. Output versus input controls and slippage

Production quotas as such are rarely observed. Usually, quotas restrict quantities marketed rather than those produced, and are typically found in industries where production is relatively controllable (e.g., tobacco, where weather effects on yields are relatively small) or in industries where marketing is controlled and a secondary market or storage is available to absorb excess production (e.g., manufacturing milk markets absorb production in excess of fluid milk quotas). When output quotas have been used for commodities for which production or marketing is not controlled, producers have found ways to subvert the quota, either legally or illegally. For instance, a marketing quota on feedgrains can be subverted by vertically integrating a grain enterprise with a livestock enterprise. Some response of this type occurred during the Australian experiment with wheat delivery quotas during 1969–1975.

The difficulty of controlling production or marketing of output may explain, in part, the importance of input quotas in agriculture, especially acreage limitations on crops. Input controls may have been used as a proxy for output controls. In many cases, inputs are easier to control and measure than output. For instance, hen quotas were used to control supply in the Australian and Canadian egg industries because the raw farm

product in that industry is ready for final consumption, making production virtually impossible to monitor.

Although input controls may be easier to enforce, they can be less effective as a control over production, and less efficient than output quotas in other senses.²⁵ Given an input restriction, producers will inevitably alter their production decisions in order to make the costs of that restriction less binding. The most immediate response may be to use the highest quality of the restricted input (e.g., the most fertile land) so that the average productivity of that input increases. In addition, producers will likely intensify their use of other inputs, so that production is greater than it would have been if input proportions had remained unchanged. In the longer run, new varieties or production technologies may be adopted in order to increase output given the input restriction. All of these effects reduce the effectiveness of an input quota in restricting output, a phenomenon often referred to as “slippage”.

With acreage controls, slippage is manifested in yield increases. The extent of slippage under acreage restrictions is governed by the elasticity of substitution between land and other inputs. If this elasticity is zero, output is reduced in proportion to the reduction in land use, and there is no slippage. If it is not zero, output is reduced by a smaller proportion than land is, and in order to achieve a given effect on output, an even tighter restriction on the input is necessary. Some studies have found slippage to be quite substantial.

The combination of acreage restrictions with price supports may have encouraged the adoption of varieties and cultural practices that increased yield at the expense of quality, as noted by Brandow (1977, pp. 258). For instance, Foster and Babcock (1990, 1993) estimated that the use of acreage allotments for tobacco had a very significant effect on both the level and the growth rate of tobacco yields, as was shown after the switch to poundage (marketing) quotas in 1965, when yields fell by 12 percent. Tobacco quality is said to have fallen under input allotments and risen under poundage quotas [e.g., Seagraves (1983)]. Similarly, James and Alston (2002) found a statistically significant reduction in an index of French wheat quality in response to set-asides implemented as part of the 1992 reform of the Common Agricultural Policy.

Environmental externalities associated with agricultural production may have implications for the choice between input controls and output controls.²⁶ When input quotas provide a second-best correction for another distortion, such as an environmental externality, they may be more efficient than output controls; indeed, they could improve net welfare. Input controls that lead to intensification of production in order to increase

²⁵ We can use the equilibrium displacement model presented in Section 4 to compare an input quota on X_1 , and an output quota, both of which reduce output and raise output price by the same amount, by fixing $\delta_Q = k_1 \eta (\sigma + \varepsilon_2) \delta_1 / D''$.

²⁶ Lichtenberg and Zilberman (1986) modeled the effects of a target-price cum deficiency-payment scheme in the presence of environmental externalities.

yields (e.g., output per cow, per hen, or per acre) might reduce or increase externalities associated with agricultural production. For instance, an acreage control *will* lead to an increase in the intensity of chemical use on the restricted acreage and *may* lead to an overall increase or decrease in agricultural chemical use (depending on the relative sizes of the scale and substitution effects). Therefore, an acreage control may increase or decrease the potential for externalities from agricultural chemicals. An increase seems more likely than a decrease in this case, especially since it seems likely that some externalities are a function of the intensity of use of a polluting input, more than a function of the total use.²⁷ Alternatively, if a quota were applied to chemical inputs, rather than to land or output, output would be reduced and there would be a clear advantage of reduced chemical pollution. Similarly, hen quotas are likely to reduce any externalities associated with effluent disposal and might reduce them better than would an output quota that resulted in the same quantity of eggs produced.

5.4. Quotas and variability

A number of studies have examined the effect of variability of supply or demand on the impacts of quotas. Variability in supply or demand can change the market outcomes under a quota, and may accordingly alter the effects of the quota on welfare and its distribution. A marketing (or production) quota insulates input suppliers from the effects of demand variability, but exacerbates the effects of demand variability on output price (by making supply perfectly inelastic). As a result, consumer welfare and quota rent have to absorb all of the variability from demand. By the same token, consumers are insulated from variability in supply (or marginal cost), which is absorbed entirely by changes in producer welfare and quota rent.

Variability may also influence the producers' planned production choices under marketing quotas. Alston and Quilkey (1980) presented some heuristic arguments, suggesting that risk-neutral producers would be expected to aim to overproduce, on average, when production is uncertain. More recent studies have formalized and extended this analysis, with mixed results [e.g., Fraser (1986, 1995), Babcock (1990), and Borges and Thurman (1994)].

Variability may also imply some response by policymakers when markets change. When demand grows under a quota, either price must rise to clear the market, or the quota quantity must increase, or some combination of the two must happen. How the policy is allowed to adjust to accommodate the changes in the market has distributional implications. Sumner and Wohlgenant (1985) raised this issue in relation to the incidence of cigarette taxes on the U.S. tobacco market, Sumner and Alston (1984) elaborate on the same point in relation to more general shifts in demand for tobacco, and Brown and Martin (1996) provide some further results.

²⁷ Hertel (1989) suggested that, without environmental targeting, acreage set-asides likely exacerbate the chemical pollution of streams and groundwater.

