Quality Responses to Agricultural Policies

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August 1999

Abstract

Most policy analyses are conducted using a model of a single market for a homogeneous commodity. Usually, the commodity of interest is not truly homogeneous, but the homogeneity assumption is imposed for the sake of simplicity. In doing so, analysts are implicitly assuming that a single-market model of a homogeneous product closely approximates true policy effects. This paper explores the implications of this assumption. The effects of the homogeneity assumption are shown for the simple case of a product available in two qualities, when market-distorting policies are introduced. It is shown that, for plausible parameter values, ignoring quality responses can have substantial impacts on the estimated welfare effects of policies. In addition, for a given transfer to producers, a model that incorporates quality responses to policies will imply different settings for policy instruments than a model of a homogeneous commodity, and in some cases, different instruments. For some transfers, including quality responses will switch the ranking of policies.

Selected paper presented at the Annual Meetings of the American Agricultural Economics Association, August 8-11, 1999, Nashville, TN.

1999

Policies and programs

AAEA 1999

Many policy analyses are conducted using a model of a single market for a homogeneous commodity. Although this approach may be taken because the analyst believes that the commodity of interest is truly homogeneous, more often the analyst assumes homogeneity for the sake of simplicity. In these cases, the analyst implicitly assumes that a model of a homogeneous commodity reasonably approximates market outcomes and policy effects for a commodity that is actually heterogeneous. The main purpose of this paper is to explore the implications of heterogeneous commodities with endogenous quality for agricultural policy analysis. To do this, the effects of the product homogeneity assumption are illustrated when the product of interest is actually available in two qualities (low and high) and market-distorting policies are introduced.

A model of two related markets is specified, which is sufficient to allow for policy-induced quality responses. To provide the contrast, a single-market model is specified in which the commodity of interest is treated as if it were homogeneous (i.e., of constant quality). Policy instruments are introduced and the effects are determined in each model. The purpose, here, is to contrast the "truth" from the two-market model, with "convention," the results from the simplified model of a homogeneous commodity. Here, both "truth" and "convention" are defined as such in a stylized setting, under various assumptions. Each of these assumptions is described and justified as the model is presented below.

Quota policies and target-price policies are introduced into each of the two models. The estimated welfare effects of the policies from the single-market model of a homogeneous commodity are compared with those from the two-market model that allows for quality responses. These qualitative comparisons show the direction of error in estimating true policy effects under the assumption of product homogeneity. It is shown that the inclusion of quality responses can substantially alter the appropriate value for a policy instrument necessary to achieve a given policy goal. Furthermore, in some cases, quality responses may even change the optimal policy choice.

1 The Two-Market Model

To represent demand and supply conditions in the two-market model, linear supply and demand functions are specified for each market. In the expressions for the quantities demanded and supplied in each market, specified below, subscripts L and H are used to denote prices or quantities in the low- and high-quality markets, respectively. Superscripts D and S denote prices or quantities defined along a demand or supply curve. In the most simple form, quantities demanded and supplied in each market are expressed as:

$$Q_L^D = a + bP_L^D + cP_H^D \tag{1}$$

$$Q_L^S = d + eP_L^S + fP_H^S \tag{2}$$

$$Q_H^D = A + BP_L^D + CP_H^D \tag{3}$$

$$Q_H^S = D + EP_L^S + FP_H^S \tag{4}$$

Each slope and intercept parameter may be expressed in terms of prices, quantities, and elasticities at the initial equilibrium. As a result, the supply and demand functions can also be specified as:

$$Q_L^D = Q_L^0(1 - \eta_{LL} - \eta_{LH}) + \eta_{LL}\frac{Q_L^0}{P_L^0}P_L^D + \eta_{LH}\frac{Q_L^0}{P_H^0}P_H^D \tag{5}$$

$$Q_L^S = Q_L^0(1 - \epsilon_{LL} - \epsilon_{LH}) + \epsilon_{LL}\frac{Q_L^0}{P_L^0}P_L^S + \epsilon_{LH}\frac{Q_L^0}{P_H^0}P_H^S \tag{6}$$

$$Q_H^D = Q_H^0(1 - \eta_{HL} - \eta_{HH}) + \eta_{HL}\frac{Q_H^0}{P_L^0}P_L^D + \eta_{HH}\frac{Q_H^0}{P_H^0}P_H^D \tag{7}$$

$$Q_H^S = Q_H^0(1 - \epsilon_{HL} - \epsilon_{HH}) + \epsilon_{HL}\frac{Q_H^0}{P_L^0}P_L^S + \epsilon_{HH}\frac{Q_H^0}{P_H^0}P_H^S \tag{8}$$

where superscripts 0 indicate the prices and quantities at the initial, undistorted, equilibrium, η_{ij} is the elasticity of demand for quality i with respect to the price of quality j, and ϵ_{ij} is the elasticity of supply of quality i with respect to the price of quality j.

Solving these four equations simultaneously should result in the values for the four endogenous variables (Q_L, P_L, Q_H, and P_H) used to initialize the functions. New prices and quantities can be found by solving a similar system of equations that incorporates policy instruments.

1.1 Decomposing Elasticity Terms

In order to reduce the number of parameters and to clarify the implications of assuming a homogeneous commodity, the price elasticities in equations (5) through (8) are decomposed into scale and substitution effects, as done by Armington (1969). For goods that comprise a weakly separable group, consumption choices may be represented in terms of a two-stages budgeting process. In the first stage, total expenditure (or total revenue, from the supply side) is allocated to the group of commodities. Changes in total expenditure on (or revenue from) the commodity group resulting from changes in the aggregate price of the group of commodities comprise the scale effect. In the second stage, that expenditure (or revenue) is allocated among the individual commodities. Changes in the allocation among commodities are based on changes in their relative prices, and comprise substitution effects.

Under the assumption that low- and high-quality varieties of the same basic commodity comprise a weakly separable group, then, their own- and cross-price elasticities of demand can be expressed as:

$$\eta_{LL} = s_L\eta - s_H\sigma \tag{9}$$

$$\eta_{LH} = s_H(\eta + \sigma) \tag{10}$$

$$\eta_{HL} = s_L(\eta + \sigma) \tag{11}$$

$$\eta_{HH} = s_H\eta - s_L\sigma \tag{12}$$

where $s_i = \frac{P_iQ_i}{PQ}$ is the value share of commodity i (the absence of subscripts indicates an aggregate price or quantity). Here, η is the overall elasticity of demand, defined as the elasticity of demand for the aggregate quantity with respect to the aggregate price. The substitution effect is given by the σ term, where σ is the elasticity of substitution between low- and high-quality commodities. So, when the price of the high-quality variety increases, the quantity demanded of the low-quality variety decreases through the scale effect (since $\eta < 0$ and the increase in P_H increases the aggregate price) and increases through the substitution effect (since $\sigma > 0$). If the substitution effect outweighs the scale effect (i.e., if $\sigma >\mid \eta \mid$), then the cross-price elasticities are positive, and the two qualities are gross substitutes for one another in consumption. If the inequality is reversed, the cross-price elasticities are negative, and the two qualities are gross complements.

The own- and cross-price elasticities of supply can be expressed similarly as:

$$\epsilon_{LL} = s_L\epsilon - s_H\tau \quad (13)$$

$$\epsilon_{LH} = s_H(\epsilon + \tau) \quad (14)$$

$$\epsilon_{HL} = s_L(\epsilon + \tau) \quad (15)$$

$$\epsilon_{HH} = s_H\epsilon - s_L\tau \quad (16)$$

The scale effects are given by the overall elasticity of supply, ϵ, which is defined as the elasticity of the aggregate quantity supplied with respect to changes in the aggregate price. Substitution effects are given by τ terms, where τ is the elasticity of transformation between low- and high-qualities in the production process. Thus, when the price of the high-quality variety increases, the quantity supplied of the low-quality variety will increase through the scale effect (since $\epsilon > 0$ and the aggregate price increases) and decrease through the substitution effect (since $\tau < 0$). As was the case for the demand side, if the substitution effect outweighs the scale effect on the supply side (i.e., if $|\tau| > \epsilon$), then the cross-price elasticities are negative, and the two qualities are gross substitutes in supply, and if the inequality is reversed, they are gross complements.

In addition to managing the number of parameters to be specified, the explicit modeling of the two-stage budgeting process clarifies the consequences of aggregating commodities. An aggregate analysis of a group of commodities would examine only the first stage of the budgeting process, ignoring the substitution effects from the second stage. Thus, treating a group of commodities as if it were a single commodity is equivalent to setting those substitution effects equal to zero (i.e., $\sigma = 0$ and $\tau = 0$). Setting either one of these parameters equal to zero imposes that the two qualities are produced and consumed in fixed proportions.

2 Representing the Aggregate Market

Because the goal of this analysis is to contrast correct measures of policy incidence with those typically obtained, some reasonable representation of the conventional single-market specification must be introduced. The difficulty, here, arises in linking a single-market representation with the "true" model that accounts for the two qualities. To do so, a number of assumptions must be made. Before introducing those assumptions, it is instructive to examine the components of a price elasticity as observed in an aggregate market.

2.1 What is an Aggregate Price Elasticity?

The meaning of something as fundamental as a price elasticity of demand or supply becomes less clear when moving from a single homogeneous commodity to an aggregate commodity. Such an elasticity can be written in arc form as:

$$\frac{\Delta Q}{\Delta P}\frac{P}{Q} \tag{17}$$

where the price and quantity are defined along a demand curve for an elasticity of demand, and along a supply curve for an elasticity of supply. The discussion that follows is conducted in terms of the elasticity of demand, but applies to the elasticity of supply as well. For a homogeneous commodity, prices and quantities are clearly defined, so that each element of the elasticity expression is obvious. However, when prices and quantities refer to those in a market for an aggregate commodity, each element requires definition.

