Producer Price Equalization

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Most previous studies of home consumption pricing and producer price equalization schemes have concentrated on static economic surplus effects under an assumption of a perfectly elastic export demand. This paper compares the effects of different types of producer price equalization schemes with free trade in the wheat, milk and egg industries allowing for a downward sloping export demand. Average values and variances of prices, quantities, revenues, and economic surplus measures are estimated for each policy in a simulation model allowing a range of values for elasticities of supply and demand, market shares, and variability of supply and export demand. The stabilization effects of equalization schemes are evaluated using these estimates.

1. Introduction

How consumption price schemes which price discriminate among markets and which pay producers an equalized or pool price have featured prominently in Australian agricultural marketing and price policy since the early part of this century and they remain an important feature of the current institutional arrangements. The schemes are operated by statutory marketing authorities empowered by Commonwealth or State legislation or by joint Commonwealth and State legislation, with the assistance of trade barriers. Stated objectives of the schemes are to raise producer returns and to stabilize both domestic consumer food costs and producer returns. At present they apply to about one-third of the gross value of Australia's agricultural output and are still both "....the major form of agricultural support used in Australia" and the "main method of stabilising agricultural prices" (Edwards and Watson 1978, p.190f and p.211).

The objective of this paper is to develop a general analysis of the effects of price equalization schemes in their different forms in a general setting. Specifically, the paper relaxes the conventional assumption of a perfectly elastic export demand function, it explicitly considers the implications of different domestic price setting arrangements, and it assesses the stabilization implications of price equalization when supply decisions are based on imperfect knowledge about future market conditions and when there are lags in production response.

We begin with a selective review of the history of equalization and some previous studies as background. Then, to set the scene for the more general model, we provide a brief description of the basic model based on two markets, one of which has a perfectly elastic demand curve, and comparative statics. Some stabilization issues are raised in this context. Next, the model is generalized to allow for a downward sloping export demand curve. A comparative statics analysis provides a picture of the longer term equilibrium implications for prices, quantities, economic efficiency and distribution. The paper then considers in more detail the implications of equalization for stability of prices, quantities, and incomes. Because of our inability to obtain analytical solutions for the realistic world of uncertainty and production lags, a set of simulation experiments are conducted for this part of the analysis. A final section summarises our main findings.

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2. Background

The early equalization schemes used a combination of production taxes and export subsidies to price discriminate against domestic consumers (see Sieper 1981). In the late 1930s this approach was supplanted with domestic prices regulation, a method that has survived almost universally to the present. Commonly equalization operates as follows. The domestic price is set in advance and above the export price. Revenues from domestic and export sales are pooled and producers receive an equalized price that is a weighted average of the high domestic and low export prices. The price paid by domestic consumers, price received by producers, output and exports are greater than they would have been without equalization, and domestic consumption is less.

Equalization schemes currently operate in this fashion for each of the major manufactured dairy products (butter, cheese, casein, skim milk powder, and whole milk powder), dried vine fruits (sultanas, raisins, currants), and eggs. The wheat industry scheme has operated in this way too, but in many years the price discrimination has been perverse with domestic prices set below export prices (see Longworth 1966, and Longworth and Knopke 1983). A similar story holds for sugar. The price discrimination is not always between domestic and export markets. With some of the schemes, the discrimination has been mainly between alternative domestic markets (*e.g* fresh and processing). The State egg industry schemes equalize returns between eggs sold for fresh use and eggs sold at lower prices for processing into products for sale on both domestic and export markets. In Victoria, milk producers receive a weighted average of the fresh milk price and the lower manufacturing milk price. The latter price is itself the outcome of the national dairy products scheme that equalizes producer prices between domestic and export markets.

Most analyses of producer price equalization build on the assumptions of a comparative static model with two markets, of which one (typically the export market) has an infinitely elastic demand curve, and the analyses ignore variability altogether.[1] This is the framework developed in the classic study of the dairy industry by Parish (1962), applied with little modification to the wheat industry by Longworth (1966), to the egg industry by Beck (1974), and others. Economists have paid much more attention to the comparative static effects of equalization on price, quantity and economic surplus than its effects on variability. It seems to be taken for granted that equalization does stabilize prices received by producers. One exception is Myers and Piggott (1981). Houck (1973) raised the question as to whether price stabilization worked to stabilize or destabilize producer gross revenues, and we might further question the stabilization effects on net revenues.

A more general and more realistic analysis of price equalization schemes needs to extend the analysis in three directions. These are: relaxing the small country assumption to recognise that the demand for exports (or processed forms of the product) is less than perfectly elastic; being more explicit about the rules followed in setting the domestic product price; and analysing stability effects of the different schemes in a world where supply adjustments reflect the biological lags in agricultural supply, imperfect knowledge and the role of price expectations. The small country assumption whereby the export demand (or processed product demand) for Australian agricultural products can be assumed to be perfectly elastic is subject to much debate. Certainly there are few commodities, including wool, in which Australia supplies ten per cent or more of total world production. There is a growing body of theoretical and empirical evidence that the excess or export demand for our products is less than perfectly elastic for a number of other reasons, even when Australia supplies only a small fraction of

[1] Longworth (1967) showed that under wheat stabilization growers' prices for wheat were more stable than both home consumption and export prices between 1948 and 1966; Myers, Piggott and MacAulay (1985) provided a more recent appraisal of wheat stabilization. Myers and Piggott (1981) provided a theoretical analysis of stabilization effects of equalization with fixed output and profit maximizing price discrimination between two markets.

the world total. Agricultural and trade policies insulate to a large extent domestic prices in many economies from world price movements. This means that the world market against which Australian exports compete is much smaller than total world production. Horner (1952), Cronin (1979), Johnson (1977) and others have used price transmission models to argue that the export demand for many agricultural commodities is much less elastic than that implied by the simple competitive model because of interventionist policies. Product heterogeneity, whether intrinsic or associated with political and economic pressures for diversified supplies, means that the cross-elasticities of demand for products from different countries are less than infinite (see, for example, Grennes *et al.* 1978, for wheat and Goddard 1985, for beef). Transport costs, tariffs and so forth effectively reduce the substitutability of supplies from different countries.For some commodities it is argued that non-competitive behaviour is important, (see, for example the McCalla 1966, and Alaouze *et al.* 1978, models of the wheat industry, and the sugar agreements). In total, these aspects of real world commodity markets mean that the elasticity of export demand facing many Australian agricultural products is much less than infinite.

There are number of options for setting the domestic price in price equalization schemes. One choice is to specify a fixed price, independent of market conditions. For example, in the 1950s and 1960s, cost of production estimates were widely used to set domestic prices for wheat and for dairy products and these prices were only loosely, it at all, related to export prices. As one consequence, the fixed domestic price could be above, below or equal to the export price. A second option is to set the domestic price as a percentage or absolute markup above the export price. And even here there are sub-options as to the choice of export price, *e.g.* an estimate of the current price or a moving average of past prices. This option captures the spirit of wheat schemes of the 1970s in which the domestic price was to be about 20 per cent above the export price. A third alternative would involve application of price discrimination rules. Here, quantities and prices would be set to maximize producer returns by equating marginal returns from the different markets. In turn, consideration can be given to price discrimination without supply control (where producers receive the pool price and base their production decisions on this price), or to price discrimination with supply control (where total production and its allocation among markets are restricted so that marginal cost and marginal revenues are equated). These different options are likely to be more important when studying variability, and in situations where export demand is less than perfectly elastic, than in the case of static analyses which assume a perfectly elastic export demand.

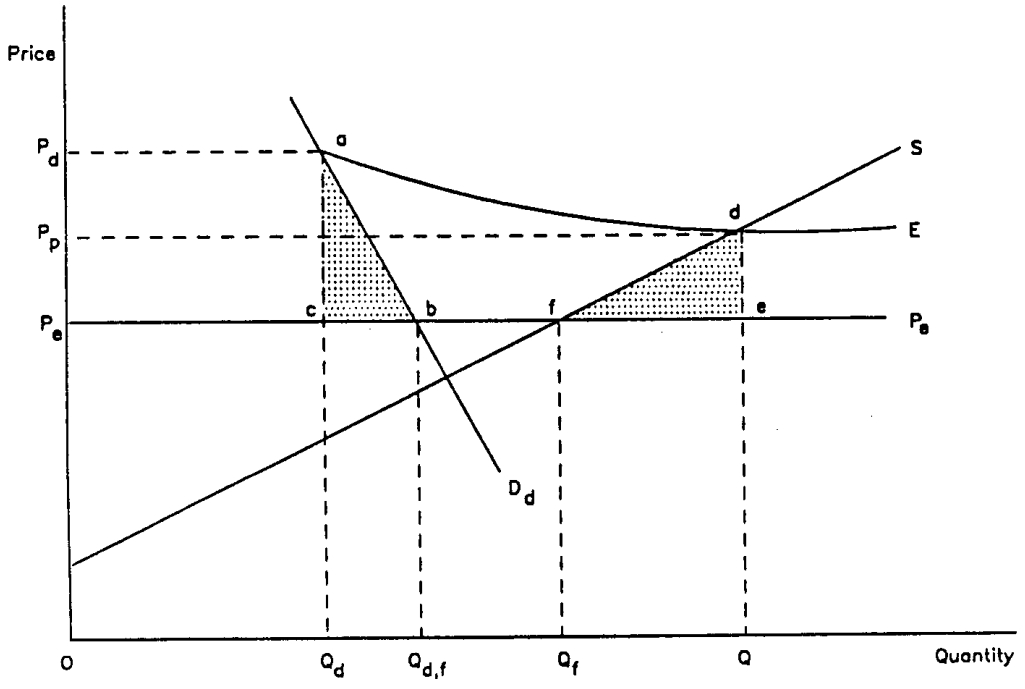
The third area of generalization requires analysing the stabilization effects of the equalization schemes. Stabilization could refer to consumer outlays, export quantities and income, or producer gross and net returns as well as consumer, producer and export prices. Sources of instability include shifts in domestic production, especially due to yield variability, and shifts in export demand (because of variability of overseas production and changes in policies); shifts in domestic demand are likely to be less important in practice. With agricultural production it is important to recognise the biological lags imposed on production responses and the reality that producers must plan production on expected, rather than known, future prices (and yields). While these considerations are found to be important in studies of buffer fund schemes by Turnovsky (1974) and Scandizzo *et al.* (1983) to our knowledge they have not been recognized in studies of the stabilization effects of price equalization schemes.

