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SOME OLD TRUTHS REVISITED*

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The primary objective in this paper is to 'promote' the use of equilibrium displacement modelling, or comparative static analyses of general function models, as a research tool in agricultural price and policy analyses. This is by no means a new tool, but it does seem to be used much less in Australia than it is in the US where it has been the basis of several important journal papers in recent times. The paper includes applications to: (a) reproduce important results obtained by Buse (1958) regarding total elasticities; and (b) examine the price premium argument that has been advanced in favour of single-desk selling arrangements. The latter is the secondary objective in the paper. Whilst equilibrium displacement modelling has its shortcomings, it is a research tool that can provide useful results with few assumptions. It can be a substitute for econometric modelling when resource and time constraints are binding. The application to the price-premium argument re-confirms the doubts that many analysts have expressed about single-desk selling.

Introduction

Several important papers in the area of agricultural price and policy analysis published over the last decade or so have been based on results derived from comparative static analyses of general function models.[1] The general features of this type of analysis are: (a) a particular market situation is characterised by a set of supply and demand (and perhaps other) functions that are general in the sense that no particular functional forms are assumed; (b) the market is disturbed by a change in the value of some exogenous variable; and (c) the impacts of the disturbance are *approximated* by functions which are linear in elasticities. The procedure is also termed 'equilibrium displacement modelling' (EDM), which is the term that will be used here, and

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[1] Examples include Gardner (1975), Gardner (1979), Perrin (1980), Perrin and Scobie (1981), Mullen, Wohlgenant and Farris (1988), Holloway (1989), Hertel (1989), Mullen, Alston and Wohlgenant (1989), Wohlgenant and Haidacher (1989), Thurman and Wohlgenant (1989), Alston (1991), Hertel (1991), Holloway (1991) and Scobie, Mullen and Alston (1991).

sometimes 'Muth modelling', this being the procedure used in the important paper by Muth (1964).

The procedure is certainly not new insofar as it involves comparative statics. Indeed, some would argue that assigning it a title other than 'comparative statics' is unnecessary. However, EDM as used in recent papers does differ from comparative statics as generally outlined in standard mathematical economics texts (e.g. Chiang 1984). In the latter, the comparative statics usually involves the use of calculus to indicate the direction of change in an endogenous variable following a change in an exogenous variable, allowing for general equilibrium effects to occur. With EDM, there is more attention given to finite changes in exogenous variables and changes in both endogenous and exogenous variables are measured in proportionate terms or as ratios of proportionate changes (i.e. elasticities). Hence, it is a distinctive form of comparative statics that warrants a title such as 'EDM'.

The primary purpose in this paper is to encourage greater use of EDM. This is attempted by two simple applications of EDM: the first entails a re-examination of the results obtained in the important Buse (1958) paper, while the second relates to an issue of contemporary debate, namely, the price-premium argument that has been advanced in favour of single-desk selling arrangements in the marketing of Australian agricultural products. The evaluation, albeit partial, of this argument is a subsidiary objective in the paper.

It is emphasised that the applications of EDM that have appeared in the professional literature are generally more sophisticated than are the applications presented in this paper. For example, several of the applications in the literature involve modelling vertical market relationships, such as the distribution of research benefits among participants at different market levels (see, for example, Alston 1991), whereas the applications in this paper are all to do with simple horizontal market relationships involving two commodities that are related in demand and supply. However, the applications used in this paper suffice to demonstrate the usefulness of EDM, and that adjustments from one market equilibrium situation to another involve complex relationships.