6. Variability, stabilization, and policy risk

The inherent variability in agricultural markets is widely recognized. In fact, it is often used as a justification for government intervention. Many policies have been implemented in the guise of stabilization but have their primary effect on raising the average returns to producers. As well as influencing the goals and rationale for policies, variability may change the incidence of a given policy. Policies that have the same incidence in a static sense, or the same incidence when supply and demand are at their expected values, may have entirely different incidence when supply or demand shift, or when actual values are realized. This section discusses issues related to variability, its effects on the typical static welfare analysis, and the trade-off between market risk and policy risk created by government intervention.

6.1. *The stabilization trade-off*

As was shown above for the case of a production quota, in general, policies that stabilize one dimension of the market (e.g., quantity) will inevitably increase the variability in some other dimension (e.g., price, quota rent, producer welfare, or consumer welfare). This is a common theme in the literature on stabilization policies. Policies that reduce price variability or output variability at the farm level are likely to destabilize some other variable, such as gross or net revenue, which may be a more relevant target for stabilization. Indeed, some policies might reduce the year-to-year variation in prices while increasing the odds of a market collapse.²⁸ Some such policies have stabilized prices, quantities, gross revenues, or net incomes for some market participants, but in doing so they have increased the variability experienced by others.

Several studies have examined this phenomenon in the context of trade policies and the variability of international prices. Johnson (1975, 1991) analyzed worldwide impacts of domestic agricultural policies and concluded, as Josling (1977) did, that freer world trade would lessen international price variability for most agricultural products. Sarris and Freebairn (1983) showed that, in the case of wheat, free trade would provide generally much higher and less variable world prices.²⁹ These studies showed that variability must be accommodated by adjustments somewhere in the market, and if one avenue for adjustment is closed (e.g., prices in one country), others must carry more of the burden. The variable import levies implemented as part of the Common Agricultural Policy in the European Union provide an excellent example. Under this policy, import tariffs were varied in order to offset changes in the world price, so that internal commodity prices in the European Union were held constant. However, this policy increased the variability of world prices by two means. First, none of the

²⁸ Brian Wright (personal communication) likened a buffer stock scheme to eliminating the minor bumps in the road in exchange for introducing a 100-foot drop somewhere down the road; an odd notion of stabilization.

²⁹ See studies in Sumner (1988), especially cautionary comments by Bruce Gardner (pp. 170–173).

variability originating from other countries was accommodated by the European Union. Second, the policy meant that any variability in EU supply and demand had to be absorbed by international markets.

6.2. *Welfare analysis in variable markets*

A number of issues arise when we modify the typical static welfare analysis to account for variation in a market. One such issue is that the equivalence between certain policies in a static setting may break down. For instance, in our initial discussion of a target-price deficiency payments program, we noted that in a static setting this would be equivalent to a per unit subsidy (of $P_1 - P_2$ in Figure 1). However, this is not true when supply or demand changes.

Consider a parallel, outward shift in demand. In the case of a target-price policy, producer price, and thus production, remain unchanged, while the consumer price increases and taxpayer costs are reduced, with a reduction in deadweight loss. In the case of a constant per unit subsidy, the same demand shift results in increased producer and consumer prices, increases in production and consumption, and an increase in taxpayer costs, but no change in deadweight loss. After demand has shifted, a smaller per unit subsidy is required to achieve the same effect on producer welfare as the original target price policy. In other words, the equivalence among instruments is conditional on a given set of market conditions.³⁰

In addition to leading to a breakdown of equivalence among policy instruments, variability means that the expected (ex ante) incidence of policy will differ from the actual (ex post) incidence. Furthermore, because measures of policy incidence are nonlinear functions of random variables (prices and quantities), the expected incidence may differ from the incidence when markets are at their expected values. Those engaged in measuring assistance to agriculture often look backwards at the actual income redistribution conferred by a policy rather than what may have been intended or anticipated before market conditions were realized. In some settings, or for some questions, the ex post measure may be misleading.

A floor price scheme is a good example. Suppose the government guarantees producers a minimum price for their commodity. In the typical ex post analysis, if the price floor had not been binding, it would be concluded that the policy had not conferred any benefits on producers, as if the policy had not existed. However, an ex ante measure would take into account the implicit assistance from the policy, which is based on the probability that the floor price would be binding. Bardsley and Cashin (1990), following Gardner (1977), suggested that the assistance provided by a government minimum price guarantee is equal to the value of an equivalent put option, and this value can be assessed

³⁰ In addition to domestic demand and supply conditions, when the commodity of interest is traded, changes in export demand or import supply may also break down the equivalence of policies applied domestically or at the border [e.g., see Tyers and Falvey (1988), Falvey and Lloyd (1991)].

using the Black-Scholes formula. Thus, whether the price floor is binding or not, the possibility that it will bind amounts to a transfer of benefits to producers from taxpayers. Bardsley and Cashin (1990, p. 219) estimated that the underwriting assistance provided an implicit transfer from Australian taxpayers to Australian wheat growers worth about A\$20–40 million per year from 1979/80 through 1985/86, equivalent to a subsidy rate of about 2–4 percent.

6.3. *Producer and policy responses*

Variability and policies that affect the degree of market variability also have indirect effects. Risk averse producers may respond systematically to policies that change price variability. In addition, changes in market conditions may provoke policy responses.

Innes and Rausser (1989) considered the implications of price stabilization for the incidence of the stereotypical U.S. commodity programs. They argued that if producers are risk averse and contingent claim (e.g., insurance) markets are incomplete, price stabilization will induce a supply response. As a result, producers may produce more for a given guaranteed price than they would for the same expected price. This producer response will modify the incidence of the policy. In addition, a policy that stabilizes prices or net incomes can confer welfare gains even when there is no behavioral response, under certain assumptions about risk attitudes [see also Moschini (1984) and Innes (1990)]. Innes and Rausser (1989) suggested that these effects could be so large that the conventional welfare implications of a target price with deficiency payments are reversed: producers can be made worse off, and society as a whole, better off. The authors also derived conditions under which production controls would improve net social welfare, but they showed that, in this case, the static effects on producers and consumers would not be reversed by the introduction of risk and risk aversion.