The price and quantity terms are defined as functions of the prices and quantities of the individual commodities within the aggregate, according to some aggregation rule. Beyond defining the aggregate price and aggregate quantity, further structure usually must be imposed in order to define the changes in price and quantity. Consider the demand for an aggregate commodity composed of high- and low-quality varieties of the same basic commodity, where demand for the low-quality variety is more elastic than that of the high-quality variety. Movement along the aggregate demand curve can occur because of a change in the price of either the low- or high-quality product, or changes in both prices. Imagine, then, a price change in the aggregate market composed entirely of a price change in the low-quality market (i.e., P_H does not change), assuming there are no cross-commodity effects. Because demand for the low-quality variety is more elastic than that of the high-quality variety, the induced change in the quantity demanded will be much greater than if the entire price change had occurred in the relatively inelastic market for the high-quality variety (i.e., holding P_L constant). Thus, an aggregate demand curve that holds the price of the high-quality variety constant and allows the price of the low-quality variety to vary will be more elastic than one that holds the price of the low-quality variety constant and allows the price in the high-quality market to vary. While neither extreme is likely to be the case, this example demonstrates that definition of aggregation rules alone is not sufficient to determine a single elasticity of demand (or supply) in an aggregate market. The composition of any change in prices or quantities must also be defined.

Theoretically, this issue has been addressed by noting (or imposing) specific relationships among the prices of the individual commodities within the aggregate. In the case of the Hicksian composite commodity, the prices of the individual commodities are assumed to remain in fixed proportions, so that $\Delta P/P$ implies the same proportional change in price for all aggregated commodities. Definition of $\Delta P/P$ and Q implicitly defines ΔQ along the aggregate demand curve. Similarly, a simple sum aggregate defines Q as the sum of the quantities of individual commodities and is theoretically consistent when the prices of individual commodities increase or decrease by the same amount per unit. Thus, the deviation from initial prices can be treated as changes in an aggregate price index, which imply specific changes in the prices of the individual commodities. Both of these aggregation methods impose structure on the relationships between prices in the individual markets. Thus, a given ΔP in the aggregate market implies specific price changes for the individual commodities. The new quantities demanded in each market after the prices change may then be aggregated according to the aggregation rule used to define ΔQ and the demand curve for the aggregate commodity.

This discussion demonstrates what is necessary to derive a meaningful demand or supply curve for an aggregate commodity. Aggregation rules must be developed that link individual quantities to the aggregate quantity, and individual prices to the aggregate price. In addition, some relationship either between the prices of the individual commodities (as in the case of the Hicksian composite commodity or a simple sum aggregate) or between the quantities of the individual commodities (as is done below) must be specified. The next section describes the aggregation rules and the relationship between individual quantities that were specified for the model used here.

2.2 A Constant-Quality Aggregate

While the aggregation rules for the Hicksian composite commodity and for the simple-sum commodity are both theoretically consistent, they rely on price conditions that are not likely to hold in the markets described here. Further, the goal for the time being is not to develop proper aggregation rules, but rather to use those rules that most closely resemble those implicit in existing work. Because such matters are generally not discussed in policy analyses, one must speculate about the aggregation assumptions made or about the nature of the data used. Future work will specify various aggregation rules in order to determine the effects of those aggregation rules on the results. For now, the aggregate quantity is defined as a simple sum of the quantities observed in each market. The aggregate price is defined so that total expenditure in the aggregate market is equal to the sum of the expenditures in the quality-specific markets, (i.e., aggregate price is a quantity-share weighted sum of the quality-specific prices). Thus,

$$Q^D = Q_L^D + Q_H^D \tag{18}$$

$$Q^S = Q_L^S + Q_H^S \tag{19}$$

$$P^D = \frac{Q_L^D}{Q^D} P_L^D + \frac{Q_H^D}{Q^D} P_H^D \tag{20}$$

$$P^S = \frac{Q_L^S}{Q^S} P_L^S + \frac{Q_H^S}{Q^S} P_H^S \tag{21}$$

In order to obtain supply and demand functions for the aggregate market, a further assumption is made about the composition of the aggregate quantity. Using the relative quantities in high- and low-quality varieties, Q_H/Q_L, as a measure of average quality, average quality is held constant in the representation of the aggregate market by assuming that quantity shares remain constant at their initial levels. In order to derive aggregate demand and supply equations, the aggregate quantity (and thus the quantities in the low- and high-quality markets) is varied, implying specific price changes in each of the low- and high-quality markets. From those quality-specific price changes, the new aggregate price corresponding to the new quantity is calculated using the definitions provided above. Using this method and the elasticity decompositions described in section 1.1, the demand and supply functions are defined in the aggregate market as:

$$Q^D = Q^0(1-\eta) + \eta \frac{Q^0}{P^0} P^D \tag{22}$$

$$Q^S = Q^0(1-\epsilon) + \epsilon \frac{Q^0}{P^0} P^S \tag{23}$$

Notably, these functions are of the same form as the quality-specific demand functions in equations (5) through (8), but include only the scale effect portion of the elasticities, with no allowance for substitution between the two qualities.

3 Initializing the Model and Introducing Policy Variables

To summarize, the two-market model consists of four equations:

$$Q_L^D = Q_L^0(1-\eta_{LL}-\eta_{LH}) + \eta_{LL}\frac{Q_L^0}{P_L^0}P_L^D + \eta_{LH}\frac{Q_L^0}{P_H^0}P_H^D \tag{24}$$

$$Q_L^S = Q_L^0(1-\epsilon_{LL}-\epsilon_{LH}) + \epsilon_{LL}\frac{Q_L^0}{P_L^0}P_L^S + \epsilon_{LH}\frac{Q_L^0}{P_H^0}P_H^S \tag{25}$$

$$Q_H^D = Q_H^0(1-\eta_{HL}-\eta_{HH}) + \eta_{HL}\frac{Q_H^0}{P_L^0}P_L^D + \eta_{HH}\frac{Q_H^0}{P_H^0}P_H^D \tag{26}$$

$$Q_H^S = Q_H^0(1-\epsilon_{HL}-\epsilon_{HH})+\epsilon_{HL}\frac{Q_H^0}{P_L^0}P_L^S+\epsilon_{HH}\frac{Q_H^0}{P_H^0}P_H^S \tag{27}$$

where the elasticity terms are as defined in equations (9) through (12) and (13) through (16). The single-market "equivalent" with the fixed proportions (constant quality) restriction embedded consists of two equations:

$$Q^D = Q^0(1-\eta)+\eta\frac{Q^0}{P^0}P^D \tag{28}$$

$$Q^S = Q^0(1-\epsilon)+\epsilon\frac{Q^0}{P^0}P^S \tag{29}$$

These models were initialized using the following values:

	Low-Quality Market	High-Quality Market	Aggregate Market
Price	0.50	1.50	1.00
Quantity	0.50	0.50	1.00
Quantity-share	0.50	0.50	1.00
Value-Share	0.25	0.75	1.00

The initial aggregate quantity is divided equally between the low- and high-quality markets, for an average quality measure (Q_H/Q_L) of 1.0. The price premium for the high-quality variety, defined as the relative price of high- and low-quality varieties (i.e., P_H/P_L) is 3.0 at the initial equilibrium. The initial values for the four elasticity parameters (η, σ, ϵ, and τ), and the resulting own- and cross-price elasticities of demand and supply are in the table below.

η	=	-0.5	and	σ	=	2
η_{LL}	=	-1.625		η_{LH}	=	1.125
η_{HL}	=	0.375		η_{HH}	=	-0.875
ϵ	=	1.0	and	τ	=	-0.5
ϵ_{LL}	=	0.625		ϵ_{LH}	=	0.375
ϵ_{HL}	=	0.125		ϵ_{HH}	=	0.875

For these parameter values, the scale effect in demand is smaller than that in supply (i.e., $|\eta| < \epsilon$), so that, in the aggregate market, supply is more elastic than demand. However, the two qualities are more substitutable in demand than they are in supply (i.e., $\sigma > |\tau|$). Finally, the substitution effect outweighs the scale effect on the demand side (i.e., $\sigma > |\eta|$), so that the two qualities are substitutes in demand, whereas they are complements on the supply side (i.e., $|\tau| < \epsilon$).

3.1 Production Quota

A production quota is introduced into each market, and that quota is varied between 1.0, the initial quantity, and zero. In the single-market model, this is done by setting the quantity produced and consumed equal to the quota, and allowing the consumer price and producer price to differ, the difference at the new equilibrium quantity being the per unit quota rent. In the two-market model, the sum of low- and high-quality quantities, $Q_L + Q_H$, is restricted to the quota quantity. The allocation of the quota between the two markets is determined by imposing an arbitrage condition that equates quota rent per unit across the two markets (clearly, this assumes that the quota is transferable). At each quota quantity, changes in consumer surplus (CS), producer surplus (PS), quota rent (QR), and net social surplus were calculated.

In order to contrast the results from the two-market model with those from the single-market, constant-quality model, it is instructive first to examine the change in the distribution of units between low- and high-quality as the quota is varied. These changes are summarized in the table below.