3. The Standard Model

(a) Static effects of equalization on prices, quantities and surpluses

A conventional model of the effects of equalization is shown in Figure 1. In this model S represents

Figure 1: The Standard Model of the Effects of Equalization



supply, D_d represents domestic demand and P_e represents export demand which is assumed to be perfectly elastic. With free trade, consumers would pay and producers would receive the export price, P_e, on all output resulting in domestic consumption of $Q_{d,f}$ and output of Q_f with the residual, $Q_f - Q_{d,f}$ being exported.

With equalization, the domestic price is fixed above the export price at P_d resulting in domestic consumption of Q_d. For the purposes of this analysis it matters little what criteria are used to set the domestic price other than to note that producer profits would be maximized by setting the home price such that marginal revenue on the domestic market equals the export price. In practice, the domestic price is usually set well below this profit maximizing level.[2] Producers receive a weighted average (equalized) price. Formally this price (P_p) is given by:

$$P_p = P_e + k_d (P_d - P_e)$$

Where k_d is the fraction of output, Q, consumed domestically ($k_d = Q_d/Q$). The pool price locus falls with quantity as shown by the rectangular hyperbola, E, that asymptotically approaches the export price line from above. Production is given by the intersection of supply with the equalized price line at quantity, Q, and price, P_p, above the free trade values. Relative to free trade, the equalization scheme results in a higher domestic price and less domestic consumption, greater production and exports, and greater producer returns. Under standard assumptions (Harberger's Three Postulates) the net social costs of lost consumers' surplus and overallocation of resources to production are represented by the shaded triangles abc and def, respectively.

[2] As far as we can tell this model was first drawn by Parish (1962). Parish (1962) had the domestic market price set to equate domestic marginal revenue and export marginal revenue (price). This unrealistic special case has not been enforced in most subsequent analyses.

In the context of this model there would be no difference between equalization enforced by domestic price fixing and equalization using combinations of taxes and subsidies. An equivalent result could be achieved by (i) using an output tax to finance an export subsidy; (ii) using a consumption tax to finance an export subsidy, or (iii) using a consumption tax to finance an output subsidy.[3] Similarly, in a static model the rules for setting the home price (either fixed, percentage markup or absolute markup) are of no consequence.

Although these alternative policies are equivalent in this static model, they may have quite different effects in a world characterised by variability and uncertainty. For example, the fixed domestic price option (by definition) holds that price constant independently of market circumstances and hence the domestic price may be above, below, or the same as the export price. By contrast, the percentage (or absolute) markup option always has the domestic price above the export price, but the domestic price is variable.

(b) Stabilization issues

Even with the standard model, and especially the unrealistic assumption that supply adjusts instantaneously to current prices, it is possible to question the common assertion that price equalization schemes promote stabilization objectives. The answer is conditional on the source of instability, that is whether instability derives from shifts in the supply curve (S in Figure 1) or the export demand curve (P_e in Figure 1), and on the variable of interest, *e.g.* producers' price, domestic consumer price, exports, export receipts, and so forth (see Appendix B and Myers and Piggott 1981).

For supply shifts with a fixed and perfectly elastic export demand curve the producers' price would be constant under free trade, equal to the export price. In these circumstances, an equalization scheme results in greater variability of the producers' price (as compared with a constant export price under free trade) but less variation in exports and export revenue (because quantity produced changes less against the downward sloping pool price line than it does against the horizontal export demand line). Price and quantity on the domestic market remain constant under both the free trade and price equalization arrangements.

Suppose, alternatively, that the source of instability is a vertical shift in the perfectly elastic export demand curve. The pool price line likewise will shift. Price equalization provides constancy of domestic consumption and price in the case where the domestic price is fixed, but not when the domestic price is set either as a markup on the export price or at a price discriminatory level. For the case of a fixed domestic price scheme, the price equalization arrangement will result in less variability of the pool producer price than of the export price (essentially because of the revenue stabilization effects of the domestic market). Also, total production is less variable with the equalization scheme. Export quantities and receipts are less variable under the fixed home price scheme than under free trade. These variability rankings could be reversed under the percentage markup or price discrimination arrangements and will be modified if there is any domestic demand variability.

The stabilizing effects are also interesting to the extent that they may lead to hidden welfare gains or losses that are not revealed in the static model. One avenue for such effects is that variances of

[3] In the context of Figure 1 there would be (i) an output tax of P_d-P_p with an export subsidy of P_d-P_e;(ii) a consumption tax of P_d- P_p to finance an export subsidy of P_p- P_p; or (iii) a consumption tax of P_d - P_e and a production subsidy of P_p - P_e. Sieper (1981) demonstrated the formal equivalence of these four alternatives in a more general setting allowing for equalization between a domestic market demand and two downward sloping export demands.

market variables could be arguments of supply or demand functions. A second avenue for hidden gains and losses does not require supply or demand to depend on any variances. An analysis of the welfare effects of stabilization in the Waugh-Oi-Massell tradition indicates that the price stabilizing effects of equalization are likely to lead to hidden welfare losses to both producers and domestic consumers under the standard assumptions of linear curves and parallel random curve shifts (see Alston, Freebairn and Arch 1988, Appendix D). Such results are sensitive to the assumptions used, especially the unrealistic assumption of instantaneous supply response. The welfare measures in the simulation model that is used to model the effects of equalization in this paper include hidden gains or losses of this type.

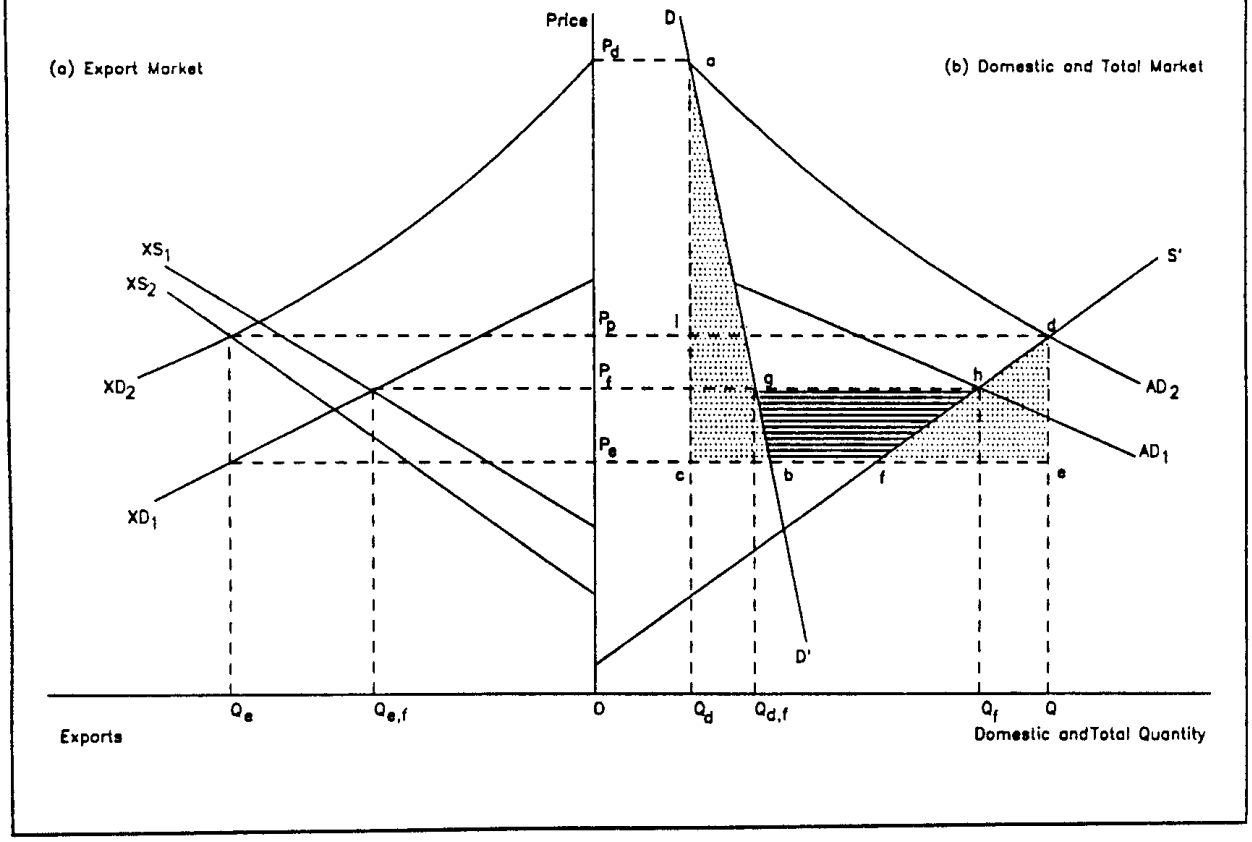
4. The Large Country Case

(a) Static effects of equalization

Next, we will incorporate equalization in a static model with a downward sloping export demand. This leads to some revision of the conclusions about the static effects of equalization that follow from an assumption that export demand is perfectly elastic.