As noted above, market variability alters the incidence of policies. From a policy-maker's perspective, then, a policy must adjust to market conditions and the induced producer responses in order for it to have the intended effects. Some studies have allowed for endogenous policy responses to changes in market conditions [e.g., Rausser and Freebairn (1974), Sarris and Freebairn (1983), Rausser and Foster (1990)] and, indeed, some have advocated the adoption of flexible policy rules so that policies would adapt optimally when market conditions change [e.g., Just (1984, 1985), Love and Rausser (1997)]. Of course, perfect adjustment for market variation requires perfect foresight regarding supply or demand shocks, producer responses to policies, and the hypothetical price and quantity at which the market would clear if it were undistorted. The danger of designing a policy whose operation and success depends on such perfect foresight is exemplified by buffer stock schemes, which have all, ultimately, collapsed.³¹

Under buffer stock schemes, government purchases are made when the market price is expected to be "too low", and stocks are released when the market price is expected

³¹ Wright (1993) discusses the dynamic incidence of agricultural policies generally, with some emphasis on floor-price schemes.

to be “too high”. The success of such schemes, then, relies on the ability of government operators to beat the market. While this may be possible in some time periods, Wright and Williams (1988) and Williams and Wright (1991, pp. 396–397) note that budgetary constraints will eventually bind, either because of imperfect foresight or because of prolonged periods requiring government purchases. Bardsley (1994) documented the 1989 collapse of the Australian wool reserve price scheme (essentially a buffer stock scheme). Before its collapse, the scheme eliminated A\$1.8 billion of reserve funds, and left wool growers with a debt of A\$2.7 billion and a wool stockpile, much of which remained unsold ten years later.

6.4. Policy risk

A hypothetical benevolent government might introduce agricultural policies to reduce price variability experienced by producers, making risk averse producers and society better off, as suggested by Moschini (1984) and by Innes and Rausser (1989). However, the same intervention introduces another source of risk, *policy risk*: the risk that producers will experience a loss arising from changes in policy or a policy-induced market collapse. Hence, any government intervention in a commodity market is likely to involve elements of policy risk, and any policy designed to mitigate market risk will entail at best a trade-off between market risk and policy risk.

Just and Rausser (1984, p. 129) presented a comprehensive discussion of how the design of policies can affect producer uncertainty and concluded that, “The inherent instability and riskiness of the U.S. food and agriculture system is the market-failure justification for U.S. agricultural policy. The implementation of policies to address such market failures is often confronted with government failure. Political-administrative instabilities resulting from government failure can exceed the inherent instabilities of the private sector”.

Evidence about policy risk has been inferred by some from the rates of capitalization of quota rents into quota asset prices. For instance, Lermer and Stanbury (1985) estimated that costs of policy risk offset half or more of potential producer benefits from supply management for eggs, broilers, and turkeys in Canada. Lermer and Stanbury (1985) attributed all of the premium in the quota rental rate (rents as a percentage of the quota value), above a risk-free rate of return, to diversifiable risk, which would not exist if quota were held in fully diversified portfolios; hence, it represents an unnecessary cost of “insurance” against loss of the quota income stream. Alston (1992), however, suggested that some of the premium must reflect the equivalent of actuarially fair insurance, so that Lermer and Stanbury (1985) probably overstated the cost of unnecessary risk-bearing from limited quota transferability.³²

³² Seagraves (1969) may have been the first to raise these issues. Also, see Barichello (1981, 1996), Barichello and Cunningham-Dunlop (1987), and Johnson (1991) for further discussion on the capitalization of quota rents into quota values.

Other studies have sought to identify the capitalization of commodity programs into land prices. Various authors have proposed that government payments may be discounted more heavily than income from the market, when they are capitalized into land values [e.g., Just and Miranowski (1993), Clark, Klein and Thompson (1993), Schmitz (1995), Weersink et al. (1999)]. This could simply reflect an expectation that government program payments will not persist, which may have been an accurate prediction, and need not imply any risk premium as such, nor any waste of the type identified by Lerner and Stanbury (1985). On the other hand, the discounting could contain an element of policy risk and excessive risk costs.

7. Costs of administration and enforcement

All of the analysis above ignores the costs of administration and enforcement of policies. Once we allow for these costs, taxpayers as an interest group are affected by regulatory instruments such as quotas, not just the instruments that involve subsidies and taxes. Taxpayers bear the costs of administration and enforcement and receive as benefits revenues raised from fines imposed as penalties. These costs therefore change the qualitative implications of policies, as well as their quantitative implications, in terms of the distribution of benefits and costs, optimal instrument combinations and settings, and transfer efficiency.

Costs of administration and enforcement may be quite substantial, and may differ among policies. The processes of initially allocating quota and dealing with the inevitable appeals for reallocation can be very costly, as is well known to anyone who has witnessed them at close hand; every producer (or other presumptive quota owner) must be dealt with on an individual basis. Similarly, substantial costs of negotiation and rent-seeking arise whenever the elimination of a quota is seriously contemplated by government. The processes involved in introducing or eliminating a subsidy, on the other hand, are much simpler (and presumably less expensive). The costs of introducing or modifying policies may be more important than the conventional measures of deadweight costs, yet we usually have no information on these costs and leave them out of the analysis.

Once policies have been introduced, the administrative costs may be relatively low, so long as producers and consumers willingly comply. But some policies create incentives for producers or consumers to break the policy rules, and there is some evidence that participants in agricultural commodity markets will respond to such incentives.³³ We need to extend our models to account for optimizing behavior in those cases where it is profitable to break the rules, or where accounting for cheating will lead to significant changes in implications of policies. This requires taking into account the market incentives to break the rules, the odds of being caught, and the penalties. In addition, many

³³ For instance, when the egg market in the state of Victoria, Australia, was supposedly being controlled by hen quotas, it was estimated that the black market accounted for 10–30 percent of all eggs [Alston (1986)].

aspects of enforcement are chosen by policymakers when they choose how vigorously to enforce policies and what penalties to apply to those who are caught in violation, and this too can be modeled. Finally, the direct costs of enforcement must be added.