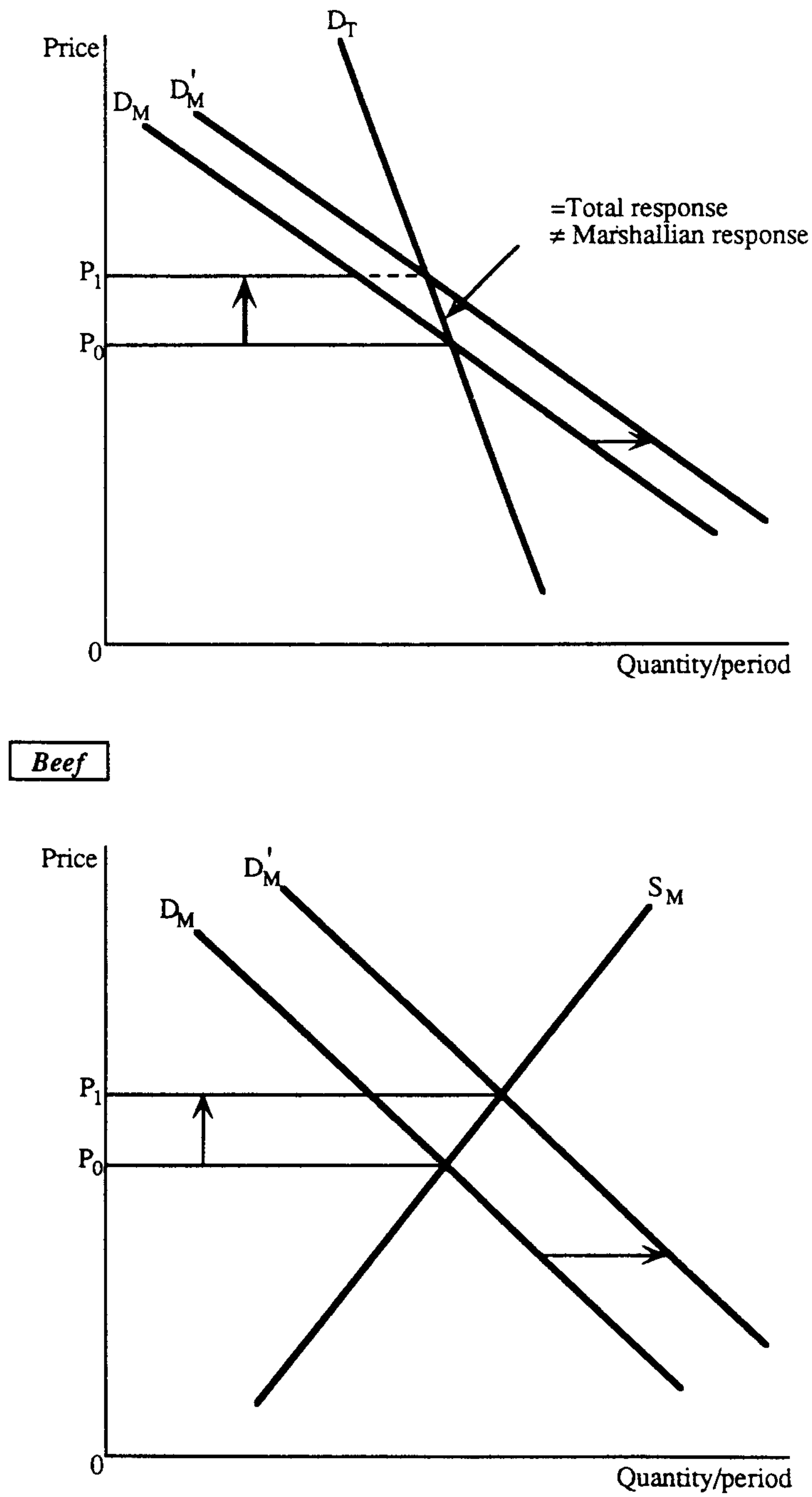
In the next section the Buse (1958) model is revisited. Thence follows an evaluation of the price premium argument, followed by a discussion of strengths and weaknesses of EDM. The paper ends with a summary and conclusions.

Buse Revisited

The aim in the Buse (1958) paper was clear: to demonstrate that the predicted change in the quantity supplied and demanded of a commodity in response to a change in its exogenously-determined price will be different when account is taken of cross-commodity feedback effects (these will be referred to here as 'general equilibrium effects') than in the case where the prediction is based on Marshallian (i.e.

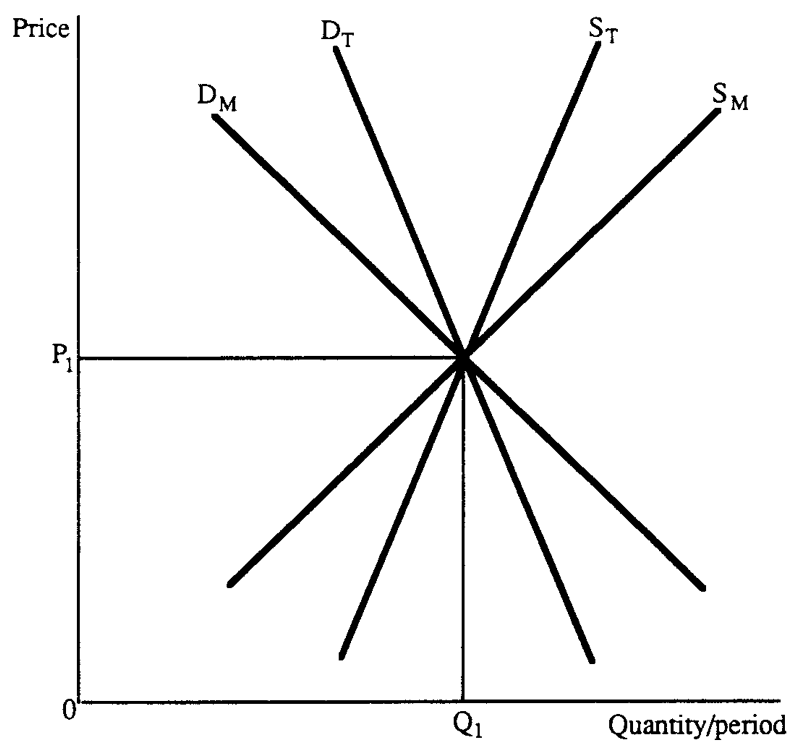
FIGURE 1

Deriving Total Demand Response for Pork



ceteris paribus or partial) elasticities that assume other prices remain constant. He derived what he called 'total' demand and supply elasticities that take into account general equilibrium effects and showed how they are related to Marshallian elasticities. Referring to Figure 1, suppose pork and beef are substitutes in demand and that the government increases the price of pork from P_0 to P_1 through stock control. This causes the demand for beef to shift to the right and the price of beef increases from P_0 to P_1. In turn, this causes the demand for pork to shift rightward. Thus, the adjustment in pork demand in response to the initial price change is from a point on D_m to a point on D_m'. The locus connecting these points, D_T, is what Buse termed the 'total demand response function' and the total demand elasticity is measured from this locus. Analogous reasoning can be applied to the supply side of the market assuming pork and beef are substitutes in supply and this leads to the concept of a 'total supply response' function and its associated total supply elasticity. The configuration of total and Marshallian demand and supply functions is shown in Figure 2. Elasticities measured from the total response functions are smaller in absolute value than those measured from the initial Marshallian demand and supply functions.