Consider first the free trade situation. In Figure 2 the export market is shown in panel a and the domestic and total market are shown in panel b. Domestic demand is given by DD', domestic supply by SS' and export demand by XD_1. Combining domestic and export demand and supply gives the export supply XS_1. Free trade market equilibrium is given where aggregate demand cuts aggregate supply, or where export demand and export supply intersect, resulting in a price P_f.

Figure 2: Static Effects of Equalization, The Large Country Case



This price applies to domestic consumers, domestic producers and the world market, resulting in production of Q_f, exports of $Q_{e,f}$ and domestic consumption of $Q_{d,f}$.

Now, consider an equalization scheme in which the domestic price is fixed above the ruling world price and producers are paid a pool price. Suppose in Figure 2 the domestic price is fixed at P_d resulting in domestic consumption Q_d. Then, the export supply curve will become the segment of the domestic supply curve beyond Q_d and is represented by XS_2 in panel a somewhat below the free trade export supply XS_1.

As in the small country case, the equalization price received by producers, P_p, is given by equation (1). Unlike the small country case, the export price now falls with quantity exported. The locus of the pool price line is given in Figure 2 by $DaAD_2$. This curve describes the relationship between the pool price and total quantity. The corresponding curve in the export market is XD_2 which shows the pool price as a function of the export quantity. The export price for any quantity exported, with or without equalization, is indicated by the export demand curve XD_1. Thus the vertical distance between XD_2 and XD_1 is equal to the difference between the producer price and the export price, the "export subsidy" per unit.

Unlike the small country case, the shape and position of the pool price line for the large country case is ambiguous. While it is downward sloping and lies above the free trade aggregate demand curve AD_1, the equalized price line AD2 may diverge from or converge towards the free trade aggregate demand curve. In equation (1), as output expands the domestic market share term k_d falls and the difference between the fixed domestic price and the export price (P_d- P_w) widens so that the total term $k_d(P_d$- $P_e)$ can increase or decrease. The conditions for convergence are derived in Appendix A. For most existing Australian equalization schemes the parameters are such that the convergent case, as shown in Figure 2, is more likely.

Then relative to a free trade arrangement, an equalization scheme with the domestic price set above the free trade price (P_d relative to P_e in Figure 2) results in less domestic consumption (Q_d rather than $Q_{d,f}$), greater production (Q rather than Q_f), more exports (Q_e rather tha $Q_{e,f}$) and a lower export price (P_e rather than P_f), and a higher average producer price (P_p rathe than P_f). Qualitatively these directions of change are the same as with an assumed small country case except here the export price is lower and this has some quantitative implications.

The net domestic costs of equalization compared to free trade are equal to the difference between the loss of consumers' surplus ($P_d agP_f$) and the gain in producers' surplus (P_p dhP_f). Using the fact that, with equalization, the implied domestic consumption tax (P_d aiP_p) equals the implied export subsidy (idec), this net social cost is equal to the shaded areas in Figure 2: triangle abc plus triangle def plus area ghfb. To reiterate, these areas represent the social costs of equalization relative to free trade at the free trade price P_f. It is convenient (and no coincidence) that the shaded triangles are based on the equalized price. However, it must not be inferred that these areas are derived by comparing equalization with free trade at the equalized price, P_e. That comparison follows.

There are some general implications of *incorrectly* assuming a perfectly elastic export demand. Starting with an equalization scheme, if it were assumed that export demand is perfectly elastic at P_e the implied free trade price would be P_e with associated quantities exported, consumed domestically, and output indicated by points j, b, and f on export demand, domestic demand and supply (these quantities are not shown to avoid cluttering the diagram). Thus we would overestimate the effects of equalization on the producer price and production, the consumer price

and consumption, exports. We would also overestimate the consumers' surplus loss (by area $P_f gbP_e$) and the producers' surplus gain (by area $P_f\ hfP_e$) from equalization relative to free trade.[4] However, in contrast to Longworth and Knopke (1983, p.643), we would *underestimate* the net social costs by the difference between these two overestimates, area ghfb. With the incorrect assumption of perfectly elastic export demand, the net social costs of equalization relative to free trade would be estimated as the sum of the two triangles (abc plus def), lower than the correct magnitude by area ghfb.

When estimating the net social costs of equalization, it may be more appropriate to evaluate them relative to the policy that would maximize net social surplus for the country. When export demand is perfectly elastic the "optimal" policy may be free trade. But when export demand slopes down, net domestic surplus would be maximized by exploiting export market power and equating marginal export revenue with marginal cost. Figure 3 duplicates the curves defining the free trade solution in Figure 2 and includes on extra curve, the marginal revenue from exports. The free trade equilibrium is given by the intersection of supply (SS') and aggregate demand (AD), the horizontal sum of domestic and export demand. This yields the free trade price, P_f with total output, Q_f of which $Q_{e,f}$ is exported and $Q_{d,f}$ is consumed domestically (as in Figure 2).

Domestic surplus would be maximized by a policy of equating marginal export revenue and marginal cost with the domestic price. This could be achieved by applying a (freely transferable) export quota of $Q_{e,t}$ or by applying an optimal export tax (at a rate equal to the reciprocal of the export demand elasticity) to achieve that quantity. These two policies would be equivalent in their price and quantity (but not surplus distribution) effects in a static world but may have quite different effects under variability. With such a policy, the export price would be P_e while the domestic price would be P_t resulting in total production of Q_t of which $Q_{d,t}$ would be consumed domestically. Compared to free trade, producers' surplus would be lower by $P_f bcP_t$ but this would be partially offset from society's viewpoint by increased consumers' surplus, $P_f adP_t$. The difference between these areas is area abcd, a loss of domestic surplus which would be more than compensated by the gain of area eP_eP_tf in the form of either tax revenue (in the case of an export tax) or quota rent (under export quotas).

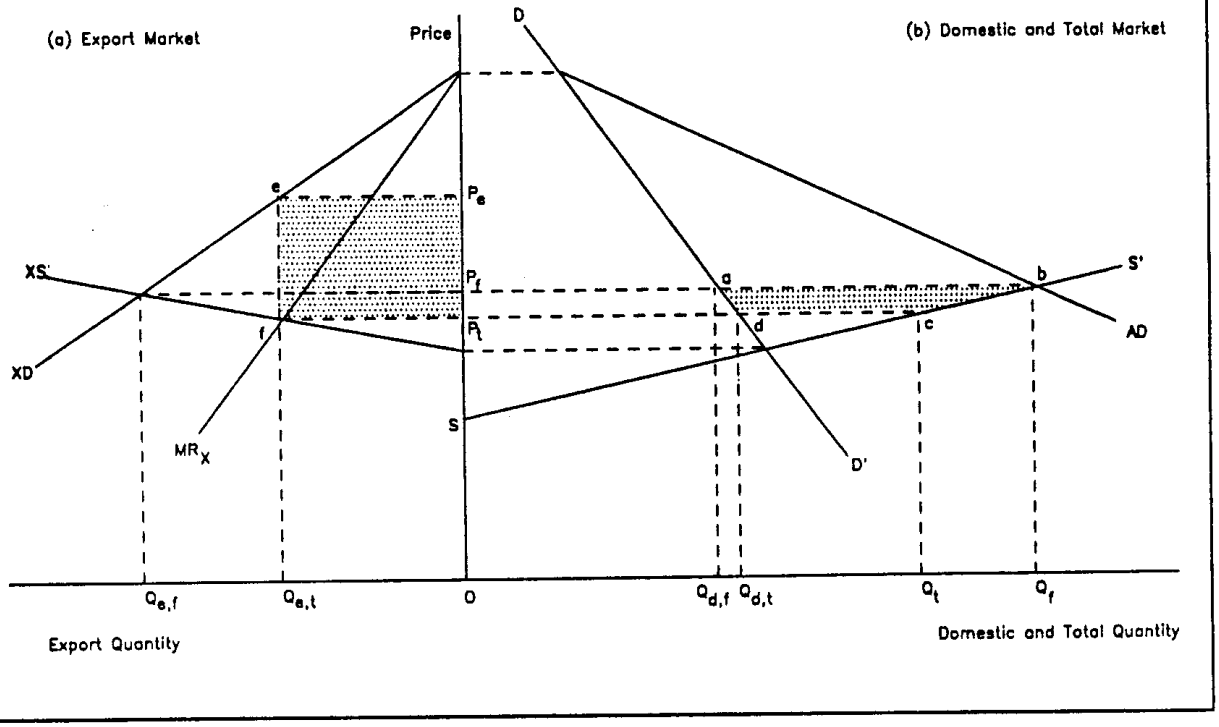
When export demand slopes down there is thus a net social cost of free trade (compared to the optimum policy) equal to area eP_eP_tf minus area abcd. If the benchmark policy is optimal export taxes, rather than free trade, then these social costs should be added to the costs of equalization relative to free trade (depicted in Figure 2) to measure the net social costs of equalization.

Probably more important than its effects on net social surplus measures, equalization implies radically different distributions of surplus than free trade or an optimal export tax or an optimal export quota. From the point of view of producers, surplus would be maximized by a policy that equated marginal revenues from all markets with marginal costs.[5] Equalization is a poor compromise from society's viewpoint: instead of exports being taxed, they are subsidized, and some of the benefits from monopolistic exploitation of domestic markets are transferred to foreigners.