At one level, this calls for no more than a routine application of the economics of crime and punishment for which there is an extensive literature, beginning with Becker (1968). Surprisingly, perhaps, the literature on agricultural policy has had very little to say on these matters. Some recent work by Giannakas (1998), and Giannakas and Fulton (2000a, 2000b, 2001a, 2001b) has redressed a significant part of this deficiency, but much remains to be done. As will be seen below, the economic problem of analyzing a policy with cheating and enforcement costs, where the policy rules and enforcement effort are endogenous, along with the settings of the instruments, has many dimensions. Dealing with all of those dimensions makes for an intractable problem; assuming them away restricts the generality of the results. Here we will add some components of imperfect enforcement, but restrict attention to some special, comparatively easy cases.

7.1. Quotas and cheating

Suppose we have an output quota policy with costly (and, therefore, probably incomplete) enforcement [this policy is modeled in detail by Giannakas and Fulton (2001a)]. In Figure 10, the unregulated supply and demand are represented by S and D . If effective, a quota of Q_Q would result in supply of S_Q , yielding a price of P_1 . At this price, producers would want to produce Q_1 , which is more than the competitive quantity, Q_0 . How much they will produce beyond their quota will depend not only on the odds of being caught and the penalty imposed if they are caught, but also on how those odds and penalties vary with the size of over-quota production. In addition, producers may be able to influence the odds of being caught by taking certain precautions, at a cost. Taking all these considerations into account, we can imagine a regulated supply function, S_R , that coincides with the unregulated supply function for quantities less than the quota, but lies above it for over-quota production, reflecting the costs of cheating (including costs of avoiding detection and expected costs of punishment), added to the ordinary costs of production.³⁴

As the regulated supply curve is drawn in Figure 10, the marginal costs of crime and punishment perceived by producers are initially infinitesimally small (perhaps reflecting that the odds of being caught or that the penalties when caught are negligible for small amounts of over-quota sales) but rise with the size of over-quota production. This could reflect a positive effect of increasing over-quota production on either the chance of being caught, the costs of avoiding detection, or the penalty per unit of over-quota production.

³⁴ Alston and Smith (1983) drew a similar diagram to represent the consequences of incompletely enforced price floor regulations. The details of the nature of the shift from S to S_R to the right of Q_Q – pivotal as drawn in Figure 10 or more nearly parallel as drawn by Giannakas and Fulton (2000a, Figure 1) or some other form – will depend on the nature of the relationship between cheating, the odds of being caught, and the penalty once caught.

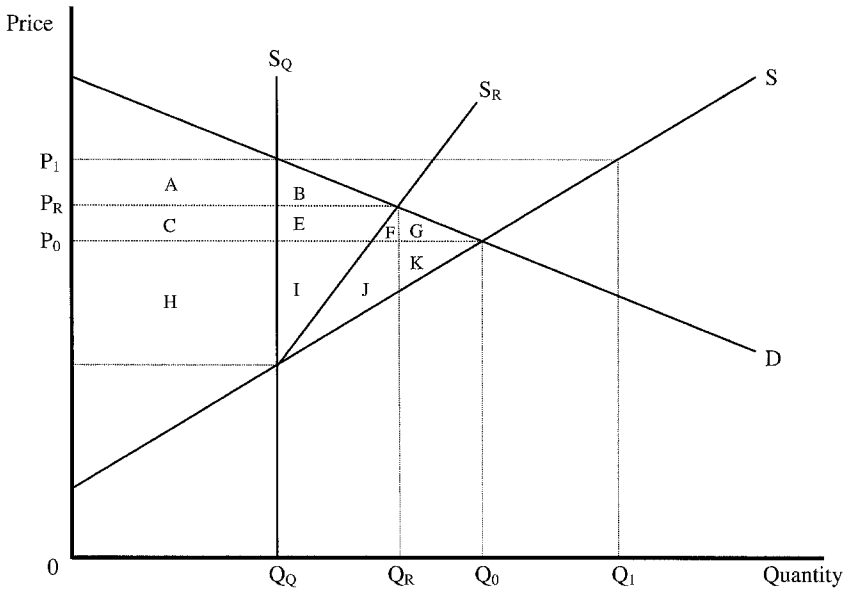


Figure 10. Output quota with imperfect enforcement.

Table 4
Welfare effects of a quota with and without cheating

Changes in	Quota with no cheating	Quota with cheating	Effect of cheating
Producer Surplus (ΔPS)	$A + C - (I + J + K)$	$C + E - (J + K)$	$E + I - A$
Consumer Surplus (ΔCS)	$-(A + B + C + E + F + G)$	$-(C + E + F + G)$	$A + B$
National Surplus ($\Delta NS = -DWL$)	$-(B + E + F + G + I + J + K)$	$-(F + G + J + K)$	$B + E + I$

Note: The entries in this table refer to areas in Figure 10.

Thus, the regulated output that is actually sold on the market, Q_R , is between the competitive quantity and the quota quantity, and the corresponding regulated price, P_R , is between the competitive price and the quota price. Several interesting welfare effects can be seen in this figure, as summarized in Table 4. Under the perfectly (and costlessly) enforced output quota, producers (who are assumed also to own the quota) would gain area $(A + C) - (I + J + K)$. If producers cheat and expand their production to Q_R , they gain only area $(C + E) - (J + K)$. Producer benefits are lower by $A - (E + I)$ when the quotas are imperfectly enforced. However, the black market returns, area $E + I$, do not necessarily go to quota owners. In addition, area $E + I$ represents net returns after deducting the expected taxpayer benefits from fines (which also should be deducted from the deadweight losses). Consumer losses are smaller, by area $A + B$, as are net social costs, by area $B + E + I$.