Quota	Q_L	Q_H	Q_H/Q_L
1.00	0.50	0.50	1.00
0.90	0.42	0.48	1.14
0.80	0.34	0.46	1.33
0.70	0.26	0.44	1.65
0.60	0.19	0.41	2.23
0.50	0.11	0.39	3.55
0.40	0.03	0.37	12.33

The relative changes in quantities in the low- and high- quality markets can be viewed as analogous to those resulting from the imposition of a per unit tax. In both cases, the price paid by consumers differs from the price received by producers by a constant amount. In the case of the per unit tax, the difference is the amount of the tax per unit. For a quota, the difference between the consumer price and the producer price is quota rent. Because the per unit quota rent acts as a per unit tax, the proportional quantity reduction in the low-quality market is expected to be larger than that in the high-quality market (based on work by Alchian and Allen (1964), Barzel (1976), and James (1999)), so that average quality increases as the quota is reduced. This is, in fact, what occurs.

As the quota is reduced, the quantity of low-quality units produced and consumed decreases by a larger proportion than the quantity of high-quality units does. In fact, at some quota quantity (approximately 0.40 for the parameter values used here), production of the low-quality good falls to zero, and all production is high quality. Using the quantity of high-quality units relative to that of low-quality units as a measure of average quality, average quality increases from its initial value of 1.0 as the quota decreases. Thus, there is clearly a quality response to the imposition of a quota.

What are the implications of the quality response for the evaluation of the welfare effects of the quota? The welfare effects of the quota policy are conveniently summarized in a surplus transformation curves (STC), as developed by Gardner (1983). The STCs in figure 1 plot the changes in consumer surplus along the horizontal axis and the corresponding changes in producer surplus (including quota rent) along the vertical axis. Movement from the origin to the left indicates the reduction in CS and the increase in PS as the quota quantity is reduced. Only quotas greater than 0.40 are represented in figure 1, since further quota reductions caused the quantity in the low-quality market to drop to zero. This quota quantity is less than the monopolist's quota quantity that maximizes producer surplus and quota rent, so the exclusion of quotas less than 0.40 is not a cause for concern. The dashed line shows the tradeoff between producer and consumer welfare, as measured in the standard single-market model, while the solid line shows the same relationship for the two-market model that incorporates quality changes. The position of the STC for the two-market model below that of the single-market model indicates that a quota policy is actually a less efficient means of transferring income to producers than the single-market model would suggest.

This result may seem counter-intuitive at first. It would seem that consumer losses from the quota would be smaller when the increased quality of production is incorporated. Further, why would producers alter the quality distribution of their production in response to the quota if doing so made them worse off? Looking at the changes in the individual surplus measures helps to explain this result. Figure 2 shows the changes in consumer surplus as measured in the two-market model (solid line) and in the single-market model (dashed line). As the quota is reduced, consumers are made worse off. However, because of the quota-induced increase in quality incorporated in the two-market model, the CS reduction is smaller than if the quality response were not taken into consideration, as in the single-market model. Thus, for a given quota, the actual reduction in CS *is* smaller than the conventional single-market model indicates, in keeping with intuition. Figure 3 plots the changes in producer surplus (excluding quota rent) as the quota quantity varies, for each of the two models analyzed. As was the case for changes in consumer surplus, the reduction in producer surplus is actually smaller when quality responses are accounted for.

If intuition about the relative changes in CS and PS with and without quality responses holds, what, then, accounts for the lower efficiency of the quota when quality responses are taken into account? Quota rent accounts for this difference. Figure 4 plots the quota rent earned for each quota quantity for the single-market and two-market models. At every quota quantity, quota rent from the single-market model overstates the true quota rent from the two-market model. This results from free transferability of the quota and the assumption of perfect competition. Free transferability of the quota allows the quota to be allocated between the low- and high-quality markets so that at the margin, quota rents per unit are equated between the two markets. This allocation will differ from one in which quota rent is maximized.

The distinction between the quota-rent maximizing outcome and that where the quota is freely transferable among perfectly competitive producers can be seen in terms of a Ramsey-type rule for optimal taxation (noting again that quota rent is equivalent to tax revenue). If two markets are to be taxed, the optimal tax structure will be the one in which the two quantities are reduced by the same proportion. This condition is actually imposed in the single-market model, since quantity proportions are held fixed by construction. However, when the quota may be freely allocated between the two markets, the result will be equivalent to the imposition of the same per unit tax in both markets. James (1999) showed that the proportional changes in the quantities of low- and high-quality commodities resulting from a per unit tax will differ as long as there is some degree of substitutability between them (i.e., $\sigma \neq 0$ and $\tau \neq 0$) and their initial prices differ. Thus, the arbitrage condition that requires quota rent per unit to be equal in the two markets imposes an allocation of quota that will not maximize total quota rent. As a result, the total quota rent earned when quality adjustments are incorporated is less than when constant quality is imposed.

In summary, for the set of parameters considered here, the following distinctions can be made between the welfare effects of a quota. For a given quota quantity, the true loss to consumers and the true benefit to producers (including quota rent), as measured in the two-market model, are both smaller than the single-market model suggests. Here, the smaller increase in producer benefits is more than offset by the smaller loss to consumers, so that the deadweight loss (DWL) from the quota, as measured in the two-market model, is smaller than indicated by the single-market model (as shown in figure 6). So, for a given reduction in quantity, the actual DWL from a quota is smaller than a single-market model would suggest. In contrast, for a given transfer to producers, the DWL actually incurred in a world where producers may alter quality is larger than the DWL measure from a model of a homogeneous commodity.

3.2 Target-Price Policies

The other policy considered here is a target-price policy. When the commodity of interest is actually homogeneous, a single target price is adequate for defining such a policy. However, when the analysis is extended to consider the case of two qualities, the target-price policy requires further definition. One can imagine a target-price policy in which a single target price is offered for all varieties of a commodity, regardless of quality. This policy is described below and referred to as the simple target-price policy.

A less-distortionary target-price policy would recognize the different qualities of the commodity being supported, and would offer different target prices for each variety or quality. In this case, we can imagine target-price schemes as pairs of target prices, one for each quality. There are infinitely many such target-price schemes. One such scheme would increase the price of each quality by the same increments relative to the initial (undistorted) quality-specific prices. An example would be to offer target prices for each quality that are \$0.25 above their pre-intervention prices (i.e., \$0.75 for low-quality and \$1.75 for high-quality). Maintaining the assumption of fixed quantity proportions in the aggregate market, the corresponding target price in the aggregate market would be \$1.25. This target-price scheme is referred to below as the constant price differential target-price scheme.

Another type of target-price scheme would offer quality-specific target prices that maintain relative prices at their initial levels. For example, if the target price offered for low-quality were \$0.75, a 50 percent increase over the pre-intervention price of \$0.50, then the corresponding price offered in the high-quality market would be \$2.25, also a 50 percent increase. The corresponding target price in the aggregate market would also be 50 percent above the pre-intervention price in the aggregate market, \$1.50. This target-price scheme is referred to below as the constant relative price target scheme.

The following table shows the quality distortions for the three target price schemes.

Price in Aggregate Market under Target-Price Policy	Simple Target Price Q_H/Q_L	Constant Price Differential Q_H/Q_L	Constant Relative Price Q_H/Q_L
1.00	0.63	1.00	1.00
1.10	0.58	0.94	1.00
1.20	0.56	0.90	1.00
1.30	0.56	0.86	1.00

The simple target-price policy decreases the average quality dramatically. The reduction in average quality is mitigated in the constant differential target-price policy. Finally, the policy that keeps relative prices at their initial levels also keeps average quality unchanged.

The substitution effects that are omitted from the model of a homogeneous commodity occur because of changes in the relative prices of the two goods. Because the constant relative price policy does not distort the relative prices of the two qualities, there are no substitution effects, and the effects of this target-price policy are the same, regardless of whether they are measured using the two-market or the single-market model. The effects of the other price policies will differ, depending on which model is used.

When the policy effects are compared between the single-market and two-market models, the differences will be larger, the larger are the distortions in relative prices and thus in average quality. The simple target-price scheme does alter relative prices, and fixes the price ratio at one when the target price binds in both markets. The constant price differential scheme also changes the relative prices of the two qualities, but does not fix them at one. Because the simple target-price policy has the most distortionary influence on the relative prices of the two qualities, the effects of this policy will be shown and discussed. This policy provides an upper bound on the error in the welfare measurement from ignoring quality responses, the lower bound being the constant relative price policy, in which there is no error.

Figure 8 shows the STCs for the simple target-price policy, as measured in the two-market model (solid line) and in the single-market model (dashed line). As was the quota, the target-price policy is a less efficient means of transferring income to producers than the single-market model indicates. Given the policy-induced decrease in quality, this result is a little more intuitive than it was for the quota.

One aspect of this result that is a bit unexpected is that consumers actually benefit from a simple target price policy more than indicated in the single-market model. It might seem that the gain to consumers would be smaller because of the decrease in quality. However, because the quantity responses to the target price are unrestricted, the increase in quantity increases consumer welfare, offsetting the decrease in consumer welfare from the decrease in average quality.

In addition to the quantity responses, the larger consumer benefit from the target-price policy has an additional explanation. Because the undistorted price in the low-quality market is lower than the undistorted price in the aggregate market, even target prices set below the undistorted equilibrium price in the aggregate market will confer benefits to consumers and producers. So, target prices between \$0.50 and \$1.00 (the undistorted prices in the low-quality and aggregate markets, respectively), benefit consumers and producers, while incurring taxpayer costs. These benefits and costs will not be reflected in the welfare measures from the single-market model, since only target prices above \$1.00 bind in that market representation. When the target price is set at a low value, it binds only in the low-quality market, and the high-quality market clears at a price above the target price. At some higher value (approximately \$1.20 for the parameters specified), the target price binds in both the high- and low-quality markets. The switch from a target price that binds only in the low-quality market to one that binds in both markets causes a kink at a target price of \$1.20 in figures 9 through 14.