[4] Longworth and Knopke (1983) recognized this but asserted that in the case of the wheat industry, with a demand elasticity for exports of -10 rather than infinity, the error would be less than 5 per cent. Godden (1978), also, noted that ceteris paribus a lower elasticity of export demand implies lower resource misallocation costs of equalization, and his results indicate smaller increases in resource misallocation costs when export demand contracts. However, Godden (1978) held constant the export price effect of the export demand shift rather than the vertical magnitude of the shift. Holding constant the magntude of the shift implies different price effects, and therefore different effects on resource misallocation costs in consumption as well as production, depending on the export demand elasticity.

[5] See Sieper (1981) and Appendix A.

Figure 3: An Optimum Export Tax Solution



(b) Stabilization issues in the large country case

It was shown above that for a small country exporter, with instantaneous supply response, equalization may increase or reduce the variance of producer prices, other prices, quantities, and revenues. Both the direction and magnitude of the effect of equalization on producer price variability are likely to depend on (i) the relative sizes of the variances of the random components of export demand, domestic demand, and supply, (ii) the slopes (elasticities) of supply and domestic demand, (iii) the share exported and the size of the domestic price distortion (*i.e.* the factors that determine the slope of the equalized price line), and (iv) whether equalization is enforced by regulation or by combining taxes and subsidies.

In the large country case the same arguments may be applied to yield the same results. There is one additional parameter that matters: the slope of the export demand curve. As in the small country case, the most likely effect of equalization is to reduce the slope and variability of the aggregate demand curve facing producers. In the large country case aggregate demand slopes down with free trade so that, even without equalisation, domestic supply and demand variability influence price variability. As in the small country case, equalisation is likely to reduce the slope of demand facing producers (*i.e.* make demand steeper) and thus increase the effect of supply variability, and to reduce demand variability, with an ambiguous net effect on producer price variability. The details of the rules for setting the domestic price are likely to have more important implications for variability in the case when export demand is less than perfectly elastic.

5. A Simulation Model

A recursive simulation model is used to attempt to generalize quantitatively some of the results of

the assessment of the effects of price equalization on stabilization in a more realistic model that allows for production lags, uncertainty and expectations in supply response. The detailed assumptions and the workings of the model are reported in Appendix C. The model contains linear equations for domestic demand, export demand and supply for a hypothetical commodity. Supply in the next period responds to a producer's expected price with price expectations formed adaptively using the price from current and previous periods.[6] Additive parallel random shift terms are included in the supply and export demand curves as originating sources of market instability; for simplicity, domestic demand is held stable. A multiplicative supply disturbance is also tried.These random terms are assumed to be (truncated) normally distributed with expected values of zero.

The simulations compare the effects of different equalization schemes and free trade under a range of market and policy assumptions. Three sets of parameters are used to correspond to conditions in three Australian industries that use equalization schemes: the Australian wheat industry, the Victorian egg industry, and the Victorian milk industry. The wheat industry equalizes returns between domestic and export markets; the Victorian egg and milk industries equalize returns between fresh and manufacturing markets with the bulk of the manufactured products being exported.[7]

Parameters of the model include a supply elasticity (E_s), a domestic demand elasticity (E_d), an export demand elasticity (E_e) an expectations coefficient (B), a domestic (high-priced) market share of total sales (k_d), the domestic markup over the producers' equalized price (M) and coefficients of variation for the random shifts of the supply curve (CV_u) and export demand curve (CV_v). The elasticities, domestic markup, and domestic market share are used to define the parameters of the linear supply, export demand, and domestic demand curves. We have chosen commodities that show a wide range of values for the key parameters: domestic (preferred) market share, export demand elasticity, domestic markup, and coefficients of variation.

Likely values for the parameters were obtained from market data, estimates in the literature and prior reasoning. Coefficients of variation of supply (quantity produced) and export demand (export price) were estimated econometrically. These "most likely" values were used as base values for the simulations. For the elasticities of supply and export demand, which are quite uncertain, values of plus or minus 50 per cent of the base value also were used. For the other parameters, values plus or minus 10 per cent of the base values were tried. Two parameters were fixed for all of the simulations: E_d (domestic demand elasticity) = -0.2; B (expectations coefficient) = 0.5. Parameter values used in the simulations are given in Table 1.

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[6] A major advantage of the adaptive expectations specification is that supply in the current period is predetermined and this allows easy solution of the model. A disadvantage is that the adaptive expectations are not "rational expectations" given the serially independent nature of the exogenous stochastic components of the model. Rational expectations would be difficulty to apply except in the case of the fixed domestic price scheme or the case of free trade. In these two cases, the long run expected (static) price solution would be a rational expectation and planned output would be the same in every period. Simulation results with rational expectations in these cases are compared to adaptive expectations in the results section, and it is shown that the results are not seriously conditional on the expectations model. The results are more likely to be seriously conditioned by the use of linear models. Previous work has shown that the welfare effects of stabilization depend crucially on the curvature of demand. We thank a referee for reminding us of this point.

[7] The Victorian egg industry also employs hen quotas. In the analysis of the egg market we consider the effects of the current arrangements relative to a partially deregulated market in which the quotas are retained along with the embargo on imports but equalization ceases. For brevity we use the term "free trade" to refer to this partially deregulated situation which is actually a long way from free trade. Thus the supply elasticity of 0.2 in this case refers to the regulated supply function, restricted by quotas on hens. The markup refers to the difference between the current domestic and equalized price which is small relative to the total distortion in prices caused by the supply restrictions in conjunction with equalization.

Table 1: Values of Variables Used in Simulation Experiments

Variable	Symbol	Best Estimates Wheat	Milk	Eggs	Range
Supply Elasticity[a]	E_s	1.0	1.0	0.2	+/-50%
Domestic Demand Elasticity	E_d	-0.2	-0.2	-0.2	fixed
Export Demand Elasticity	E_e	-10	-6	-1000	+/-50%
Expectations Coefficient	B	0.5	0.5	0.5	fixed
Supply Variability[b]	CV_u	22	5	4	+/-10%
Export Demand Variability[b]	CV_v	21	13	13	+/-10%
Domestic Share[c]	k_d	20	40	96	+/-10%
Domestic Markup[d]	M	5	20	3	+/-10%

a. This is the long run elasticity of *planning supply* curve. In the case of eggs it is the elasticity of supply in the presence of hen quotas.

b. Best estimates were obtained by rounding off estimates of coefficients of variation around trends in export prices and output. See Alston, Freebairn and Arch (1988) for details.

c. The long run static (expected) equalization output was set arbitrarily at 100 quantity units. Thus the expected domestic share with equalization in percentage units is equal to the expected domestic consumption in quantity units.

d. The equalized producer price in static equilibrium was arbitrarily set at 100 price units. Thus the absolute markup is also a measure of the domestic markup as a percentage of the expected long run equalized price.

Simulations were run using all the possible 3^6 = (729) combinations of the values for parameters for each industry. These sets of values allow an assessment of the effects of policy and market parameters on the consequences of equalization and at the same time bracket likely values for the major Australian commodities that have equalization schemes.

For each set of values for market and policy variables, simulations were used to generate a series of one thousand observations of equilibrium values (with both free trade and equalization) of the following variables: producer price, domestic price, export price, output, domestic consumption, exports, total revenue, domestic revenue, export revenue, producers' surplus, consumers' surplus, and total domestic surplus (see Appendix C for details). Then, for each set, means and variances of prices, quantities, revenues and surpluses were computed.

6. Simulation Results

(a) Effects of equalization on the means of variables

Results of the simulations for the mean values, using the "most likely" parameter estimates for each industry, are summarized in Table 2. The entries in Table 2 are ratios obtained by dividing the mean of each variable under equalization by the corresponding mean under free trade. Thus, when a "ratio of means" is greater (less) than one, equalization increases (reduces) the expected value of that variable relative to free trade. For example, in the Victorian milk industry equalization has the effect of raising the average domestic price by 33.6 per cent, lowering the average export (manufacturing milk) price by 3.3 per cent, and increasing the average producer price by 11.5 per cent relative to the average prices under a free market policy structure.

Table 2: Mean Effects of Equalization Relative to Free Trade in the Wheat, Milk and Egg Industries

	Ratio of Mean with Equalization to Mean with Free Trade		
	Industry		
Variable	Australian Wheat[a]	Victorian Milk	Victorian Eggs[b]
Prices:			
Domestic	1.058	1.336	1.141
Export	0.998	0.967	-
Producer	1.010	1.115	1.107
Quantities:			
Domestic	0.989	0.952	0.976
Export	1.016	1.258	-
Total	1.010	1.115	1.020
Revenues:			
Domestic	1.053	1.274	1.124
Export	1.013	1.216	-
Total	1.021	1.243	1 .137
Surpluses:			
Consumer	0.977	0.906	0.950
Producer	1.026	1.247	1.130
Total	1.000	0.985	0.993

Notes:

a. The total surplus ratio is fractionally less than 1.0 but not sufficiently so to show up in the third decimal place
b. Blanks in eggs column resulted because with free trade exports would be zero.

For the three commodities, equalization increases the expected values of the domestic consumer price, producer price, exports, output, domestic revenue, export revenue, total revenue, and producers' surplus, and it reduces the expected values for the export price, domestic consumption, domestic consumers' surplus and total domestic surplus. These results are the same as those from the static model in Figure 2. In the wheat and egg industries the effects of equalization on means of variables are relatively small, mainly because the domestic price distortions are small. In the case of milk, as we would anticipate, the effects are larger due to the large domestic price markup. The expected percentage changes in price, quantity or income due to equalization correspond almost exactly to those that would be obtained from comparative statics.[8] The effects on surplus measures differ because they include hidden gains and losses from stabilization and destabilization effects on prices and quantities.