How does cheating affect transfer efficiency? If we were able to impose a fully enforceable output quota of Q_R it would achieve greater producer benefits than the imperfectly enforceable quota set at Q_Q , with a smaller deadweight loss. For the same reason, then, for a given producer benefit, transfer efficiency is lower under an imperfectly enforced output quota than under a perfectly enforced output quota. In addition, the net costs of enforcement must be added to the other deadweight losses, further reducing the efficiency of transfers (even more so when tax revenues with a marginal cost of $1 + \delta$ are used to fund enforcement efforts). Policymakers can make the policy more like a perfectly enforced quota by increasing enforcement effort (which would shift S_R further towards S_Q), but this is simply a trade-off between the costs of enforcement and the deadweight losses in the commodity market. If that trade-off has been optimized already, then S_R represents the least-cost regulated supply function.

Figure 10 could also be used to represent the contrast between an output quota (set at Q_Q) and an input quota set at the quantity that would be used to produce Q_Q in the absence of intervention.³⁵ In this case, however, the difference between S and S_R reflects the increased cost of production under an input quota arising from the intensification of the use of other (nonquota) inputs, or slippage. In both cases, what we see is evidence of producers incurring expenses in order to circumvent the constraint of the quota, either the costs of cheating or the costs of distorting the input mix. This observation makes it easier to understand how input quotas are sometimes chosen over output quotas to achieve the same goal. Holding enforcement costs constant, an input quota would be preferred if $S_{R-INPUT\ QUOTA}$ is closer to S_Q than $S_{R-OUTPUT\ QUOTA}$. This would be likely if producer costs of cheating under an output quota were relatively low (reflecting small penalties or difficult detection) or if slippage were relatively low (reflecting low input substitution possibilities). The odds are pushed further in favor of input quotas if they are easier to enforce than output quotas.

7.2. Deficiency payments and cheating

Consider a target-price and deficiency-payments scheme, where the cheating takes the form of producers overstating the amount of their production in order to receive larger deficiency payments [this policy is modeled by Giannakas and Fulton (2001b)]. This situation is represented in Figure 11. Given a target price of P_T and no cheating, relative to the competitive equilibrium (P_0, Q_0) producers gain area $A + B$, consumers gain area $E + F + G$, and taxpayers lose area $A + B + C + E + F + G$, so that there is a deadweight loss of area C . If producers cheat, however, and claim to have produced Q_2 when in fact they produced only Q_1 , then they receive additional benefits of H , against which they must count any expected costs of penalties for cheating that is detected. But, as pointed out by Giannakas (1998), this additional amount is a lump-sum transfer from taxpayers and does not involve any additional distortions in production or

³⁵ See Alston (1981, 1986) for some discussion of this scenario.

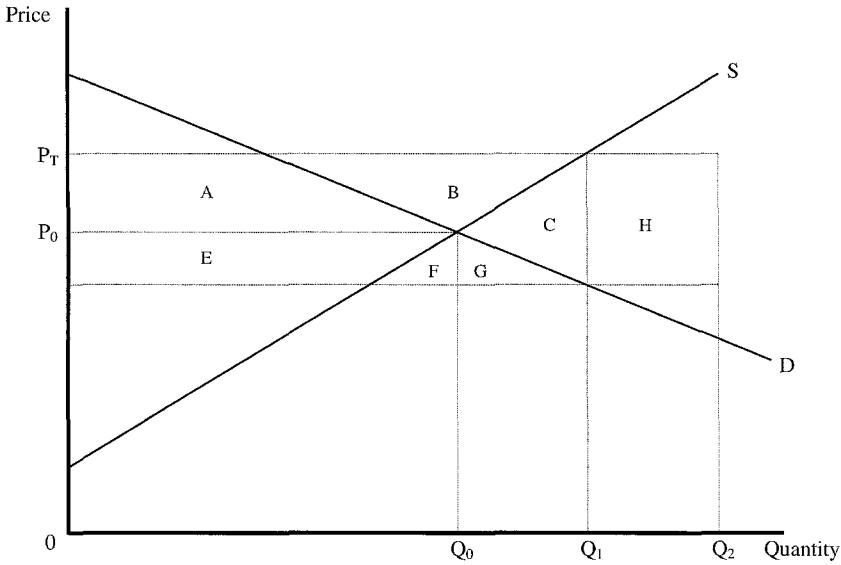


Figure 11. Cheating with a target price and deficiency payments.

consumption. Alternatively, if a total transfer of $A + B$ were intended, and producers cheat by overstating their production, then the target price could be set lower than P_T and the taxpayer costs and net social costs would be reduced (i.e., reduce the target price until the area corresponding to $A + B + H$ is reduced to the size of $A + B$ in Figure 11). Ironically, cheating increases the transfer efficiency of a target-price and deficiency-payments policy. Of course, this assessment has not factored in the costs of enforcement, which will reduce the transfer efficiency, and some enforcement will be necessary in order to limit the total amount being transferred. Nor has it accounted for the deadweight losses from taxation to finance the policy and its enforcement. In addition, the existence of cheating means that the benefits will be shifted towards those who have a higher propensity for cheating, which may not be consistent with the goals of the policy.

These results show that, even in a very stylized representation of the problem, cheating may increase or reduce the efficiency of transfers. Given a quota quantity, cheating is likely to reduce the total producer benefit, the total deadweight loss, and transfer efficiency. With a target-price and deficiency-payments scheme, cheating enhances transfer efficiency, increasing producer benefits but with no effect on deadweight loss (if $\delta = 0$), or with an increase in deadweight loss but a reduction in the average deadweight loss (if $\delta > 0$). A more complete understanding of the effects of cheating and costs of enforcement and administration requires a more complete specification of the details of the penalties and so on. Once these details have been specified, empirical estimates of the implications of cheating may be simulated or estimated econometrically.

8. Dynamics of factor and product supply, and policy incidence

The analysis in Section 3 showed how the incidence of policy turns on the conditions of supply of output and, ultimately, inputs. Understanding supply response is critical to understanding policy incidence. The models used above are based on static supply functions, and typify models used commonly in the analysis of commodity programs. Hence, in these models, policy incidence is static, too, and is determined by the elasticities that characterize the static supply functions. In contrast, in econometric models of supply response, the most challenging elements relate to the treatment of uncertainty and expectations, the lags between decisions and their consequences, and the dynamic evolution of supply response.³⁶ Thus, there is little connection between the typical static representation of supply in commodity policy models and econometric models of agricultural supply response, the most conspicuous features of which are dynamics and uncertainty. Questions arise, accordingly, about the interpretation of measures of policy incidence based on static supply models.