Figure 9 shows the gain to consumers from the simple target-price policy as the target price is increased. It is clear that the benefit measures from the two models differ primarily for lower target prices, but as the target price is increased substantially, the gains to consumers become less disparate. Figure 10 plots the total deficiency payments made to producers, as measured in the single- and two-market models. Here again, the difference between the measures from the two models is largest for target prices below \$1.20. Figure 11 combines the information presented in figures 9 and 10, and shows the net effect on consumers and taxpayers from the target-price policy. The higher subsidy payments actually made (as measured in the two-market model) offset the higher gain to consumers, so that the net cost to consumers and taxpayers of the target-price policy is larger than the constant-quality model suggests. While the cost of the target-price policy is larger when quality responses are taken into account, so are the benefits to producers, as shown in figure 12. This is not surprising, since producers receive benefits for target prices below the initial aggregate price, as discussed above.

The net effect of all of these changes is shown in figure 13, which plots the deadweight loss from the target-price policy as the target price is increased. Here, the DWL from the policy is shown to be larger than the single-market model indicates. As was the case for the quota, for a given benefit to producers, the target-price policy has a larger deadweight loss than indicated by a single-market model. Contrary to the quota, though, where the DWL for a given quota quantity was actually smaller when allowing for quality adjustments, the DWL for a given target price is larger when quality responses are incorporated.

4 Policy Implications

The previous sections make qualitative comparisons between the welfare effects of the quota and target-price policies with and without adjustments for quality responses. In order to determine how important these policy effects are, the quantitative differences must be examined. One way of doing so is to look at the different values for policy instruments that have equivalent effects in the two models.

Taking the quota first, consider three different quota values: 0.87, 0.80, and 0.65. The transfer to producers (including quota rent) that would be expected using the single-market model of a homogeneous good and the actual transfer to producers from the two-market model that accounts for quality adjustments are listed in the table below, for each of these quota quantities.

Quota Quantity	Expected Transfer to Producers From Single-Market Model	Actual Transfer to Producers From Two-Market Model
0.87	0.22	0.16
0.80	0.30	0.22
0.65	0.39	0.30

Using the single-market model, a quota set at 0.80 would be expected to transfer \$0.30 to producers. However, if producers actually adjust the quality of their production in response to the quota, the 0.80 quota would only provide producer benefits of \$0.22. In order to transfer the \$0.30 intended, the quota would have to be set at 0.65. Similarly, the 0.80 quota only provides benefits that would be expected from a quota of 0.87, using the single-market model. This shows that quality responses substantially influence the quota quantity necessary to make a given transfer to producers. Further, as can be seen in the STCs in figure 1, the maximum producer benefit attainable by implementing a quota is substantially decreased (from 0.40 to 0.31) when quality responses are incorporated. This implies that a quota policy alone will be inadequate for making transfers to producers greater than \$0.31.

Consider next simple target-price policies, where the target price is set at \$1.05, \$1.20, and \$1.30. The transfer to producers and the taxpayer cost from each model and for each target price are presented below.

Target Price	Expected Based on Single-Market Model		Actual Based on Two-Market Model	
	Transfer to Producers	Taxpayer Cost	Transfer to Producers	Taxpayer Cost
1.05	0.05	0.16	0.22	0.65
1.09	0.09	0.29	0.24	0.72
1.20	0.22	0.72	0.34	1.02
1.30	0.34	1.17	0.49	1.52

Based on the homogeneous goods model, a target price of $1.20 would be expected to transfer $0.22 to producers at a cost to taxpayers of $0.72. The actual transfer and cost are substantially larger: a $0.34 transfer to producers (what would have been expected from a target price of $1.30) at a cost to taxpayers of $1.02. In order to achieve an actual transfer of $0.22, the target price could be set much lower, at $1.05, reducing the taxpayer cost to $0.65. Similarly, if the goal of the policy were to provide the maximum benefit to producers without exceeding a budget of $0.72, the target price should be set at $1.09, rather than $1.20, for a transfer to producers of $0.24. As for the quota, incorporating quality responses to target-price policies significantly alters the setting of the policy instrument that will meet a specific policy goal.

Not only do quality adjustments influence the appropriate settings for policy instruments, given specific policy goals, but they also may change the choice of policy instrument for some policy goals. Figure 15 shows the STCs for a quota and a target price policy from the single-market model. These STCs intersect at a transfer to producers of $0.39. So, for transfers smaller than this amount, a quota policy is preferred, since it has a smaller DWL, and for larger transfers, the target-price policy is preferred. Figure 16 includes the same STCs as figure 15, and also plots the STCs from the two-market model. The STCs from the two-market model intersect at a transfer of \$0.31 to producers, so that for smaller transfers, a quota is preferred, while for larger transfers, the target-price policy is preferred. Thus, for transfers between \$0.31 and \$0.39, a single-market model would indicate that a quota should be used, when a target-price policy actually incurs a smaller DWL.

5 Concluding Remarks

The simple model presented here shows that imposing the homogeneity assumption in the analysis of a commodity that is actually heterogeneous may have important effects. For this model and the parameter values used here, ignoring quality responses to policies substantially influences the welfare effects of the policies. In addition, the model of a homogeneous commodity and the two-market model that allows for quality responses imply different settings for policy instruments to meet a specific policy goal. For some policy goals, including quality responses to policies even changes the preferred policy. Given the narrow focus of this paper on a commodity available in two qualities, with linear supply and demand, and the specified set of parameters, the natural next step is to evaluate whether the results change when the scope is broadened.

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Figure 1. Surplus Transformation Curves for a Quota