(b) Effects of equalization on variability

The main purpose of the simulation model is to study the effects of equalization on variability. In this context, the details of the equalization arrangements matter. Three types of schemes are considered, all of which have the same expected long-run outcome but which may have different short-run effects. In the first scheme the domestic price is fixed independently of export prices; in the second scheme the domestic price is set as a constant absolute markup on the expected export price; and in the third scheme the domestic price is determined by adding a proportional markup to the expected export price. The latter two schemes are defined so that the expected (long run) outcome is the same in all three schemes.

Results for variability effects, using the "most likely" parameter estimates are given in Table 3 (Australian wheat), Table 4 (Victorian milk) and Table 5 (Victorian eggs). The entries in these tables are ratios obtained by dividing the variance of each variable (price, quantity, revenue, or surplus) under each type of equalization scheme by the corresponding variance that would result under free trade. When a "ratio of variances" is greater (less) than one, equalization increases (reduces) the variance relative to free trade.

In the case of wheat (Table 3), the three types of equalization would destabilize two variables, export prices and total surplus, relative to free trade while all other variables would be stabilized relative to free trade.[9] Differences between types of equalization scheme have little effect on variability, except for variances of domestic prices, quantities and revenues which are zero when the home price is fixed. In general the stabilizing effect of equalization is greater for the fixed domestic price scheme than when the domestic price varies with export prices and greater for the absolute markup scheme than the percentage markup scheme.

The magnitudes of the effect of equalization relative to free trade on variability are large, especially compared to the effects on the means. The variability of domestic consumer prices, quantities, revenues and surpluses is eliminated in the case of the fixed domestic price policy and reduced by 70

[8] They will differ slightly in every case because the sample means of the random shifts are not exactly zero. They will differ in the case of eggs for another reason. In the simulations we imposed a restriction that imports would not be allowed under free trade. Thus the possible range of results was restricted, and the expected values from sets of simulations where the restriction is binding in any instance will be different from the static solutions. The restriction was binding in some instances in the simulations for the Victorian egg industry.

[9] At first blush it seems incongruous that total surplus can be destabilized by a policy that totally stabilizes consumers' surplus and significantly stabilizes producers' surplus. The explanation is that, with free trade, there is a strong negative covariance between producers' and consumers' surpluses which reduces the variability of total surplus relative to its components. Under equalization, this covariance is reduced or eliminated.

Table 3: Effects of Equalization on Variability in the Australian Wheat Industry Relative to Free Trade

Variable	Ratio of Variance with Equalization to Variance with Free Trade		
	Fixed Domestic Price	Constant Absolute Markup	Percentage Markup
Prices:			
Domestic	0.0000	0.3018	0.3412
Export	1.0077	1.0081	1.0082
Producer	0.6293	0.6292	0.6301
Quantities:			
Domestic	0.0000	0.3018	0.3412
Export	0.9204	0.9583	0.9612
Total	0.9163	0.9410	0.9429
Revenues:			
Domestic	0.0000	0.2844	0.3213
Export	0.9310	0.9555	0.9573
Total	0.8189	0.8759	0.8802
Surpluses:			
Consumer	0.0000	0.2948	0.3331
Producer	0.8390	0.8412	0.8417
Total	1.0118	1.0125	1.0125

per cent relative to free trade with the markup policies. The variability of producer prices is reduced by nearly 40 per cent and the variability of producers' surpluses is reduced by 16 per cent. There is only a marginal (4 to 7 per cent) reduction in the variability of export revenues. Variability increases by about one per cent for export prices and total surpluses.

The qualitative results were generally similar for the other commodities (milk and eggs) but there are some important differences. In the case of the dairy industry, as with wheat, equalization destabilizes export prices and total surplus. With the percentage markup scheme, equalization also destabilizes export revenue for Victorian milk. All of the other variables are stabilized. The stabilizing and destabilizing effects are more pronounced for milk than wheat, probably due to milk's larger domestic share and larger domestic markup.

The three types of equalization scheme reduce the variance of producers' milk prices by about 60 per cent and reduce the variance of producers' surplus by over 45 per cent but they increase the variance of total surplus by over 35 per cent. Differences among types of equalization scheme are more pronounced in the Victorian dairy industry, especially for domestic price, consumption and revenue. With the fixed domestic price option these three variables are totally stabilized; with the fixed absolute markup scheme the variances are reduced by 75 per cent compared to free trade; with the percentage markup scheme the variances are twice as much as with the absolute markup scheme.

Table 4: Effects of Equalization on Variability in the Victorian Dairy Industry Relative to Free Trade

Variable	Ratio of Variance with Equalization to Variance with Free Trade		
	Fixed Domestic Price	Constant Absolute Markup	Percentage Markup
Prices:			
Domestic	0.0000	0.2922	0.5587
Export	1.0206	1.0232	1.0248
Producer	0.3771	0.3808	0.4006
Quantities:			
Domestic	0.0000	0.2922	0.5587
Export	0.6281	0.7701	0.8495
Total	0.6187	0.7058	0.7574
Revenues:			
Domestic	0.0000	0.2302	0.4398
Export	0.9223	0.9881	1.0240
Total	0.5208	0.6735	0.7652
Surpluses:			
Consumer	0.0000	0.2647	0.5060
Producer	0.5375	0.5436	0.5653
Total	1.3593	1.3751	1.3843

The case of eggs is different again. In this case we imposed the additional restriction that imports would not be allowed. Given the small export share, this restriction was binding in some instances with equalization; it was always binding with "free trade". To allow for market clearing, the domestic pricing rule for eggs was that in any period the "Fixed" domestic price (set either as a constant for all periods, or a constant absolute or percentage markup over the expected export price for each period) would be a minimum price. In those periods when demand at that price exceeded the available supply, the domestic price was allowed to increase to clear the market. The other distinctive feature of eggs is that in the absence of equalization there would be no exports. The stabilizing effects of equalization are quite dramatic for eggs. Most of the variances are reduced by more than 80 per cent, many by more than 90 per cent. The sole exception is output. The variance of output is reduced by only 20 per cent.

The explanation is fairly obvious. In the case of eggs, equalization enables the domestic price to be almost completely stabilized. Only a small fraction of output is exported so that variation in export prices is largely unimportant. The export market is used as a residual market to absorb the variability induced by shifts of supply. Thus the domestic market is almost entirely insulated from the effects of domestic supply variability.

Table 5: Effects of Equalization on Variability in the Victorian Egg Industry Relative to Free Trade

Variable	Ratio of Variance with Equalization to Variance with Free Trade		
	Fixed Domestic Price	Constant Absolute Markup	Percentage Markup
Prices:			
Domestic	0.0225	0.0297	0.1363
Export	-	-	-
Producer	0.0482	0.0524	0.1267
Quantities:			
Domestic	0.0225	0.0297	0.1363
Export	-	-	
Total	0.7936	0.7990	0.8398
Revenues:			
Domestic	0.0187	0.0252	0.1203
Export	-	-	-
Total	0.0154	0.0233	0.1309
Surpluses:			
Consumer	0.0209	0.0278	0.1296
Producer	0.0151	0.0212	0.1096
Total	0.1848	0.1957	0.3694

(c) Sensitivity of stabilizing effects to parameter values

The theoretical analysis indicated that the extent of the stabilizing or destabilizing effect of equalization would depend on the size of the export demand elasticity, the supply elasticity, the domestic market share, domestic price relative to producer equalized price and whether the source of variability is supply or demand. To explore these relationships further, the variances of producer prices with equalization [$V(P_e)$] and with free trade [$V(P_f)$] for wheat were regressed against a general quadratic function of the six market and policy variables (variance of supply shift, variance of export demand shift, magnitude of export demand elasticity, supply elasticity, domestic market share and domestic price markup over the producer's price, *i.e.* P_d-100 using the ranges of values shown in Table 1. These regressions were computed using logarithms of the variables so the parameters are elasticities, indicating the effects of each of the variables on variability of the producer price and on the producer price stabilizing effect of equalization. The estimates are shown in Table 6. For example, in the first equation the coefficient of 0.018 indicates that a 1 per cent increase in the coefficient of variation of the supply equation will increase the variance of the free trade price by 0.018 per cent.

Table 6: Regressions of Logarithms of Variances of Producer Prices for Wheat Against Logarithms of Parameters Used in Simulations

Regressors (logarithms)	Dependent Variable[a]: Variance of Free Trade Price $\ln[V(P_f)]$	Variance of Equalized Price[b] $\ln[V(P_e)]$	Variance Ratio $\ln[V(P_e)/V(P_f)]$
Intercept	0.095 (0.022)	1.33 (0.020)	1.24 (0.007)
Supply Variability $[Cv_u]$	0.018 (0.002)	-0.003 (0.002)	-0.021 (0.001)
Export Demand Variablity $[CV_v]$	0.982 (0.002)	0.975 (0.002)	-0.007 (0.001)
Export Demand Elasticity[c] $[E_e]$	-0.037 (0.001)	-0.046 (0.001)	-0.009 (0.0002)
Supply Elasticity $[E_s]$	0.014 (0.001)	0.006 (0.001)	-0.009 (0.0002)
Domestic Market Share $[k_d]$	-0.002 (0.004)	-0.511 (0.004)	-0.510 (0.001)
Domestic Markup[d] [M]	0.000 (0.004)	0.005 (0.004)	0.005 (0.001)
R^2	0.997	0.998	0.995
N	729	729	729

Notes:

a. Parameters are elasticities (standard errors in parentheses).

b. Equalization with fixed domestic price

c.. These are elasticities with respect to the magnitude of the export demand elasticity.

d. While the domestic markup and domestic market share are not directly relevant to free trade equilibrium, they are used to derive the parameters of domestic demand. Thus they indirectly affect the free trade results.