In a classic article, Cassels (1933) identified the key issues in analyzing agricultural supply response, and these have remained largely unchanged in spite of the major advances in theory, availability of detailed data, computing power, and econometric estimation techniques. A significant proportion of the rather extensive literature on supply analysis during the past 65 years has concerned treatments for problems raised by Cassels (1933).³⁷ Primarily these efforts have related to the dynamics of response and the formation of expectations, beginning with Nerlove (1958). That the essential problems persist can be seen in the more recent reviews by Colman (1983) and Just (1993). Both of these authors discussed the issues in choosing between models in which results from the (static) theory of the firm can be imposed as restrictions (e.g., static econometric models based on cost functions or profit functions, or programming models) and other models that connect less closely to that set of theory but, at the same time, are more realistic in their use of other theory related to dynamics and expectations (i.e., the so-called ad hoc single-equation econometric models). These discussions centered on the development of models with a view to econometric estimation and prediction, rather than policy analysis, but the same types of arguments can be made for policy models. There is a trade-off between the different types of model characteristics (consistency with static producer theory versus incorporation of

³⁶ In particular, biological processes in agricultural production take time, so that decisions about the commitment of inputs and planned production are based on incomplete information about weather and other events during the growing season (or several seasons), and about what prices will be when products become available for sale. These biological lags can involve several years in certain livestock industries, and much longer for some perennial crops and forestry. In addition, responses to given price changes and other events evolve over time, increasing with length of run as more things become more variable.

³⁷ Alston et al. (1995, pp. 18–19) provide a summary overview of that literature, including documentation of a number of more comprehensive reviews.

dynamics and expectations), the dimensions of which will vary depending on the types of questions being addressed and availability of data and so on.

If we decide that we must use a more realistic representation of supply response, going beyond the simple static model used above, we also have to reconsider the criterion for the welfare analysis. Changes in producer surplus can reasonably be used to represent changes in profit in the simple static model. However, in a model with dynamics and uncertainty, we may have to define a different measure of producer welfare change and we may have to aggregate over multiple periods. Such approaches may be too difficult for many problems.

8.1. Evolution of supply response

As characterized by Cassels (1933) and many writers since, there is no such thing as *the* supply function but, rather, there is a family (or fan) of supply curves for a particular commodity – more elastic supply curves for longer lengths of run. By choosing a particular supply elasticity for a commodity we are, implicitly, choosing a particular length of run.

Why does the supply elasticity increase with increases in length of run? In the theory of the (competitive) firm, factors are often defined as either fixed or variable (with fixed prices), so that the firm faces factor supply functions that are either perfectly inelastic (for the fixed factors) or perfectly elastic (for the variable factors). In the context of this theory, length of run is defined in terms of the numbers of factors that are fixed: at longer lengths of run, fewer factors are fixed. When more factors are variable, the firm has more dimensions for economizing on inputs as it increases its output in response to a price increase and, accordingly, marginal costs do not rise as quickly. This can be seen as a special case of a more general view in which firms face upward-sloping supplies of all factors of production (some of which may be highly elastic), that become more elastic as length of run increases. It is the evolution of these factor supply functions, becoming more elastic with increases in the length of run (or, equivalently, the reduction in the importance of quasi-fixed factors), that gives rise to the increasing elasticity of the output supply function. At the industry level, factor supply functions are likely to slope up even when prices are exogenous to individual firms. Here, too, the source of upward-sloping output supply is upward-sloping input supply, including the supply of firms themselves, and with increases in length of run the factor supply functions become more elastic, as does the output supply function.

8.2. Implications of dynamic output supply response

When we use comparative statics to measure the welfare implications of commodity policies, we are taking a static approximation to a dynamic problem. Figure 12 depicts a family of supply curves with increasing length of run and elasticity as we go from the market period (S_M) to the short run (S_{SR}), intermediate run (S_{IR}), and long run (S_{LR}).

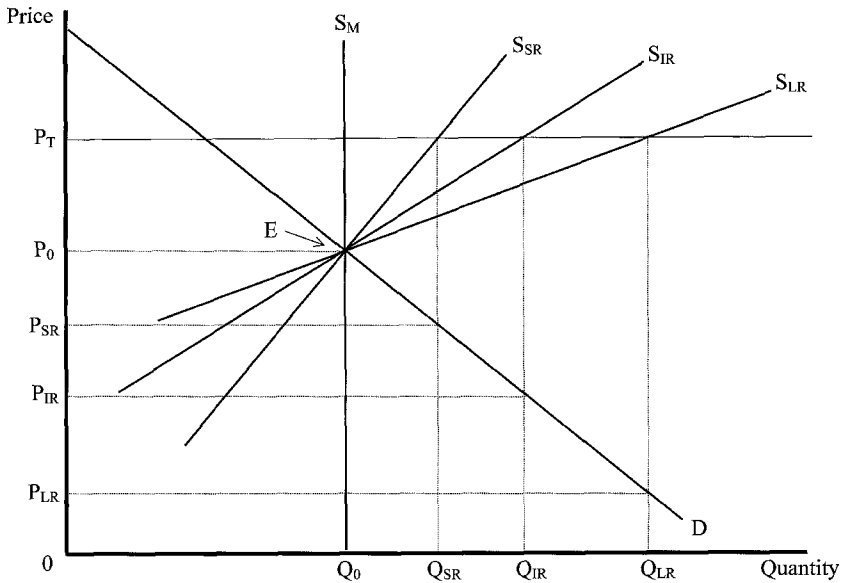


Figure 12. Supply elasticity and length of run.

These discrete alternatives represent a selection from a continuum of supply curves that all pass through the current equilibrium of supply with demand at point E in Figure 12.