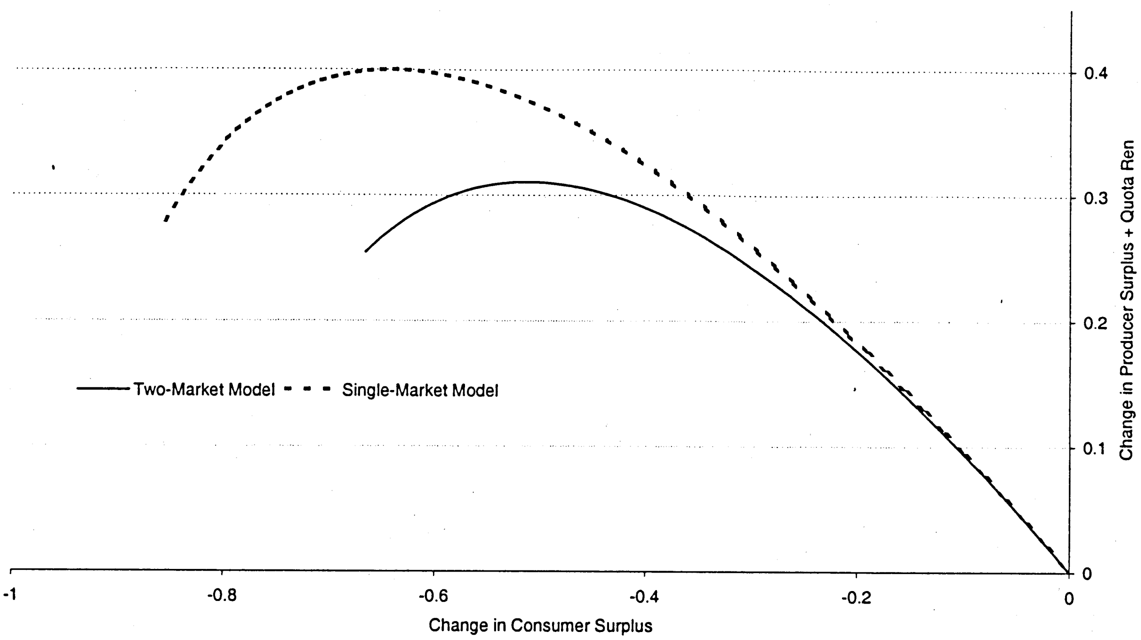


Figure 2. Change in Consumer Surplus from a Quota

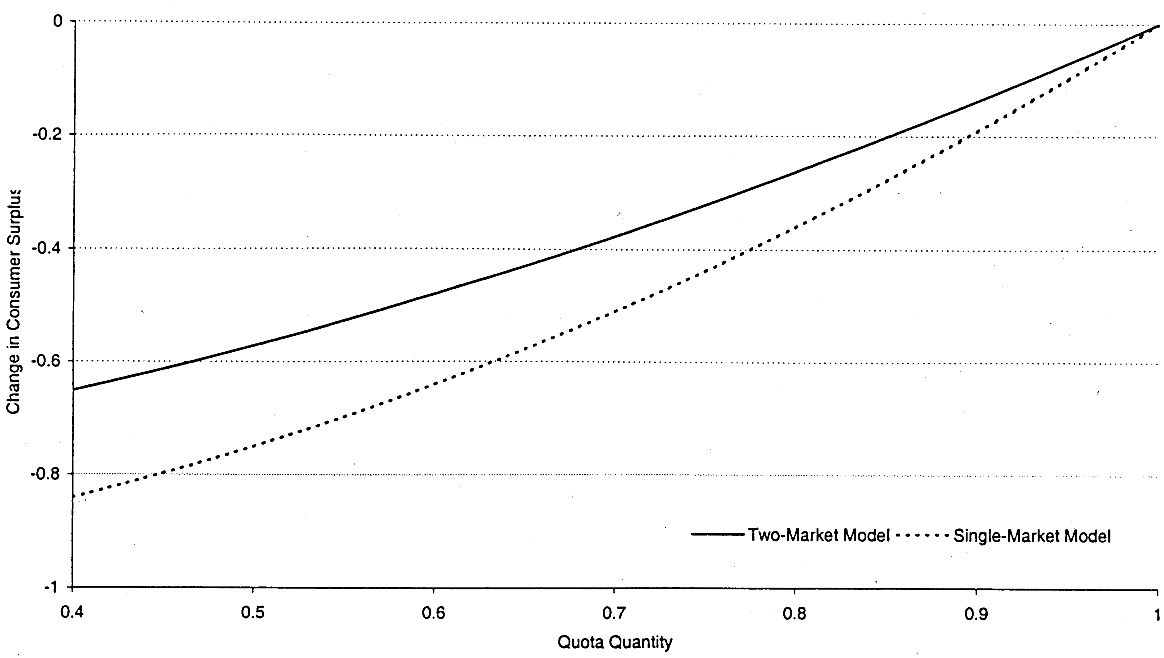


Figure 3. Change in Producer Surplus from a Quota

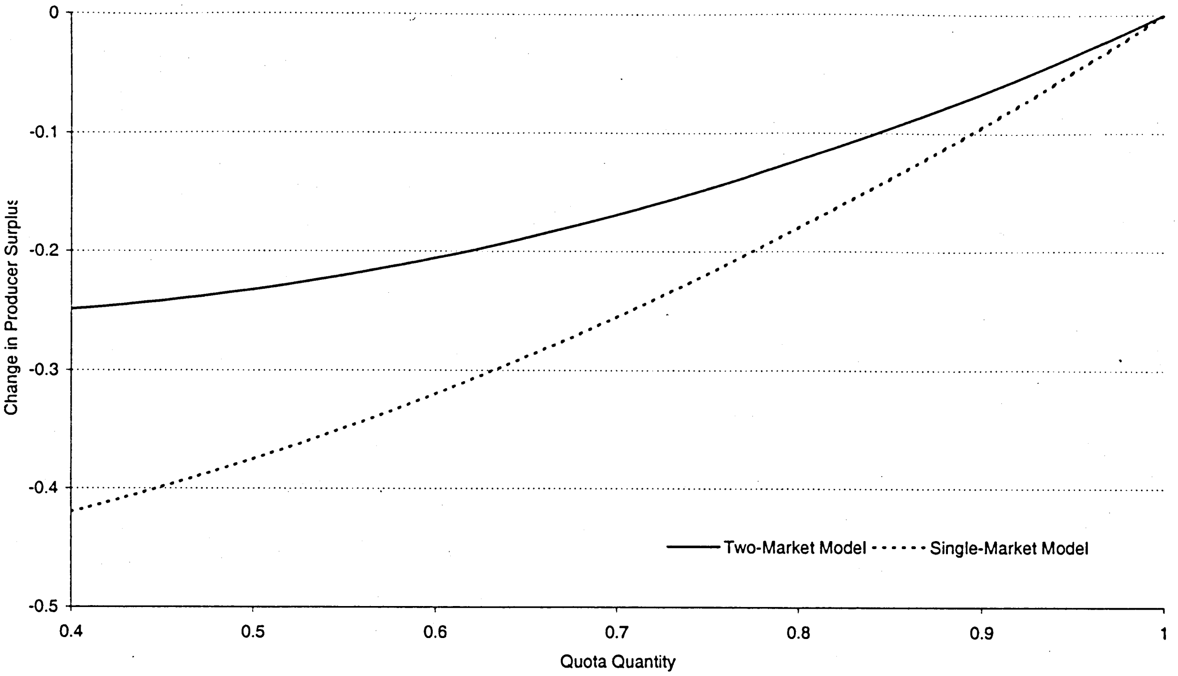


Figure 4. Quota Rent from a Quota

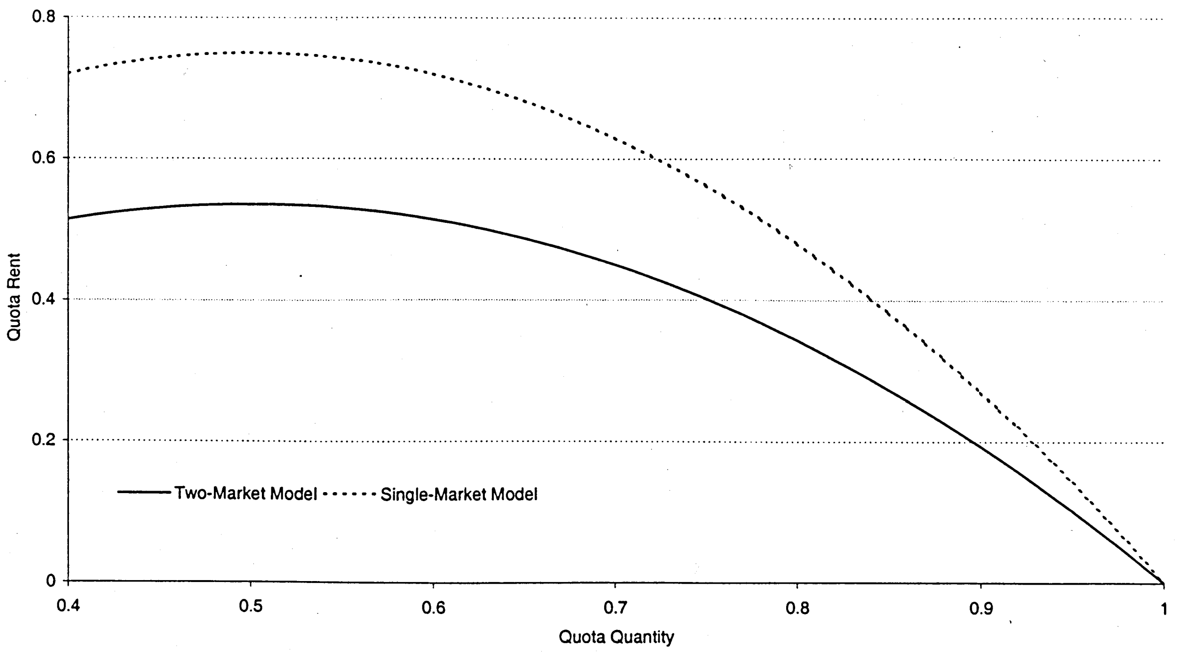


Figure 5. Net Producer Benefits from a Quota