As would be expected, the variance of the free trade price depends positively on the variances of the domestic supply and export demand curves, but it decreases as export demand becomes more elastic. Surprisingly, the variance of the free trade price increases as supply becomes more elastic.[10] The variance of the equalized price is affected significantly by these parameters and by the domestic market share.

In the regression for variance ratios, a positive elasticity indicates that an increase in the parameter *reduces* the stabilizing effect of equalization relative to free trade. A negative elasticity indicates that an increase in the variable *increases* the stabilizing effect of equalization relative to free trade. All of the six parameters are statistically significant in the regression for variance ratios. At the means of the variables, an increase in the supply shift variance, demand shift variance, supply elasticity, magnitude of the export demand elasticity, or domestic share will increase the stabilizing effect of equalization. The opposite applies to the domestic price markup. However, while all of the elasticities are statistically significant, all but one of them are very small. The one exception is the elasticity of the stabilizing effect of equalization with respect to domestic market share which is -0.5. Of course, this "parameter" depends on other market parameters.

(d) Effects of a multiplicative supply disturbance

All of the results so far have been based on an assumption that the supply disturbance is additive. However, a significant part of the random component of supply is due to weather variation influencing yields which might more realistically be treated as entering multiplicatively. The model was therefore recomputed using a multiplicative supply disturbance. The effects of these two assumptions about supply disturbances on means and variance ratios for the wheat industry are compared in Table 7 using the base (most-likely) parameter values from Table 1, and assuming that the domestic price is fixed independently of the export price. From the results in Table 7, it can be seen that the use of a multiplicative rather than additive supply disturbance has a negligible influence on the effects of equalization on means and variances in the wheat industry.

(e) Rational expectations

The results are all conditioned on the use of adaptive expectations which, as mentioned above, are not generally consistent with rational expectations. To examine the importance of the expectations assumption, the model was run using a rational expectations specification for the three industries. This was done to compare the case of free trade and the case of equalization where the home price is fixed independently of market conditions. In these two cases, given the other assumptions of the model, a rational price expectation will be the long run expected value (of either the free trade or the equalized price) so that planned output in both cases will be constant.

The use of the alternative expectation models had negligible effects on variability under equalization relative to free trade for most variables. The effects on the means of variables were even less significant. The differences were most pronounced in the milk industry. As can be seen in Table 8, the most striking differences were in export markets. Relative to adaptive expectations, under rational expectations equalization has a much smaller stabilizing effect on exports and supply, a slightly greater stabilizing effect on the producer price and producer surplus, a slightly greater

[10] The analysis in Appendix B indicates that an increase in supply elasticity will reduce the variances of price under free trade. This contradictory empirical result is almost surely due to the use of the adaptive expectations model. We are grateful to a referee for pointing this out.

Table 7: Effects of Multiplicative vs Additive Supply Disturbances in the Australian Wheat Industry

	Ratios of Means and Variances with Equalization to Means and Variances with Free Trade			
	Means		Variances	
Variable	Additive Disturbance	Multiplicative Disturbance	Additive Disturbance	Multiplicative Disturbance
Prices:				
Domestic	1.058	1.058	0.000	0.000
Export	0.998	0.998	1.008	1.008
Producer	1.010	1.010	0.629	0.630
Quantities:				
Domestic	0.989	0.989	0.000	0.000
Export	1.016	1.015	0.920	0.933
Total	1.010	1.010	0.916	0.928
Revenues:				
Domestic	1.053	1.053	0.000	0.000
Export	1.013	1.013	0.931	0.941
Total	1.021	1.021	0.819	0.827
Surpluses:				
Consumer	0.977	0.977	0.000	0.000
Producer	1.026	1.026	0.839	0.848
Total	1.000	1.000	1.012	1.024

Notes:

The equalization scheme considered is the one where the domestic price is fixed, independent of export market conditions.

destabilizing effect on the export price and export revenue, and a slightly smaller destabilizing effect on total surplus.

The use of the alternative expectations model does not change the directions of effects (with the exception of output variability which is by definition zero under rational expectations and therefore cannot be affected by equalization). It has generally a small influence on the magnitudes of effects.

The exercise also serves as a test for sensitivity of results to the expectations coefficient. In the cases tried here, given the way the model is specified, rational expectations is a special case of adaptive expectations where the expectations coefficient is zero. Thus we can also say that the results are not highly sensitive to that variable in the lower range. In the upper range some greater sensitivity arises because an explosive cobweb can be created as the coefficient approaches unity.

Table 8 : Effects of Equalization on Variability in the Victorian Dairy Industry Relative to Free Trade with Alternative Expectations Models.

Variable	Ratio of Variance with Equalization to Variance with Free Trade	
	Adaptive Expectations (B = 0.5)	Rational Expectations (B=0)
Prices:		
Domestic	0.0000	0.0000
Export	1.0206	1.0324
Producer	0.3771	0.3750
Quantities:		
Domestic	0.0000	0.0000
Export	0.6281	0.9865
Total	0.6187	1.0000
Revenues		
Domestic	0.0000	0.0000
Export	0.9223	1.1688
Total	0.5208	0.5364
Surpluses:		
Consumer	0.0000	0.0000
Producer	0.5375	0.5364
Total	1.3593	1.3547

(f) Implications of stabilization effects

Our results have shown that equalization may stabilize some variables and destabilize others in each of the industries considered here. In all cases considered, the equalization arrangements lend greater stability to most of the variables. The notable exceptions are the export price and total surplus which tend to be more variable when equalization stabilizes the producer price, output, and exports. These results follow from the parameters used in the analysis but are fairly insensitive to small changes from the most likely parameter values.

It has been suggested (*e.g.* Whipple 1986) that there may be a positive supply response to the greater producer price stability conferred by equalization. The implication of a rightwards supply shift due to stabilization is for an additional social surplus effect of equalization that has not been incorporated in our model. The social surplus gain due to this supply shift would offset some of the social costs of resource distortions due to equalization. Conceivably, the supply shift could be large enough to more than offset the triangles of social cost so that there is a net welfare gain from equalization. In wheat, for example, there would need to be only a one or two per cent increase in output, in response to a reduction in producer price variability (as measured by variance) of the order of 40 per cent, to result in a net domestic surplus gain from equalization.

Unfortunately, we have no clear view of whether variability influences supply decisions in important ways nor of whether producer price is the relevant response variable in this context. What we can say is that there would need to be only a small response of supply to changes in variability for the welfare effects of stabilization induced by equalization to swamp the static welfare effects.

7. Summary of Results and Concluding Comments

In the standard approach to analyse the effects of equalization schemes it is assumed that equalization stabilizes producer prices and that export demand is infinitely elastic. This paper questions these two assumptions. The effect of equalization on producer price variability is shown to be theoretically ambiguous, even when export demand is perfectly elastic. Whether equalization does in fact stabilize producer prices is an empirical question. Our results indicate that an affirmative answer is likely for Australian equalization schemes currently operating.

The assumption of a perfectly elastic export demand is an extreme one that greatly simplifies the task of modelling the effects of equalization. In almost every instance the assumption is questionable except in the very long run, and in some instances, such as in the Victorian milk market, it clearly is inappropriate.

Allowing for some slope to export demand modifies the implications of equalization relative to free trade and relative to other policies that might be employed as alternatives to equalization. In most likely situations the effects of equalization on prices, quantities, revenues, and surpluses will be in the directions that would be predicted using an assumption of perfectly elastic export demand. However, an incorrect assumption of perfectly elastic export demand will lead to overestimates of the effects of equalization on the producer price and production, the consumer price and consumption, and exports. While the consumers' surplus loss and producers surplus gain from equalization, relative to free trade, would also be overestimated, the net social cost of equalization relative to free trade would be *underestimated*.

Further, when export demand is less than perfectly elastic, free trade may not be the appropriate benchmark. The costs of equalization relative to the policy that would maximize social surplus are equal to the sum of the costs of equalization relative to free trade and the costs of free trade relative to an optimal export tax. The use of free trade rather than optimal export taxes as a benchmark is an additional source of underestimates of the social costs of equalization in the large country case. The extent and importance of these errors will depend on the size of the error in assuming a perfectly elastic export demand.

The simulation results indicate that equalization significantly stabilizes the producers' price and that the stabilizing effect is greater the greater is the fraction consumed domestically. In the case of eggs, equalization stabilizes all prices, revenues, quantities, and surpluses. For the other commodities, equalization also stabilizes the domestic price, quantities produced, exported and consumed domestically, revenues, and consumer and producer surplus. For wheat and milk, however, two variables are destabilized, the export price and total surplus. These qualitative results are insensitive to the type of equalization scheme (fixed domestic price, fixed absolute domestic markup over export, or fixed percentage markup over export) and insensitive to whether the supply disturbance is additive or multiplicative. For milk, the extent of stabilizing and destabilizing effects depends significantly on the type of equalization scheme.