FIGURE 2
Configuration of Marshallian (M) and Total (T) Demand and Supply Response Functions



The general equilibrium effects referred to are those which are due to relatedness of commodity demands and/or supplies that is due, in turn, to substitution and complementarity. There is plenty of empirical evidence that indicates relatedness in agricultural commodity markets. In the case of Australia, a leading example on the supply side is provided by competitive resource allocation among broad-area agricultural enterprises, with wool, meats and grains generally being competitive (or substitutes) in supply (see Johnson, Powell and Dixon 1990 for estimates of own- and cross-price elasticities) and, on the demand side, by substitution among meats (see MacAulay, Niksic and Wright 1990 for a summary of the empirical evidence). In the case of developing countries, one often finds that basic food commodities such as rice, corn, cassava and groundnuts are related in both demand and supply.

Buse's results have considerable conceptual significance; for example, the Marshallian own-price elasticity coefficient can be in the relatively elastic range and the total elasticity in the relatively inelastic range. One would reach different conclusions as to, say, the directional movement in total revenue following a price change depending on which elasticity was used for prediction purposes. Some would argue that the practical significance of his results is not so great because, given our dependence on secondary data generated in a *mutatis mutandis* world, it is unlikely that one would ever be able to estimate demand and supply elasticities that are truly partial elasticities; rather, the estimated elasticities are more likely to be hybrids of partial and total elasticities. Nevertheless, the conceptual difference is real and it seems reasonable that it be incorporated in our analytical thinking.

Buse (1958) derived his results by manipulating an explicit simultaneous system of demand and supply functions for two commodities. The system was explicit in that the functions were assumed to be linear in logarithms. An alternative way of deriving Buse's results is through the use of an EDM with no assumptions about functional forms. In general functional form, Buse's model can be written as:

$$(1)\qquad \begin{cases} D_1 = D_1(P_1, P_2, W) \\ S_1 = S_1(P_1, P_2, X) \\ D_2 = D_2(P_1, P_2, Y) \\ S_2 = S_2(P_1, P_2, Z) \\ D_2 = S_2 = Q_2 \end{cases}$$

where

P = price;
D = quantity demanded;
S = quantity supplied;
Q = equilibrium quantity;
W, X, Y, Z = exogenous shift variables; and
$1, 2$ = subscripts denoting commodities 1 and 2.

The endogenous variables are D_1, S_1, Q_2 and P_2 (P_1 being determined by government and enforced through stock control).

Buse was particularly interested in the impact of a change in P_1 on the equilibrium values of D_1 and S_1 (and their difference which represents excess supply). These impacts are conveniently represented by total elasticities. As shown in Appendix 1, a set of general equilibrium elasticities (one for each endogenous variable) is obtained as the solution to the matrix equation:

$$(2) \qquad \begin{bmatrix} -1 & 0 & 0 & \eta_{12} \\ 0 & -1 & 0 & \varepsilon_{12} \\ 0 & 0 & -1 & \eta_{22} \\ 0 & 0 & -1 & \varepsilon_{22} \end{bmatrix} \begin{bmatrix} G(D_1, P_1) \\ G(S_1, P_1) \\ G(Q_2, P_1) \\ G(P_2, P_1) \end{bmatrix} = \begin{bmatrix} -\eta_{11} \\ -\varepsilon_{11} \\ -\eta_{21} \\ -\varepsilon_{21} \end{bmatrix}$$

where

η_{ij} (ε_{ij}) = the Marshallian price elasticity of demand (supply) of commodity i with respect to the price of commodity j ($i, j = 1,2$); and

$G(v,P_1)$ = the general equilibrium (or total) elasticity of endogenous variable v($v = D_1, S_1, Q_2, P_2$) with respect to P_1.

Buse's total elasticities correspond to $G(D_1, P_1)$ and $G(S_1, P_1)$ which, by application of Cramer's rule, are given by:

$$(3) \qquad G(D_1, P_1) = \eta_{11} + \eta_{12}\ G(P_2, P_1)$$

and

$$(4) \qquad G(S_1, P_1) = \varepsilon_{11} + \varepsilon_{12}\ G(P_2, P_1)$$

where

$$(5) \qquad G(P_2, P_1) = (\varepsilon_{21} - \eta_{21})/(\eta_{22} - \varepsilon_{22})\ .$$

These results generalise to the case of several commodities related in demand and/or supply.

It may be possible to make qualitative statements about the sign and magnitude of the total elasticities once assumptions are made about the sign and magnitudes of the Marshallian elasticities (see Buse 1958, p. 890). For example, if the two commodities are substitutes in both supply and demand, $G(P_2, P_1)$ is positive and, with cross-price elasticities less in magnitude than own-price elasticities, it would be less than unity. Hence, $G(D_1,P_1)$ and $G(S_1,P_1)$ would be less elastic than, and of the same sign as, their Marshallian counterparts.

Clearly, ignoring general equilibrium effects when predicting adjustment to an own-price change will be of greater consequence the larger are cross-price elasticities relative to own-price elasticities. By the homogeneity condition of demand theory, this condition would be true for a commodity that has close substitutes in demand but a low income elasticity of demand.