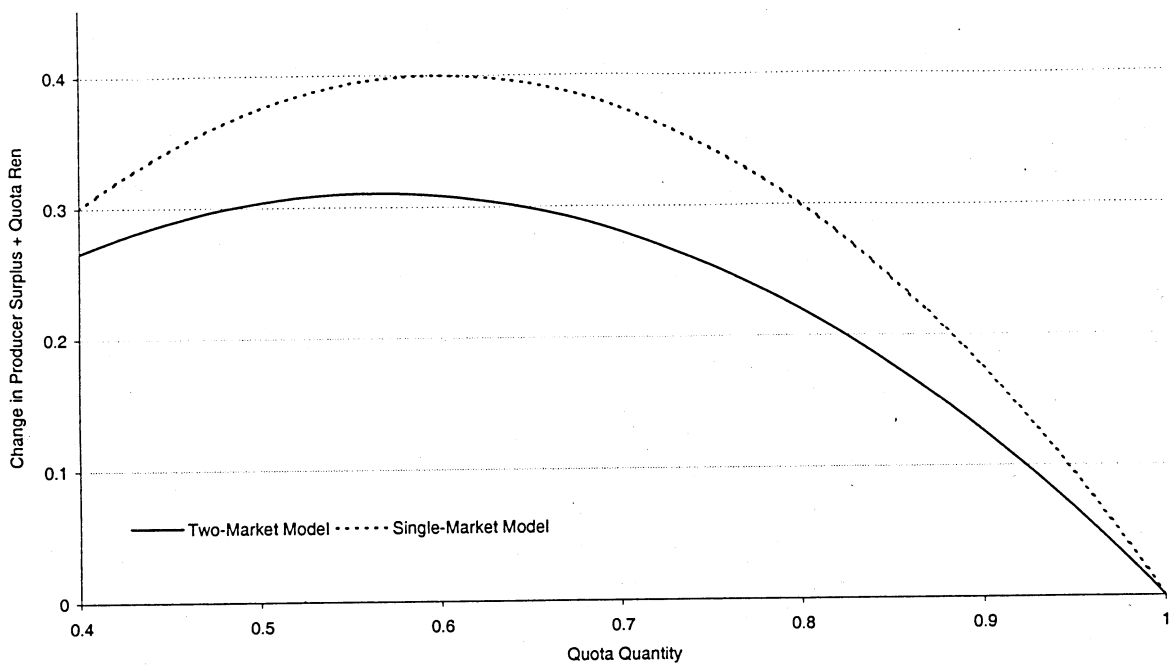


Figure 6. Deadweight Loss from a Quota Policy

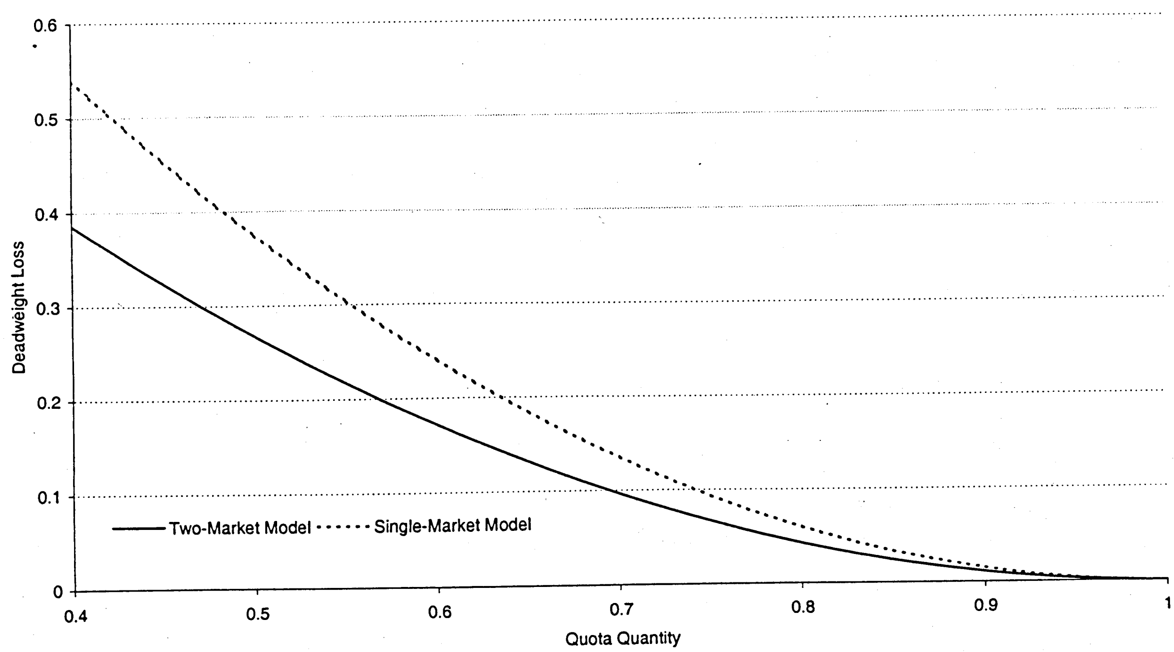


Figure 7. Deadweight Loss per Dollar of Producer Benefit for a Quota

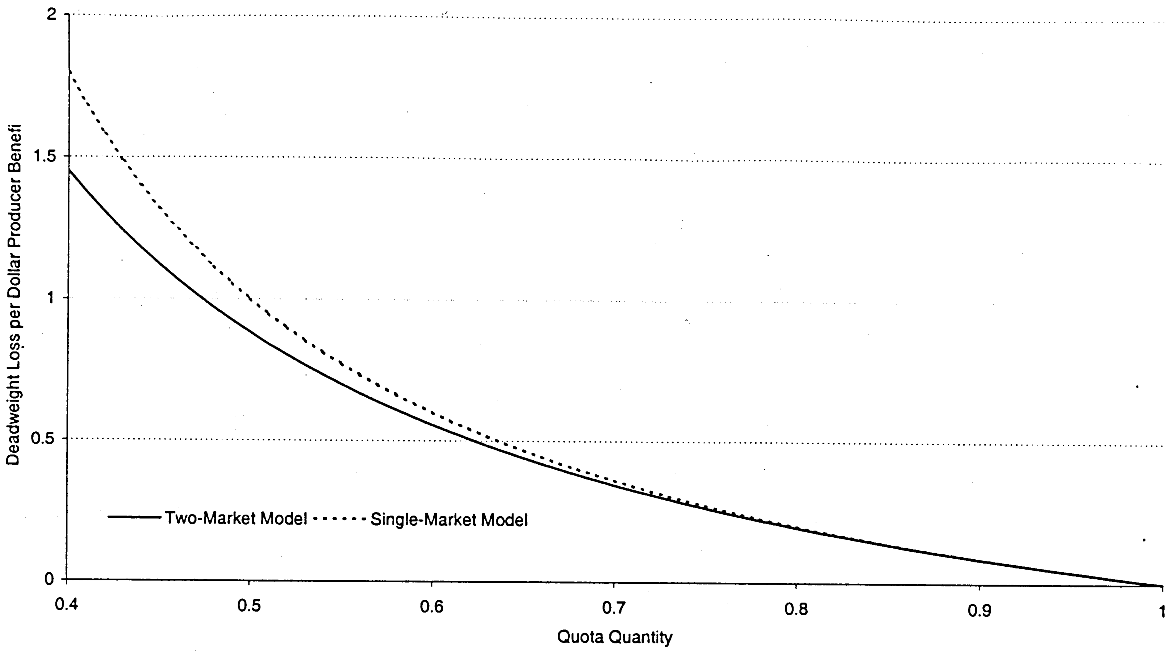


Figure 8. Surplus Transformation Curves for a Simple Target-Price Policy