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Appendix A: Algebraic Formulae and Some Properties

General Model

Using linear equations the general problem can be written as:

(A.1) $P_d = a - b\,Q_d$ (domestic demand),

(A.2) $P_e = c - d\,Q_e$ (export demand),

(A.3) $Q = Q_d + Q_e = e + f\,P_p$ (supply),

where Q_d is quantity sold on domestic market, Q_e is quantity sold on export market, Q is quantity produced, P_d is domestic price, P_e is export price, P_p is producer price, a, c and e are shift parameters, and b, d and f are non negative slope parameters

Price dependent demand equations have been used so that the small country case is readily represented in equation (2) by $d = 0$ and $P_e = c$. Variability can be incorporated into the model by treating the shift parameters, a, c and e, as independent stochastic variables with respective means and variances E(a), E(c), E(e), Var(a), Var(c) and Var(e).

Free Trade

Under conditions of free trade all prices in (A.1), (A.2) and (A.3) are equal so that

(A.4) $P = P_d = P_e = P_p$.

Solving (A.1), (A.2), (A.3) and (A.4) for P and Q:

(A.5) $Q = [e(b+d) + fda + fbc]/(b + d + fbd]$, and

(A.6) $P = (ad + bc - bde)/(b + d + fbd)$.

For the small country case $d = 0$ and in (A.5) $Q = e + fc$ while in (A.6), $P = c$.

We can express the variance of the free trade price and supply as:

$$Var(P) = [d^2Var(a) + b^2Var(c) + b^2d^2Var(e)]/(b+d + fbd)^2$$

$$Var(Q) = [b+d)^2Var(e) + f^2b^2Var(c)]/(b+d + fbd)^2$$

Pool Pricing, Fixed Domestic Price

In (A.1) the domestic price is set at some predetermined level, P_d, and producers are paid a pool price:

$$(A.7)\ P_p = [P_dQ_d + P_eQ_e]/Q = P_e + Q_d(P_d - P_e)/Q.$$

Because P_d is fixed so also Q_d becomes predetermined.

In the small country case we have $P_e = c$, a constant, and the pool price line is a rectangular hyperbola from the domestic price to the horizontal export demand curve. This nice property does not hold with the large country case because the export price falls with greater output. For the large country case, and assuming for convenience $P_d > P_e$ (with the symmetrical argument holding for $P_d < P_e$), the pool price line is downward sloping. However, it does not necessarily converge to the export demand curve as it does in the small country case. Formally, differentiating the formulae for the difference between the pool and export prices,
(i.e. $D = P_p - P_e = Q_d(P_d - P_e)/Q$) gives

$$(A.8)\ \partial D/\partial Q = Q_d[-(P_d-P_e)/Q^2 - (\partial P_e/\partial Q_e)(\partial Q_e/\partial Q)/Q]$$

$$=-Q_dP_e[(P-P_e)/P_e + (Q_e/P_e)(\partial P_e/\partial Q_e)\,(Q/Q_e)]/Q^2$$

$$=-Q_dP_e/[(P_d-P_e)/P_e + (Q/Q_e)/E_e]/Q^2$$

where E_e is the elasticity of export demand. Now from (A.8)

$$\partial D/\partial Q \gtrless 0 \text{ as } (P_d-P_e)/P_e \lessgtr |(Q/Q_e)/E_e|$$

The pool price line is more likely to converge to the export curve with increased quantity: (i) the larger the magnitude of the export demand elasticity with convergence always occurring in the perfectly elastic case, (ii) the greater the percentage mark up of the domestic price over the export price, and (iii) the greater share of output exported.

For instance, suppose 50 per cent of the good is exported ($Q_e/Q = 0.5$) and the domestic price is twice the export price ($(P_d-P_e)/P_e = 1$) so that the markup is 100 per cent. Then the two demand curves would be parallel if the (constant) export demand elasticity were -2, and would be convergent (divergent) with increasing exports if the export demand elasticity were more (less) elastic. With an export share of 80 per cent and 100 per cent markup, the critical value for the export demand elasticity would be -1.25 and with a 20 per cent export share it would be -5. With a 50 per cent export share and a 50 per cent markup the critical export demand elas-

ticity would be -4 and with a 200 per cent markup the critical value would be -0.5. For most existing Australian equalization schemes the parameters are such that the convergent case is likely but the divergent case is possible.

To solve for quantity produced, Q, substitute (A.7) into (A.3)

$$Q = e + fP_e (1 - Q_d/Q) + fQ_dP_d/Q$$

$$= e + f(c - dQ + dQ_d)(1 - Q_d/Q) + fQ_dP_d/Q.$$

Expanding and collecting terms gives:

$$Q(1 + fd) - (e + fc + 2fdQ_d) + fQ_d(c + dQ_d - P_d)/Q = 0$$

Multiplying through by Q gives a quadratic which may be solved as:

$$(A.9)\ Q = \{e+fc + 2fdQ_d \pm \sqrt{[(e+fc + 2fdQ_d)^2}$$

$$- 4(1+fd)fQ_d(c+dQ_d-P_d)] \}/2(1+fd)$$

For the small country case, d = 0, and (A.9) becomes

$$(A.9')\ Q = \{e+fc \pm \sqrt{[(e+fc)^2+4fQ_d(P_d-c)]} \}/2$$

where we note e + fc is the free trade supply defined above (because $P_e = c$). Since supply under equalization exceeds free trade supply (given $P_d > P_e = c$ in the small country case) then only the positive root of (A.9') is relevant and by implication also for (A.9).

Since the formulae for producers' price and quantity supplied involve nonlinear functions of the random variables it is not possible to derive analytical expressions for the variability of these variables due to variation of the intercepts of (A.1), (A.2) and/or (A.3).

Pool Pricing with Domestic Price as a Percentage Markup on Export Price

The domestic price P_d in (A.1) is related to the export price Pe in (A.2) as:

$$(A.10)\ P_d = (1 + x)P_e$$

where x is the proportionate markup factor. Then, the pool price received by producers becomes:

$$(A.11)\ P_p = [P_dQ_d = P_eQ_e]Q = P_e(1 + xQ_d/Q).$$

So long as the domestic demand curve is less elastic than the export demand curve (at ruling domestic and export prices, respectively) the pool price line is both downward sloping and converges towards the export curve. This is because, in (A.11), increased output results in a fall in both the export price (as more is exported) and the domestic share, Q_d/Q (as relatively more of total production is exported). The latter implies that $P_p - P_e = xQ_d/Q$ approaches zero with increased supply.

Obtaining a solution for quantity supplied, Q, involves using (A.10) to substitute out P_d in (A.1), using (A.11) to substitute for P_p in (A.3), and a set of algebraic manipulations (available from the authors) to solve for Q. The resulting quadratic function (similar to that derived with the fixed domestic price situation discussed above) has a general solution:

$$(A.12)\quad Q = \{H_2 \pm \sqrt{(H_2^2 + 4H_1H_2)}\}/2H_1$$

where

$$H_1 = 1 + fbd/[b+d(1+x)] + fx(1+x)bd^2[b+d(1+x)]^2$$

$$H_2 = e + [fcb + fad(1-x)]/[(b+d(1+x)] + 2fdx(1+x)(cb+da)/[b+d(1+x)]^2$$

$$H_3 = [a - (1+x)(cb+da)/\{b+d(1+x)\}]fx(cb+da)/b[b+d(1+x)]$$

When there is free trade, that is the markup term $x = 0$, H_3 is zero and $Q = H_1/H_2$ which becomes the solution described in (A.5) above. This suggests the positive root of (A.12) is taken.

Again, as in the case of pool pricing with a fixed domestic price, the equalized price and output are nonlinear functions of the random terms (a, c and e) and it is not possible to get analytical solutions for the variances.

Price Discrimination with Supply Control

Under this producer profit maximising institutional arrangement, the total quantity is allocated between the domestic and export markets to equate marginal revenues. Using (A.1) and (A.2) marginal revenue in the domestic and export markets, MR_d and MR_e respectively, are set equal to each other, giving:

$$MR_d = a - 2bQ_d = MR_e = c - 2dQ_e$$

which, using $Q = Q_d + Q_e$ can be used to solve for Q_d and Q_e as:

(A.13) $Q_d = (a-c)/2(b+d) + (d/b+d)Q$

(A.14) $Q_e = (c-a)/2(b+d) + (b/b+d)Q$

Under profit maximisation and supply controls we set marginal cost (P_p) equal to marginal revenue:

$P_p = MR_e = MR_d$.

Then, the profit maximising supply can be solved as:

(A.15) $Q = [af(b+d) - f(a-c) - e(b+d)]/[b+d + 2fbd]$.

By combining (A.15) with (A.13) and A.14) equations may be obtained for domestic and export quantities and thus, using (A.1) and (A.2), prices. These are linear functions of the random terms (a, c and e) so variances may be derived.

Price Discrimination with Pool Pricing

Production is allocated so as to maximize producer revenue for any given level of sales. This is achieved by equating marginal revenue and following the market allocation rules (A.13) and (A.14), but producers receive a pool price given by:

(A.16) $P_p = [P_dQ_d + P_eQ_e]/Q = P_e + Q_d(P_d-P_e)/Q$,

and use this pool price in setting production levels via the supply equation (A.3).

The domestic and export prices with price discrimination are determined by substituting (A.13) and (A.14) into (A.1) and (A.2) respectively to give:

(A.17) $P_d = (ab + 2bd + bc)/2(b+d) - bdQ/(b+d)$,

(A.18) $P_e = (2bc + cd + ca)/2(b+d) - bdQ/(b+d)$.

We then substitute (A.14), (A.17) and (A.18) into (A.16) which in turn is substituted into the supply equation (A.3). This gives a quadratic function for Q. The solution for quantity supplied, Q, is:

(A.19) $Q = \{H_5 \pm \sqrt{(H_5^2+4H_4H_6)}\}/2H_4$.

where:

$H_4 = 1 + fdb/(b + d)$,

$H_5 = e + f(2bc + 2da - dc)/2(b + d)$,

$H_6 = f(a - c)^2/4(b + d)$.