Whilst Buse was only concerned with the elasticities given by equations (3), (4) and (5), other elasticities with respect to P_1 can be defined (see Appendix). For example, the total cross-price elasticity of demand and supply of commodity 2 with respect to the price of commodity 1 is given by:

$$(6)\qquad \begin{cases} G(Q_2, P_1) = \eta_{21} + \eta_{22}\, G(P_2, P_1) \\ \qquad\qquad\quad\; = \varepsilon_{21} + \varepsilon_{22}\, G(P_2, P_1)\,. \end{cases}$$

(For precision, the elasticities defined in (3) and (4) could be termed 'total own-price elasticities'). Examples of the application of this concept in the Australian context would include measuring the total response in the equilibrium quantity of manufacturing milk supplied and demanded following a change in the administered price of market milk, or measuring the impact of a change in the exogenously-determined export price of some commodity on the equilibrium quantity of some related, non-traded commodity. The sign of $G(Q_2,P_1)$ is ambiguous if commodities 1 and 2 are substitutes (or complements) on both sides of the market because the Marshallian demand and supply functions for commodity 2 move in opposite directions in response to a change in the price of commodity 1.

As shown in Appendix 1, EDM can also be used to derive general equilibrium elasticities for each endogenous variable with respect to any exogenous variable. It is worth noting that, when the Buse model is altered to make P_1 endogenous (i.e. the model becomes one in which demand and supply for each commodity determine their prices), general-equilibrium elasticities for the quantities traded of each commodity can be expressed as functions of Marshallian own-and cross-price elasticities and the general-equilibrium price elasticities. For example,

$$(7)\qquad G(Q_1, W) = \varepsilon_{11}\, G(P_1, W) + \varepsilon_{12}\, G(P_2, W)$$

or

$$(8)\qquad G(Q_1, W)/G(P_1, W) = \varepsilon_{11} + \varepsilon_{12}\, [G(P_2, W)/G(P_1, W)\,]$$

where Q_1 is the equilibrium quantity traded of commodity 1. Note the similarity of (8) to (3) and (4). It can be shown (Alston 1992, pers. comm.) that the Buse results can be derived as a special case of a model in which the price of commodity 1 is endogenous and the own-price elasticity of demand for commodity 1 approaches infinity.

Buse (1958) acknowledged that important analytical results governing multi-market equilibria had been known for some time, the basic relationships having been outlined by Hicks (1939). Notwithstanding this, Buse's paper was an important contribution in that it highlighted precisely how the own- and cross-price elasticities interact, with the application being to agricultural commodity markets where there are clearly some strong cross-market relationships. EDM provides a convenient framework for deriving the relationships involved irrespective of underlying functional forms.

Single-Desk Selling

A contemporary issue in debate about Australia's agricultural marketing arrangements is the efficacy of single-desk selling arrangements, especially in relation to export selling. The issue has been investigated, for example, in Industries Assistance Commission (now Industry Commission) inquiries into the rice industry (Industries Assistance Commission 1987), the wheat industry (Industries Assistance Commission 1988), the dried vine fruits industry (Industries Assistance Commission 1989) and statutory marketing arrangements (Industry Commission 1991). Department of Primary Industries and Energy (DPIE) Minister Crean, in an address to the Victorian Rural Press Club, challenged the Australian Wheat Board to demonstrate why its single-desk seller status was necessary (Anon. 1991) and DPIE Secretary Miller has made reference to 'the old days when growers still believed in single-desk selling' (Miller 1991). The AWB's monopoly on wheat exports has received much publicity throughout 1992.

Proponents of single-desk selling arrangements try to justify them on one or more of several grounds. They include, for example, the opportunity to extract price premia in some markets, the need to countervail buying power, the need to undertake product promotion, the preference of some centralised importing agencies to deal with a statutory authority and the need to assure quality. These arguments have been questioned in debate on the issue (especially in the various inquiries mentioned above). The aim in this section is to demonstrate how EDM can be used to assess the validity of what has probably been the main plank in the platform of those who have argued for single-desk selling; namely, the price premium argument.

The essence of the price premia argument for single-desk selling arrangements is that, through controlling the flow of exports to a particular market by having a single Australian seller into those markets, higher prices can be obtained than those obtained in the absence of a single-seller arrangement. Underpinning the argument is the view that Australia has 'market power' in the markets concerned. Evaluation of the argument based on experience is difficult for three reasons. First, where a statutory body has enjoyed single-seller status for a long time, as in the case of wheat and rice, there is no basis for comparisons with a situation of multiple Australian sellers. Second, the type of data one would wish to have to attempt a direct test of the argument (i.e. detailed data on prices received in various markets) would be regarded as being commercially confidential. Third, there is the problem of disentangling price premia that are attributable solely to market power from those that are due to other considerations such as quality and any special conditions associated with a sale (e.g. credit arrangements). At least part of the price premia attributable to this latter source represents a return that is necessary to cover the costs of services embodied in particular sales, and is not a rent to be returned to producers of the primary product. Nevertheless, it is important to evaluate the price-premium argument (as well as others) advanced for single-desk selling because there are potential disadvantages associated with having such an arrangement, including lack of competitive discipline in the provision of the selling function.