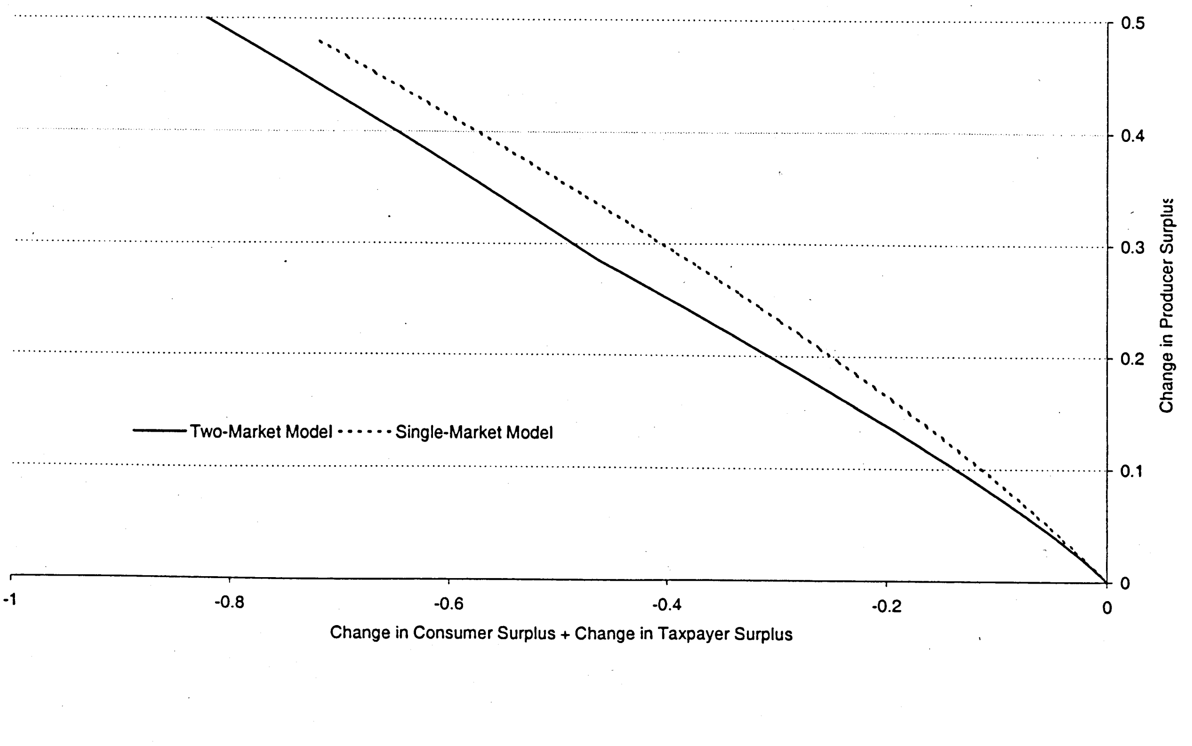


Figure 9. Gain to Consumers from a Simple Target-Price Policy

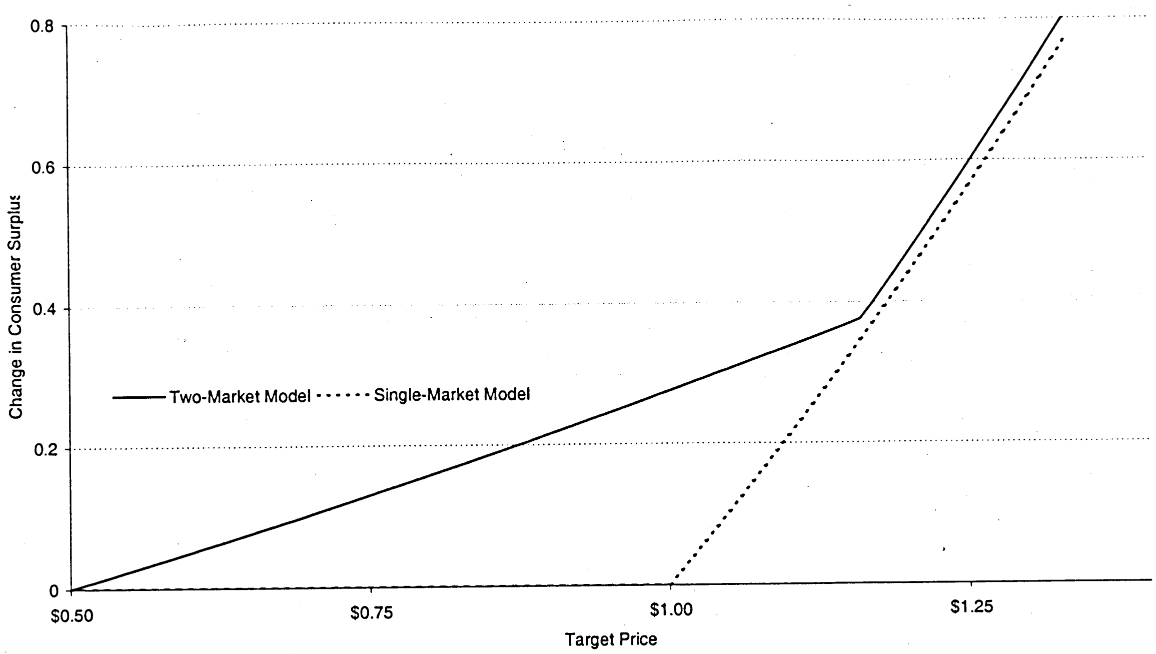


Figure 10. Taxpayer Cost for a Simple Target-Price Policy

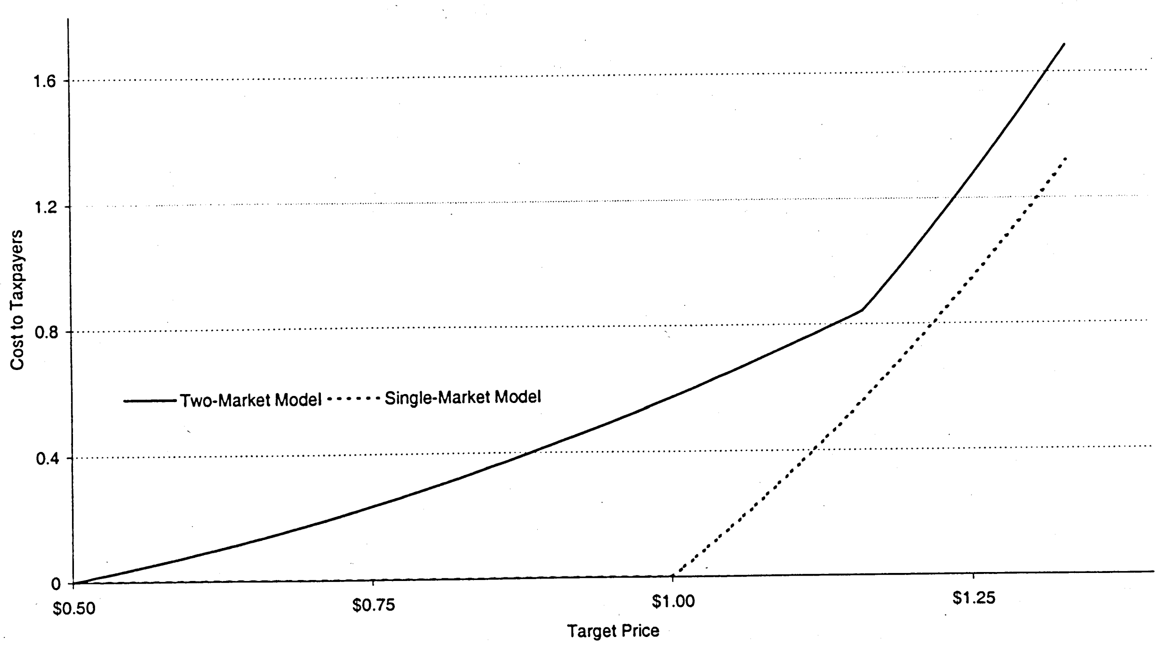


Figure 11. Net Effect on Consumers and Taxpayers from a Simple Target-Price Policy