Variances cannot be derived in this case. With a similar problem, Myers and Piggott (1981) used log differential measures of variability.

Optimal Export Tax

Under this arrangement, which maximizes returns to the home country, prices, production and sales are set so that marginal revenue on the export market, MR_e, equals price on the domestic market, P_d, and marginal cost of supply, P_p, that is:

(A.20) $MR_e = P_d = P_p = P$.

Solving equations for these expressions we obtain:

(A.21) $P = (bc + 2da)/(b + 2d) - [2db/(b+2d)]Q$,

(A.22) $Q = [(b + 2d)e + 2fda + fbc](b + 2d + 2fdb)$.

Once again, prices and quantities are linear functions of the random terms so analytical solutions for variances may be obtained easily.

Appendix B: Variability of Prices and Quantities

The algebra for the variance of the equalized price is difficult but we can demonstrate the arguments with a much simpler model. Consider the following linear supply and demand model:

(B.1) $Q = aP + u$ (supply),

(B.2) $P = -bQ+v$ (demand; for a small country $b = 0$),

where P is price, Q is quantity supplied and demanded, a and b are positive slope parameters, and u and v are random (horizontal) supply and (vertical) demand shifts with constant means (E(u) and E(v)) and variances (V(u) and V(v)), and zero covariance. Solving for price by substituting equation (B.1) into equation (B.2) yields:

(B.3) $P = (v-bu)/(1+ab)$,

and the variance of price is:

(B.4) $V(P) = [bV(u) + V(v)]/(1+ab)^2$.

Partial differentiation of equation (B.4) with respect to the parameters and underlying variances of supply and demand indicates the effects of changes in these factors on price variability:

$\partial V(P)/\partial V(u) = b^2/(1+ab)^2 > 0$,

$\partial V(P)/\partial V(v) = 1/(1+ab)^2 > 0$,

$\partial V(P)/\partial a = -2bV(P)/(1+ab) < 0$,

$\partial V(P)/\partial b = [2bV(u)-2aV(v)]/(1+ab)^3 \gtrless 0$.

Solving for quantity by substituting equation (B.2) into equation (B.1) yields:

(B.5) $Q = (av+u)/(1+ab)$,

and the variance of quantity is:

(B.6) $V(Q) = [a^2V(v)+V(u)]/(1+ab)^2$.

Partial differentiations of (B.6) with respect to parameters and underlying variances indicates the effects of changes in these factors on quantity variability:

$$\partial V(Q)/\partial V(u) = 1/(1+ab)^2 > 0,$$

$$\partial V(Q)/\partial a = a^2/(1+b)^2 > 0,$$

$$\partial V(Q)/\partial a = [2aV(v)-2bV(u)]/(1+ab)^3 \gtrless 0,$$

$$\partial V(Q)/\partial b = -2aV(Q)/(1+ab) < 0.$$

These results are summarised in Table B.1. An increase in either the variability of supply [V(u)] or the variability of demand [V(v)] increases the variability of both price and quantity. An increase in the *supply elasticity* (increase in a) will unambiguously reduce the variance of price but may increase or reduce quantity variability depending on the relative elasticities of supply and demand and supply variability relative to demand variability. In the extreme case where either supply is perfectly inelastic or demand variability is zero, quantity variability unambiguously increases with increases in the supply elasticity. An increase in the *demand elasticity* (decrease in b) will unambiguously increase quantity variability but may increase or reduce price variability.

Table B.1: Effects of Different Factors on Variability of Price and Quantity

Effect of:	Price Variability	Quantity Variability
Greater variability of demand V(v)	+	+
Greater variability of supply V(u)	+	+
More elastic supply (greater a)	-	-/+
More elastic demand (smaller b)	-/+	-

Appendix C:The Simulation Model

The simulation model includes independent linear equations for domestic demand, export and supply for a hypothetical commodity, defined as follows:

(C.1) $Q_d(t) = a - bP_d(t)$ (domestic demand),

(C.2) $Q_e(t) = c - d[P_e(t) - u(t)]$ (export demand),

(C.3) $Q(t) = e + fP_p^*(t) + v(t)$ (supply), and

(C.4) $Q(t) = Q_d(t) + Q_e(t)$ (market clearing).

In time t, $Q_d(t)$, $Q_e(t)$ and $Q(t)$ are quantities consumed domestically, exported and total production; $P_d(t)$ and $P_e(t)$ are domestic and export prices; $P_p^*(t)$ is the producers' expected price; u(t) is a random vertical shift in export demand and v(t) is a random horizontal shift in supply; and a, b, c, d, e and f are non-negative parameters.

The intention is to compare the effects of equalization and free trade under a range of market and policy assumptions. The first step is to define the parameters of the model using assumptions about elasticities, market shares, and the distortion in prices caused by equalization. To do this we assume arbitrarily that, with equalization, in static equilibrium (with the random terms u(t) and v(t) equal to zero), the producers' expected (and actual) equalized price (P_p) and output (Q) would be 100 units. Then the parameters of the supply function are defined as functions of the elasticity of supply (E_s):

(C.5) $e = 100(1-E_s)$; $f = E_s$.

The domestic price is defined by choosing a markup (M) over the producers' price:

(C.6) $P_d = P_p + M = 100 + M$.

The quantity consumed by the domestic market at this price (Q_d) is equal to an assumed domestic market percentage ($k_d = 100\ Q_d/Q = Q_d$) and lies between zero and 100. Then the parameters of domestic demand are equal to:

(C.7) $a = Q_d(1-E_d)$; $b = -E_d(Q_d/P_d)$.

where E_d equals the assumed value for the elasticity of domestic demand.

Exports are equal to output (Q = 100) minus domestic consumption ($Q_e = 100-Q_d$) and, since the equalized price ($P_p = 100$) is a weighted average of the domestic and export prices, the export price is defined as:

(C.8) $P_e = (10000 - Q_dP_d)/(100 - Q_d)$,

that is the export price equals export revenue (total revenue minus domestic market revenue), divided by the export quantity. Then, the parameters of export demand are defined using the elasticity of export demand (E_e) as:

(C.9) $c = (100 - Q_d)(1-E_e)$; $d = -E_e(100-Q_d)/P_e$.

Thus for each set of assumptions about the elasticities of supply and demand, the domestic market share, and the extent of the domestic price distortion caused by the policy, we have a different set of parameters of supply and demand.

Producers' price expectations are assumed to be formed adaptively according to:

(C.10) $P_p^*(t) = BP_p(t-1) + (1-B)P_p^*(t-1)$

where P_p^* is the expected producer price P_p is the actual producer price, and B is the co-efficient of expectations that lies between zero and one.

Values for the shift terms (u(t) and v(t)), are drawn independently at random from a normal distribution with a mean of zero and truncated at plus and minus two standard deviations, using a range of standard deviations. Then, for each set of parameters, after initialising the recursive process with static solutions, the series of supply and export demand shifts (u(t) and v(t)), are used to generate series of stochastic free trade and equalization equilibriums.

For each iteration, quantity supplied is predetermined (at different levels for the two policies). The free trade price is computed according to:

(C.11) $P_p(t) = P_d(t) = P_e(t) = [a+c+du(t) - Q(t)]/(b+d)$

The associated quantities demanded are determined by substituting this price into equations (C.1) and (C.2).

With equalization both the domestic price and quantity are predetermined by assumption. Output is determined through equation (C.3), as a function of the expected price (a function of lagged prices) and random shifts of supply.

Exports are equal to the difference between output and domestic consumption ($Q_e(t) = Q(t)-Q_d(t)$ so that the export price is defined as:

(C.12) $P_e(t) = u(t) + [c - Q_e(t)]/d$

Then the equalized price for the current iteration, to be used to define the expected producer price in the next iteration, is:

(C.13) $P_p(t) = [P_d(t)Q_d(t) + P_e(t)Q_e(t)]/Q(t)$.

Total, export and domestic market revenues are computed using these prices and quantities. Total consumers' surplus for each iteration (t) with each policy (i) is computed as:

(C.14) $C(i,t) = 0.5\ Q_d(i,t)\ (a/b - P_d(i,t))$.

Producers' surplus is slightly more complicated. It is computed as ex post (actual) revenue minus ex ante (planning) costs. Actual revenue is $R_p(i,t) = P_p(i,t)\ Q(i,t)$. Ex ante costs are computed as the area beneath the planning supply curve (i.e. with the supply shift at its expected value of zero) up to planned output (the quantity that would be produced if the supply shift was zero: $Q^*(i,t) = Q(i,t) - v(t)$.

Different formulae are used to compute costs and thus producers' surplus, depending on whether the supply elasticity is greater or less than unity. In cases when the supply elasticity is greater than or equal to unity, producers' surplus for each policy (i) and iteration (t) is computed as:

(C.15) $PS(i,t) = R_p(i,t) - 0.5[P_p^*(i,t) - (e/f)]Q^*(i,t)$.

When the supply elasticity is less than unity the formula is:

(C.16) $PS(i,t) = R_p(i,t) - 0.5\ f\ P_p^*(i,t)^2$.

Total domestic surplus is computed as the sum of domestic producers' and consumers' surpluses:

(C.17) $TS(i,t) = PS(i,t) + CS(i,t)$.

For each set of parameters and each of the policies two thousand iterations with random shifts were performed and then the last thousand sets of estimates were used to compute means and variances of prices, quantities, revenues, and surpluses. The program is available from the authors.