The Industry Commission (1991, pp. 48-49), in its report on statutory marketing arrangements, concluded as follows:

> 'There are doubts about whether Australian agricultural commodities fulfil the necessary requirements which allow export controls to achieve market power premiums on overseas markets. Notwithstanding these doubts, to the extent that any increased return to producers from export sales could be achieved through controlling export sales, it would benefit Australia's domestic economy. From Australia's viewpoint, the market power premium would involve income transfers from overseas consumers to the domestic economy.
>
> However, export licensing or single-desk selling themselves can impose costs, since they limit market entry and can prevent competitive pressures from ensuring that sales into premium markets are undertaken at least cost. Administering and policing export controls also are not costless. Thus the objective of capturing a market power premium on export markets through controls on competitive access would only be sound if any extra costs imposed by those controls were less than the extra income obtained'.

The recent spate of debate about market power and single-desk selling arrangements is certainly not the first time these issues have been raised. Earlier Australian studies relevant to the issue include, for example, Freebairn and Gruen (1977) and Smith (1977), and in both of these studies reservations are expressed about the gains attributable to market power which are to be had from single-desk selling into export markets. In contrast, Rae (1988) is of the view that the single-desk selling arrangement for New Zealand apples and pears helped that industry out-perform its Australian counterpart during the 1970s and 1980s, and this was partly because of market-power considerations.

What can EDM contribute to the debate? It seems clear that evaluation of market power and the benefits it may offer to Australian exporters has to be evaluated on a case-by-case basis. While generally Australian sellers might have limited power in export markets, there may be particular markets where they do. However, the characteristics of the market setting, such as whether there is an alternative source of supply other than Australian product and the existence and strengths of cross-relationships in demand and supply, are likely to vary across export markets. Hence, there is not a single multi-market commodity model which will be universally applicable to the analysis of market power and the gains from single-desk selling.

The following model characterises one plausible scenario. It represents the demand and supply situation for two commodities, 1 and 2, in the hypothetical Republic of Allaru. While Allaru has a self-sufficiency policy for commodity 2 (its domestic price fluctuates so as to balance domestic demand and domestic supply), it imports the balance of its commodity 1 requirements only from Australia, perhaps because of transport cost considerations. In algebraic form, the model is:

$$(9)\qquad \begin{cases} D_1 = D_1(P_1, P_2, W) \\ S_1 = S_1(P_1, P_2, X) \\ D_2 = D_2(P_1, P_2, Y) \\ S_2 = S_2(P_1, P_2, Z) \\ M_1 = D_1 - S_1 \\ D_2 = S_2 = Q_2 \end{cases}$$

where the notation is as previously defined, with M_1 added to denote imports.

A critical assumption is that M_1 is controlled by an Australian exporting agency, either through acting as a single-desk seller or allocating export licenses. An implication of this assumption is that the Australian exporting agency can influence the price of wheat in Allaru (by varying M_1) and this is the essence of the price-premium argument advanced by proponents of single-desk selling.

How much market power does Australia have in this case? The answer can be found through applying the procedures outlined in Appendix 1. What is required is a measure of the sensitivity of P_1 to changes in M_1. However, it will be useful for our purposes to examine the sensitivity of all the endogenous variables in the two-market model with respect to M_1. That information can be obtained as the solution to the matrix equation:

$$(10)\qquad \begin{bmatrix} 1 & 0 & -\eta_{11} & \eta_{12} \\ D_1 & 0 & -\varepsilon_{11}S_1 & -\varepsilon_{12}S_1 \\ 0 & 1 & -\eta_{21} & -\eta_{22} \\ 0 & 1 & -\varepsilon_{21} & -\varepsilon_{22} \end{bmatrix} \begin{bmatrix} G(D_1, M_1) \\ G(Q_2, M_1) \\ G(P_1, M_1) \\ G(P_2, M_1) \end{bmatrix} = \begin{bmatrix} 0 \\ M_1 \\ 0 \\ 0 \end{bmatrix}$$

where the notation is as previously defined.

The key result which gives an indication of market power is the value of $G(P_1, M_1)$, which can be termed the 'total price flexibility of P_1 with respect to M_1'. It measures the percentage change in P_1 following a one per cent change in imports after allowing for general equilibrium effects. Using Cramer's rule, its value is given by

$$(11)\qquad G(P_1, M_1) = (\varepsilon_{22} - \eta_{22}/d_1)$$

where

(12) $$d_1 = [\varepsilon_{21} - \eta_{21}]\,[(r-1)\,\varepsilon_{12} - r\eta_{12}] - [\varepsilon_{22} - \eta_{22}]\,[(r-1)\,(\varepsilon_{11} - r\eta_{11})]$$

$= \text{determinant of the LHS matrix in (10); and}$

(13) $$r = D_1/M_1 \quad (>1).$$

Assuming own-price elasticities exceed cross-price elasticities in absolute value (i.e. $|\eta_{ii}| > |\eta_{ij}|$ and $|\varepsilon_{ii}| > |\varepsilon_{ij}|$), d_1 is negative and, hence, $G(P_1,M_1)$ is negative as expected.

One thing that is clear is that, when trying to gauge the impact on price of Australia's exports to Allaru, account needs to be taken not only of the demand elasticity for the product within Allaru (i.e. η_{11}), but also of cross-demand elasticities, own-and cross-price supply elasticities, as well as the ratio of demand to imports. This is intuitively obvious. But the advantage of approaching the issue of market power in the manner demonstrated here is that it shows precisely how different parameters affect the degree of influence Australian exports have on price.