Suppose a target price is applied to the market for the commodity in Figure 12 at P_T . In the current market period no supply response is possible, everything is fixed, and the effect is to make a lump-sum transfer from taxpayers to producers equal to $(P_T - P_0)Q_0$. In the short run, some supply response is possible, output increases to Q_{SR} and price falls to P_{SR} , leading to benefits to consumers, an increase in benefits to producers, and an increase in the burden on taxpayers, with an associated deadweight loss. The supply response to the increase in price from P_0 to P_T progressively expands to Q_{IR} in the intermediate run, and Q_{LR} in the long run, and the effects on price and welfare are progressively amplified.

Given that the producer welfare effects change with the length of run being considered, which is the "correct" measure? Just, Hueth and Schmitz (1982) suggest two measures, each of which is a discounted sum of the changes in producer surplus over the life of the policy. When the relevant production function is intertemporally separable, the benefit to producers from a target-price policy is equal to the sum of discounted producer surplus changes, where the change in producer surplus for each future period is measured from a supply function of the corresponding (incrementally increasing) length of run. An alternative measure that does not require intertemporal separability is the sum of discounted changes in producer surplus, as measured using the short-run supply curve for each period, less the present value of expenditures on investment in fixed assets. Bullock, Garcia and Lee (1996) extend the formal analysis

presented by Just, Hueth and Schmitz (1982, Appendix C) to allow for different (i.e., other than “naive”) expectations processes in the evaluation of welfare change under a dynamically evolving supply response.

The time path of measures of policy incidence will vary among policy instruments. For instance, with a target-price and deficiency-payments policy, the evolution of supply response involves ever-greater benefits to both producers and consumers, at the expense of ever-greater taxpayer costs and deadweight losses. In contrast, with a conventional per unit subsidy, the benefits may initially go entirely to producers but, with the evolution of supply response, may later shift toward consumers – and will end up entirely as a benefit to consumers when long-run supply response is perfectly elastic. On the other hand, with a quota, the evolution of supply response might not change the cost to consumers, and does not eliminate producer benefits in the long run, though it does reduce the quota rents and producer benefits over time.³⁸ This helps account for why quotas, and not subsidies, are more often found in industries for which the long-run supply is highly elastic, such as tobacco, eggs, poultry, and fresh milk.

8.3. Evolution of factor supply and policy incidence

As the length of run increases, the incidence shifts not only between producers and consumers; as supply becomes more elastic relative to demand, it also shifts among the factors. Some factors are relatively fixed in the short run and relatively variable in the long run. As a result, short-run incidence may differ qualitatively as well as quantitatively from longer-run incidence, particularly if the policy induces technological change.

For instance, consider the nature of the response of California’s milk supply to a policy-induced increase in price. Ultimately, a permanent increase in production might imply a proportional increase in the use of all inputs. But it may take farmers in the industry two years after deciding to increase output in response to a higher price to add any additional cows to the total milking herd (although some short-term adjustments could be made by delaying culling). Additional output could be achieved perhaps by intensifying the use of other inputs such as purchased feed or growth hormones. In the short run, in which the number of milking cows is essentially fixed (corresponding to less than two years), the supply of feed to the dairy industry is likely to be highly elastic so that feed (or land) is not the limiting factor; cows are. In the intermediate run, however, say two to five years, the dairy industry can supply itself with additional milking cows at approximately constant cost. The cows are no longer the critical specialized factor. In some industries, and this might be an instance, processing capacity may be less elastically supplied than other inputs over the short and intermediate lengths of run, although it would be expected to be highly elastically supplied in the long run.

³⁸ Another possibility is that quota restrictions may imply a slower rate of technological change than would arise otherwise [e.g., see Alston (1986)].

In the intermediate and longer lengths of run, it may be managerial capacity that limits industry supply response more than other things.

Thus, the incidence of policies in the dairy industry will change with length of run. In the short run, but not in the longer run, for instance, the primary beneficiaries of a subsidy may be the owners of milking cows, not always the same people as those who supply other inputs such as land, feed, or equipment used in dairy farming. The differential dynamic incidence of policy is even more readily apparent for specific instances such as the U.S. whole-herd buyout program, where compensating some dairy producers for exiting the industry, and eliminating their herds, benefited those remaining in the industry who owned cows, but only in the period before replacement cows could be (and were) raised [e.g., see Chambers (1987)].

These types of issues are relatively important where dynamics in supply response are relatively important. Perennial crops provide good examples. Alston et al. (1995) provide a comprehensive analysis of the California almond industry and its reserve policy. In the almond industry, like many other tree crops, after a decision has been made to expand production by planting new trees there will be long lags before those new plantings come into production (say four years), and even longer lags before they reach their productive potential (say eight years), which can be maintained for a long time (up to twenty-five years). In the very short run, there cannot be any significant production response to a price increase. The Almond Board of California has exploited that fact in diverting some production from edible uses (a type of price discrimination strategy) in order to drive up the market price for edible uses. In the short run this policy cannot be undermined by supply response to the higher average revenue that results from the diversion. In the long run, however, the supply of almonds is likely to be highly elastic (there is an abundant supply of land and other resources suitable for almond production and no evidence of decreasing returns to industry scale, and the policy does not limit entry or production). While this policy can raise average revenues and profits in the short run, in the longer run it stimulates entry and raises industry productive capacity, depressing prices.

8.4. Dynamic evolution of markets in response to policy

The farm program for U.S. tobacco provides another good example of the dynamic evolution of markets in response to policy, with some surprising implications for the incidence of the policy. As documented by Johnson (1984), when the farm program for U.S. flue-cured tobacco was first introduced during the 1930s, the U.S. industry dominated the world market. From 1940, supply was controlled (initially using acreage allotments; since 1965 using poundage quotas), which held up the domestic and world price for U.S. tobacco. Over time, in response to the higher price of U.S. tobacco, production in other countries increased and export demand facing the United States fell.

In an analysis of the dynamic effects of the policy, Seagraves (1983) reported that during 1935–39, the United States produced 64 percent of the world's flue-cured

tobacco and 83 percent of the world's net exports. By 1980–82, these numbers had fallen so that the United States produced only 17 percent of world production, and only 21 percent of exports. In recent years, the United States has been importing roughly one-third of tobacco used in cigarette production in the United States, while exporting one-half of the tobacco grown in the United States.