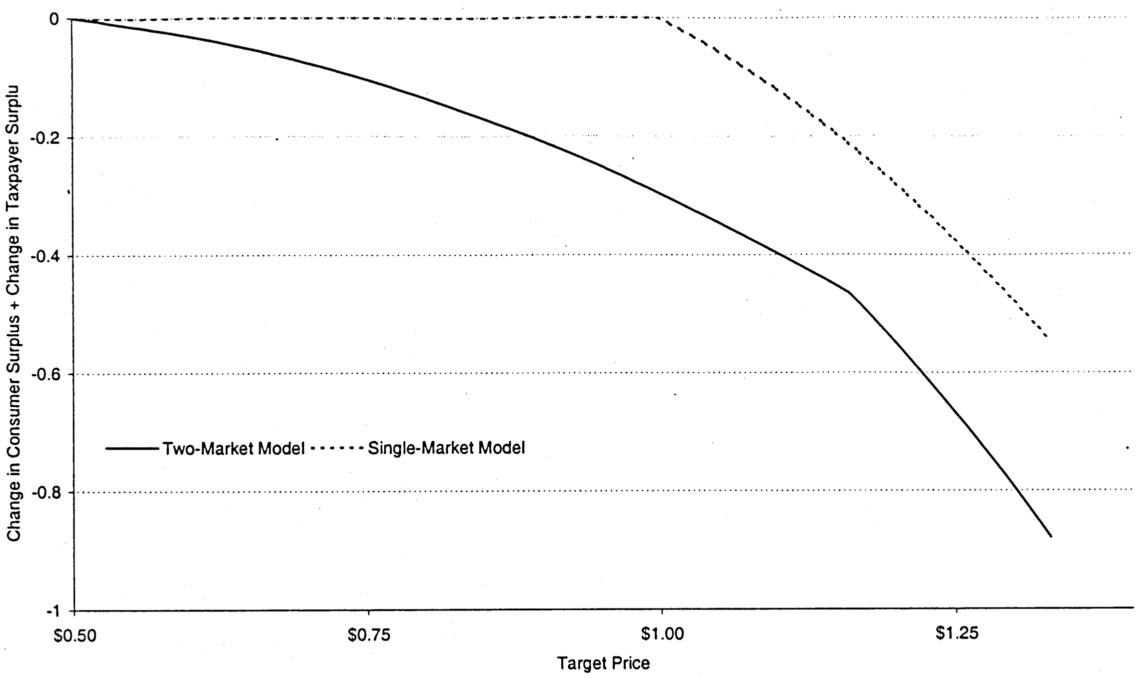


Figure 12. Producer Benefit from a Simple Target-Price Policy

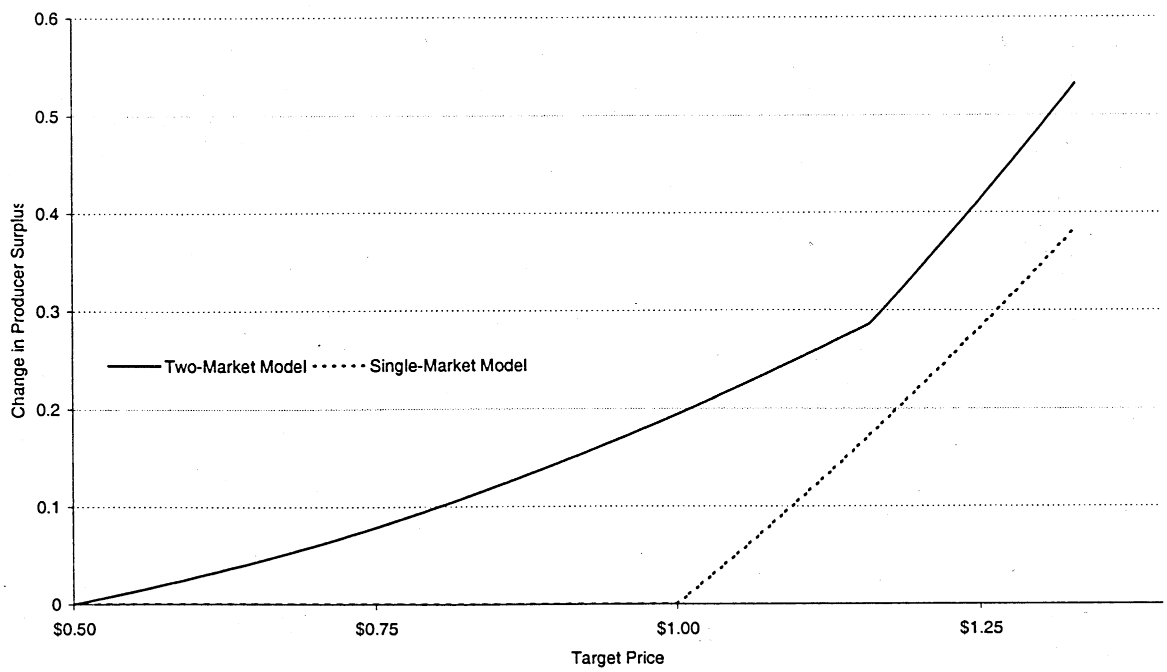


Figure 13. Deadweight Loss from a Simple Target-Price Policy

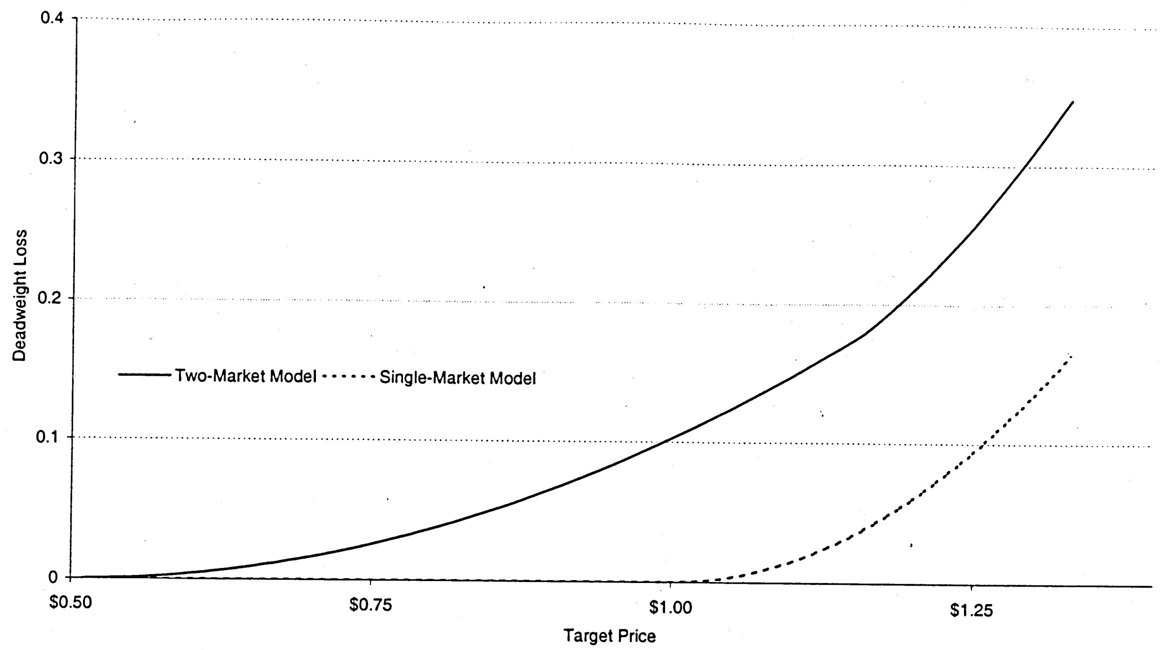


Figure 14. Deadweight Loss per Dollar Producer Benefit from a Simple Target-Price Policy

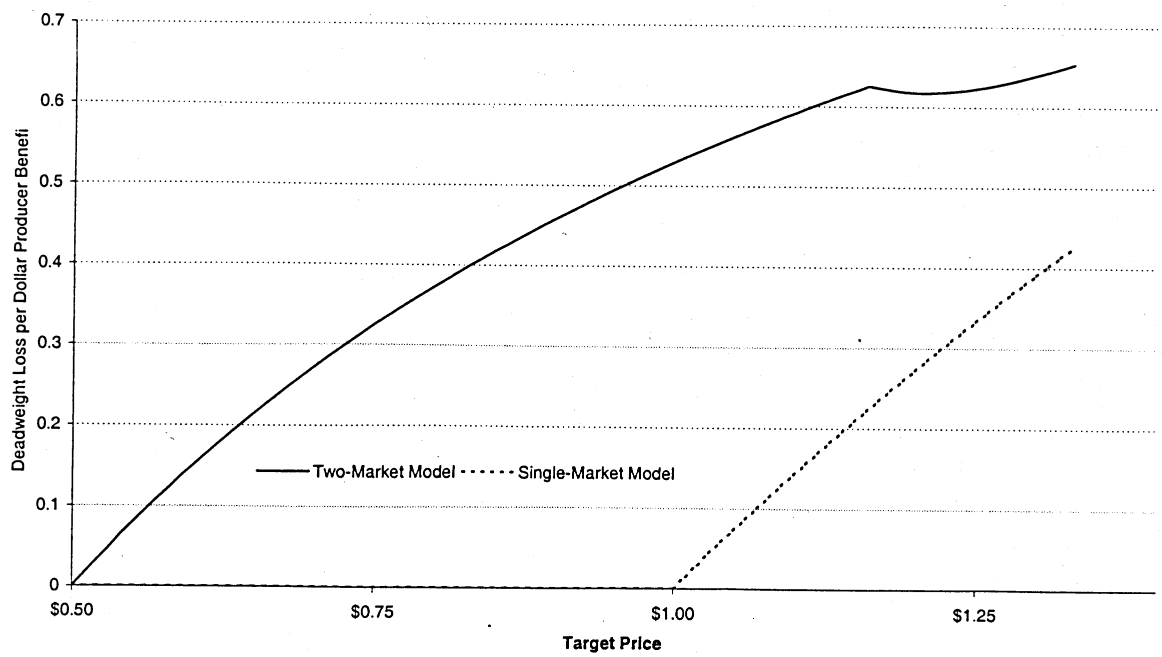


Figure 15. Surplus Transformation Curves from the Single-Market Model

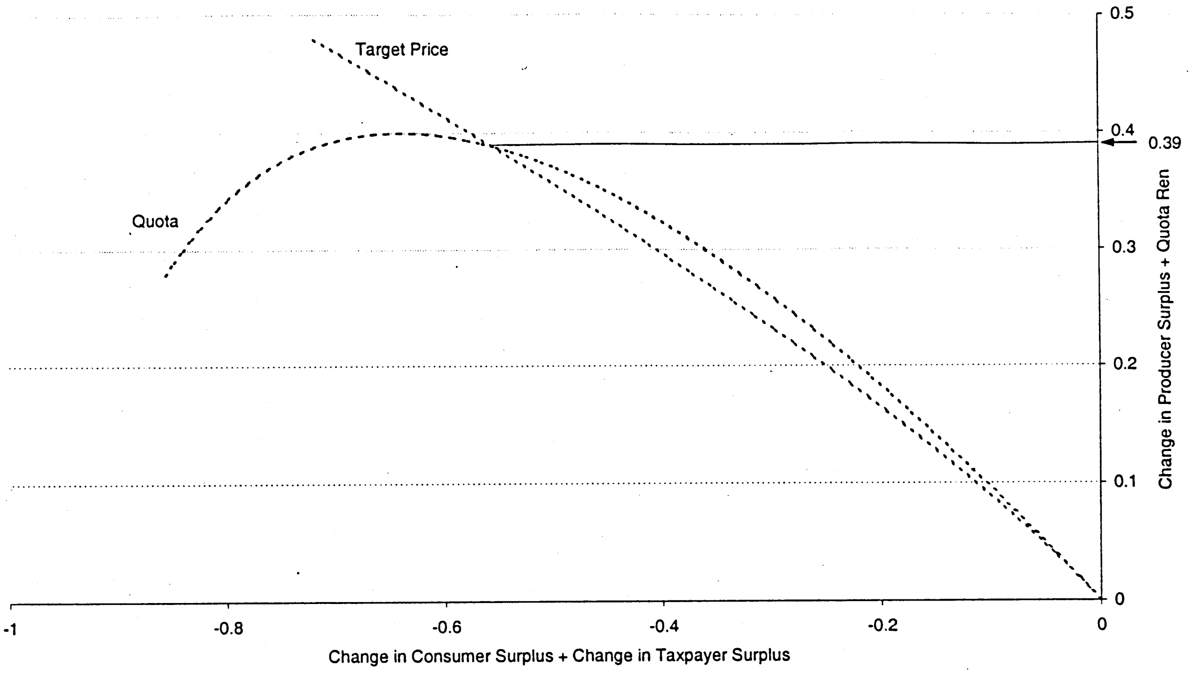
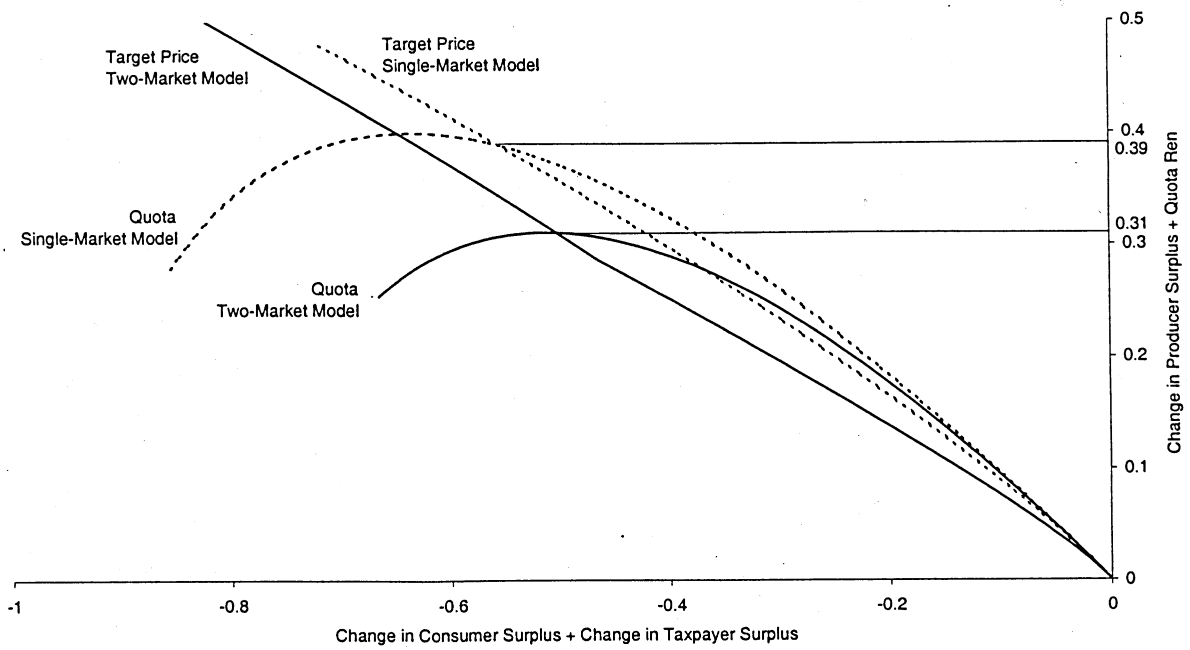


Figure 16. Surplus Transformation Curves for Quota and Target-Price Policies from the Single-Market and Two-Market Models



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