TABLE 1

Signs of Partial Derivatives of $G(P_1, M_1)$[a]

Partial with respect to	Sign
η_{11}	*−ve*
η_{12}	*−ve*
η_{22}	*−ve*
η_{21}	*−ve*
ε_{11}	*+ve*
ε_{12}	*+ve*
ε_{22}	*+ve*
ε_{21}	*+ve*
r	*+ve*

[a] $G(P_1, M_1)$ is the total price flexibility of P_1 with respect to M_1 and is negative. It is assumed that commodities 1 and 2 are substitutes in demand and supply. Consider, for example, the negative partial derivatives of $G(P_1, M_1)$ with respect to η_{11} and η_{21}. An *increase* in η_{11} (which is negative) means a less elastic Marshallian demand and a less elastic general equilibrium demand. Hence $G(P_1, M_1)$ becomes larger in absolute terms or *smaller* in real terms. An increase in η_{12} (which is positive) means a greater cross-price elasticity and hence a more inelastic general equilibrium demand function and a *smaller* (in real terms) value of $G(P_1, M_1)$.

The signs of the partial derivatives of $G(P_1, M_1)$ for the cases where commodities 1 and 2 are substitutes in both demand and supply are shown in Table 1. The economic logic underlying the signs of the partial derivatives will be apparent when it is borne in mind that, in examining the equilibrium displacement effects of changes in imports, we are working with general-equilibrium supply and demand functions. The presence of substitution relationships makes these functions more inelastic than their Marshallian counterparts. The stronger the substitution relationships, the more inelastic are the general-equilibrium supply and demand functions relative to their Marshallian counterparts and, hence, the greater are the price impacts of a given reduction in imports.

The importance of the strength of the substitution relationships is also verified when the adjustment to a change in imports is considered in a sequential fashion. When the level of imports changes, the price of commodity 1 changes and this, in turn, causes the price of commodity 2 to change. This leads to further change in the price of commodity 1. The degree of 'price transmission' from commodity 1 to commodity 2 is given by:

$$(14) \qquad G(P_2, M_1)/G(P_1, M_1) = (\varepsilon_{21} - \eta_{21})/(\eta_{22} - \varepsilon_{22}),$$

as was the case in the Buse model.

The logic of the positive sign of the derivative with respect to r $(=D_1/M_1)$ is that, ceteris paribus, a higher value for r means that the Australian seller is satisfying a smaller proportion of Allaru's demand requirements for commodity 1 and, hence, Allaru's (excess) demand for Australian exports is more elastic. A given change in imports from Australia will, therefore, have a smaller impact on price (i.e. the real value of $G(P_1, M_1)$ is greater).

Values of $G(P_1, M_1)$ corresponding to various combinations of values of its arguments are shown in Table 2. Note that the measure of market power is inversely related to the Marshallian elasticities and the ratio of demand to imports. The numbers in parentheses show the percentage change in P_1 with respect to a one per cent change in M_1 when general-equilibrium effects are ignored. The implications of ignoring general equilibrium effects are significant in percentage terms, with the degree of market power being underestimated by about 30 per cent.

Notwithstanding this underestimation, the general picture that emerges from the sensitivity analysis shown in Table 2 is that the price in Allaru is relatively inflexible with respect to Australian exports (i.e. market power is weak) and that the extent of market power is highly sensitive to Australia's relative share of the Allaru market for commodity 1. We should keep in mind that Australia's market share will fluctuate through time in response to shifts in Allaru's Marshallian demand and supply functions for *both* commodities 1 and 2.

TABLE 2

Percentage Increase in Price of Commodity 1 Associated with a One Per Cent Reduction in Imports of Commodity 1 for Different Parameter Combinations[a]

Supply Elasticities	Demand Elasticities			
	Base	Base x 2	Base x 3	Base x 4
	.... r = 1.333			
Base	1.45 (1.03)	0.81	0.57	0.43
Base x 2	1.21	0.73	0.52	0.41
Base x 3	1.04	0.66	0.48	0.38
Base x 4	0.91	0.60	0.45	0.36 (0.26)
	.... r = 2.0			
Base	0.82 (0.59)	0.49	0.35	0.27
Base x 2	0.62	0.41	0.31	0.25
Base x 3	0.50	0.35	0.27	0.22
Base x 4	0.42	0.31	0.25	0.21 (0.15)
	.... r = 4.0			
Base	0.36 (0.26)	0.23	0.17	0.13
Base x 2	0.25	0.18	0.14	0.11
Base x 3	0.19	0.15	0.12	0.10
Base x 4	0.16	0.13	0.10	0.09 (0.06)

[a] Base demand elasticities are $\eta_{11} = -0.6$, $\eta_{12} = 0.4$, $\eta_{22} = -0.4$ and $\eta_{21} = 0.2$; base supply elasticities are $\varepsilon_{11} = 0.5$, $\varepsilon_{12} = -0.3$, $\varepsilon_{22} = 0.4$ and $\varepsilon_{21} = -0.15$; the demand and supply elasticities are parameterised by multiplying all the base values by 2, 3 and 4; $r = D_1/M_1$; the numbers in parentheses are the percentage price changes when general equilibrium effects are ignored.