Alston and Sumner (1988) estimated the static welfare effects in 1987, and concluded that the quota was close to the quantity that would maximize the net U.S. gains in that year.³⁹ But over time, the potential U.S. market power has been progressively eroded, as a result of some market power being exercised through the quota. Whether the policy has been *dynamically* optimal, so as to maximize the present value of U.S. benefits over time, has not been evaluated.⁴⁰

Any policy by a large exporter that restricts supply to the world market (as for U.S. tobacco and almonds) raises the world price along with the domestic one, and confers benefits on overseas producers, to some extent at the future expense of U.S. producers: today's domestic producers may be gaining at the expense of tomorrow's. Conversely, policies that lead to greater output and exports of, say, wheat would be expected to have dynamic domestic consequences arising from their negative effects on competing wheat producers overseas. Domestic supply responses to subsidies on output (or exports) increase with length of run. At the same time, foreign supply response to lower world prices also increases with increases in length of run, which means that the demand for wheat exports also becomes more elastic with increases in length of run. Dynamic responses such as these account for the (surprising to some) shift of the European Union from being an importer, before the Common Agricultural Policy was first introduced, to being the world's largest exporter of wheat 30 years later, with significant political and budgetary problems arising from the larger-than-anticipated responses to the policy. Like U.S. tobacco, and California almonds, dynamic responses to the EU wheat policy progressively undermined the effectiveness of the policy as a means of transferring income to producers efficiently.

9. Conclusion

The incidence of agricultural policy depends on the details of the policies and the contexts in which they are applied, especially concerning the conditions of supply of factors of production to the industries concerned. It is necessary to account for these details that vary from one setting to the next. Hence, we cannot generally make the

³⁹ Sumner (1996) summarizes the main results.

⁴⁰ Studies have looked at the optimal time path of trade taxes, and the same types of issues are likely to arise here. For instance, see Gaskins (1971) and Karp (1987). Alston et al. (1995, Ch. 7), analyze a very similar problem for the almond industry, although the competitive fringe here includes domestic as well as foreign entrants.

types of broad generalizations that we may wish to make, such as that farm program benefits are ultimately capitalized into land, based on theory alone.

The literature on the incidence of agricultural policies includes two main types of studies. Specific studies of particular policies (such as the U.S. tobacco program) or particular events (such as the collapse of the Australian wool reserve price scheme) sometimes tell us a great deal about incidence. However, not many of the empirical studies that have been done have characterized the policies, or the markets in which they apply, in sufficient detail to provide much information about policy incidence beyond the distinction between domestic and international, or producer and consumer welfare effects. In particular, few studies of commodity policies have provided clear statements about the elasticities of supply of different factors of production to the industry in question, which is a central determinant of incidence among factors of production. The other main type of study takes a more general look either at certain policy issues (e.g., broad-brush comparisons of particular instruments), or at agricultural industries (e.g., overall assessments of the effects of agricultural policy in the United States). While the latter types of study can teach us much about the determinants of incidence, they usually forsake too much of the necessary detail to offer much empirically, if our claims about the importance of details are valid.

Two important elements of realism are often lacking from studies of commodity policies and their incidence. These are (1) a realistic representation of the policy instruments, and (2) an appropriate representation of the conditions of factor supply and product demand, and technology. In relation to the instruments, quite substantial differences in incidence can be found as a result of apparently innocuous details – such as whether a quota applies to inputs or outputs or is transferable, or whether we have a subsidy versus a target price with deficiency payments – especially when we allow for market variability and dynamics.

In this chapter we have emphasized two main types of domestic commodity policy instruments, supply control policies (output or input quotas) and subsidies. For each of these instruments we have identified a real-world departure from the common theoretical characterization, which has potentially profound implications for the evaluation of each, and for the comparison between them. First, real-world quotas, whether applied to inputs or outputs, are typically not transferable, and this has very serious implications for the social costs of supply controls. Second, allowing for the deadweight costs of taxation to finance subsidies means that subsidies involve much greater deadweight losses, and a much heavier burden on taxpayers, than a conventional analysis would indicate. In addition, both subsidies and supply controls are costly to introduce, administer, and enforce. These costs, and the effects of producer responses to the incentives to cheat, also change the deadweight losses from each of the policies, their distributional consequences, and their efficiency as means of transferring income to producers.

The second set of concerns relates to the (mis-)representation of the market context in which a policy is applied. We often see policies analyzed using unrealistic combinations of assumptions about supply and demand conditions and policy instruments. For

instance, often in the literature, policies that apply to individual commodities, or groups of commodities, are analyzed as though they apply to agriculture in aggregate; and elasticities that are relevant for agriculture as a whole are used as though they apply to individual commodities. One form of fallacy of composition is to conduct an analysis of U.S. agriculture that treats the entire industry as though it has the same policy as the wheat industry has; another is the use of a perfectly inelastic supply of land, as may be a good approximation for U.S. agriculture, in the analysis of the U.S. wheat price-support policy. There are few policy questions for which either of these approximations will be reasonable. Another common failing is the use of elasticities, especially for demand, that reflect a failure to account for the role of international trade. If the results are to be meaningful, we must match elasticities to both the length of run and the market of interest.

As well as being intrinsically interesting, understanding the effects of policies is also a first step to understanding why certain policies are chosen, and to prescribing policies. While we have made considerable progress in theoretical models that help us think about these issues, we have relatively little to show in terms of empirical understanding of incidence of farm commodity policies. More meaningful empirical analysis requires better measures of the conditions of supply of different factors of production in particular industries, taking into account the level of aggregation and length of run, better empirical estimates of the *relevant* commodity supply and demand elasticities, and more realistic representation of policy instruments. Important elements of the unfinished agenda for work in this area also include further theoretical development and empirical work on dynamic incidence of policy, policy risk, endogenous quality, the costs of administration and enforcement of policies, and the consequences of cheating.

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