As a next step one can investigate how ability to influence the price in Allaru translates into ability to increase the revenue obtained from a given quantity of Australian exports. To do this, assume that the demand for Australian exports of commodity 1 in all other markets is perfectly elastic at some price level P_w. Then,

(15) $$R_1 = P_1M_1 + P_w Q^* \; P_w M_1$$

where

R_1 = total export revenue earned from commodity 1; and

Q_1^* = total Australian exports of commodity 1 to all markets.

Differentiating (15) with respect of M_1 and converting to elasticities yields:

(16) $$G(R_1, M_1) = [(P_1M_1/R_1)] \, [1 + G(P_1, M_1)] - [P_w M_1/R_1]$$

which is the general-equilibrium elasticity of R_1 with respect to M_1.

Suppose, initially, that $P_1 = P_w$ (i.e. Australia does not try to exercise market power in its sales to Allaru). Then:

(17) $$G(R_1, M_1) = (M_1/Q_1^*)\, G(P_1, M_1).$$

For example, if sales to Allaru accounted for 20 per cent of exports and $G(P_1, M_1) = -1.5$, then $G(R_1, M_1) = -0.3$. A one per cent reduction in exports to Allaru, compared to the situation where Australia does not exploit market power, would cause total export receipts to increase by 0.3 per cent.

Suppose there are n markets for commodity 1 where Australia has some market power, that these markets cannot be arbitraged by other traders and that Australia faces a perfectly elastic demand in all other markets at price P_w. It can be shown that, compared with the situation where the price in all markets initially equals P_w, the revenue impact of reductions in exports is as follows:

(18) $$ER_1 = \sum_i s_{1i}\, EM_{1i}\, G(P_{1i}, M_{1i})$$

where $ER_1 = dR_1/R_1$;

$s_{1i} =$ proportion of total exports of commodity 1 going to market i;

$EM_{1i} = dM_{1i}/M_{1i}$;

$G(P_{1i}, M_{1i}) =$ total price flexibility of commodity 1 in market i with respect to Australian exports; and

$i = 1,\ldots,n$.

The percentage increases in export revenue for the situation where Australia has market power in two export markets that, together, account for 20 per cent of Australian exports, are shown in Table 3. Of course, it is not known how important 'premium' markets are in terms of their percentage share of Australian exports of commodities such as wheat or rice, but a reasonable expectation is that a figure of 20 per cent would be an upper limit. As well, the values of the total price flexibilities used in the calculations for Table 3 (–0.5 to –1.5) may well overstate actual market power.

In panel (i) of Table 3, the percentage decreases in imports in both markets have been set at five per cent. The point to note is that, even when the prices received are quite sensitive to imports from Australia, the percentage increase in overall export revenue is minuscule. In panels (ii) and (iii), the percentage reductions in imports in each market differs. The further point to note from those figures is that, not only is the percentage increase in overall export revenue generally small, but it is also sensitive to the pattern of reduction in imports in different markets.

TABLE 3
Percentage Increase in Total Export Revenue from Reducing Exports to Two Markets Accounting for 20 Per Cent of Australian Exports

$G(P_{12}, M_{12})$	$G(P_{11}, M_{11})$		
	−0.5	−1.0	−1.5
	.... (i) 5% reduction in M_{11} and M_{12}		
−0.5	0.50	0.87	1.25
−1.0	0.63	1.00	1.38
−1.5	0.75	1.13	1.50
	.... (ii) 5% reduction in M_{11}; 1% reduction in M_{12} ...		
−0.5	0.40	0.78	1.15
−1.0	0.43	0.80	1.18
−1.5	0.45	0.83	1.20
	.... (iii) 1% reduction in M_{11}; 5% reduction in M_{12} ...		
−0.5	0.20	0.28	0.35
−1.0	0.33	0.40	0.48
−1.5	0.45	0.53	0.60

[a] It is assumed that Australia faces a perfectly elastic demand in all other markets, that market 1 accounts for 15 per cent of Australian exports and that market 2 accounts for 5 per cent of Australia exports. The percentage increases are calculated using revenue under competitive pricing as the base. P_{1i} and $M_{1i} (i = 1,2)$ denote price for commodity 1 in market i and imports of commodity 1 in market i, respectively.

The percentage increases in export revenue would be greater for larger reductions in imports in the two markets (i.e. greater export restriction by Australia) but, as shown by the results in Table 3, the increases would still be small. These results are consistent with what is already known about the revenue increases that are possible under price discrimination. That is, the revenue increases that are possible will be greater the greater are the differences in price elasticities in different markets and the greater the proportion of output sold in the more price inelastic markets.

While revenue increases achieved by the use of market power represent a transfer from overseas consumers to Australia, these increases have to be compared with any increases in costs incurred by Australia's farmers from having a single-desk selling arrangement in place. Determining whether marketing costs are smaller or larger as a result of having a single-desk seller is beyond the scope of this paper, although it should be noted that lack of competitive discipline in the selling function is not conducive to cost minimisation.

A point also worth making is that the revenue comparisons have been made against a base of competitive pricing; that is, the case where exports to the two markets are those which would occur when the prices in those markets equalled the 'world price'. This may not be the appropriate comparison. If a single-desk selling arrangement was not in place, shrewd private traders might be able to take advantage of the market power which exists. If they are doing this, then the further revenue increases from switching to a single-desk selling arrangement will be less (or, indeed, even negative if the private traders, perhaps through better market intelligence, can judge the elasticities better than the single-desk seller). Of course, proponents of single-desk selling argue that private traders would simply erode away the price premia which can be obtained by over-supplying the markets. But the price premia and associated transfers to Australian producers could be protected through auctioning the rights to export (limited) quantities to the premium markets. Such an arrangement has been suggested previously (see, for example, Freebairn and Gruen 1977).

There is another potentially important point which is made clear by the solution to (10). The model used was one in which Allaru did not trade in commodity 2 because of a policy of self-sufficiency. When exports of commodity 1 from Australia are *restricted*, the solution to (10) shows that:

$$G(Q_2, M_1) = M_1\,(\varepsilon_{22}\eta_{21} - \varepsilon_{21}\eta_{22})/d_1 \tag{19}$$

and

$$G(P_2, M_1) = -M_1\,(\varepsilon_{21} - \eta_{21})/d_1 \tag{20}$$

Assuming commodities 1 and 2 are substitutes in demand and supply, the sign of $G(Q_2, M_1)$ is ambiguous meaning that 'self-sufficiency' in commodity 2 could involve a lower or higher level of consumption of that commodity. However, the sign of $G(P_2, M_1)$ is unambiguously negative, assuming commodities 1 and 2 are substitutes. Self-sufficiency in commodity 2 is achieved at a higher price when imports of commodity 1 are reduced. The impact of the reduction in imports of commodity 1 on the price of commodity 2 in Allaru will be greater the stronger the cross-price effects. An issue which could be of importance is whether the government of Allaru would be content with allowing its consumers to pay a higher price for commodity 2. If it is not content with such a state of affairs, then it may retaliate against its reduced access to imports of commodity 1 from Australia in a manner which erodes Australia's market power. This it could do, for example, by introducing policies to shift the supply curve for commodity 2 to the right, opening up its borders to imports of commodity 2 or importing commodity 1 from other sources. It is worth noting, too, that if Allaru adopted a policy of stabilising the price of commodity 2 in the face of fluctuations in the availability of imports of commodity 1, the general equilibrium effects which work to enhance Australia's ability to influence the price of commodity 1 would be eliminated.

In passing it is worth noting that, while the discussion of the price premium argument has been concentrated on export marketing, the analysis is just as relevant to domestic marketing where, for example, a state marketing board can influence flows of a commodity to different outlets. In some of those outlets it might have substantial market power while in others it might face a highly elastic demand. Cross-commodity effects are likely to be important. The revenue impacts from restricting supply to premium markets will be greater than in the export marketing case to the extent that 'premium' markets account for a greater proportion of total sales.

Strengths and Weaknesses of Equilibrium Displacement Modelling

EDM involves the application of comparative static analysis to general function models (i.e. models involving no assumptions about functional forms). Its main strength is that it allows qualitative assessments to be made of the impacts on endogenous variables of infinitely small changes in exogenous variables. As such it is a powerful analytical procedure. For example, in the applications given in this paper, this technique helped reveal precisely how cross-commodity relationships influence the outcomes from changes in exogenous variables. Partial differention of the expressions for changes in endogenous variables allows estimation of the sensitivity of those changes to underlying parameters such as cross elasticities of demand and supply.

The procedure is also valuable in allowing headway to be made in measuring the displacement effects of small (say, in the order of 10 per cent or less) finite changes in exogenous variables in situations where there is neither the time nor research resources available to engage in econometric modelling. This is the manner in which it has been used in several recent papers such as Mullen, Alston and Wohlgenant (1989) and Scobie, Mullen and Alston (1991). Assessments of the effects of changes in exogenous variables can be made provided one is prepared to make assumptions about elasticity values, perhaps undertaking sensitivity analysis in addition. Elasticity values can be based on previous econometric work, constraints from economic theory, intuition or all three of these. This use of equilibrium displacement modelling is particularly relevant in the case of developing countries where data for econometric modelling may be either unavailable or are not to be believed.

Although attention in this paper was concentrated on investigating the equilibrium displacement effects of a change in a single exogenous variable, changes in two or more exogenous variables can be modelled using the same procedures, with the proportionate change in each endogenous variable being the sum of products of elasticities and proportionate changes in exogenous variables. For example, the revenue impacts of a simultaneous decline in imports and a shift in the demand and/or supply of commodity 2 could have been analysed using EDM.

It has been suggested (Myers 1992, pers. comm.) that the usefulness of EDM in measuring the impacts of finite changes in exogenous variables is more apparent than real. The argument runs as follows. The procedure uses a linear approximation to estimate the impacts of finite changes. This being the case, what is lost by simply assuming linear functions at the outset? Indeed, doing so would be more transparent than assuming general functional forms and then measuring impacts by a procedure which assumes implicitly that the underlying functional forms are linear. Whilst the author has some sympathy with this point of view, the point remains that EDM provides a first-order approximation to the effects of finite changes in exogenous variables irrespective of the true underlying functional forms. Because the procedure happens to give exact results when the underlying functions are linear (see Alston and Wohlgenant 1990) is not a compelling reason to use linear functions from the outset.[2] In the author's view, it is preferable to acknowledge that, in practice, one can never know the true functional forms and proceed by using general functional forms and providing first-order approximations to displacement effects, emphasising in the process that the results are approximations. All of this is quite explicit.

Because the procedures really amount to comparative static analysis, they suffer from the usual criticism that paths of adjustment are ignored. This could be overcome to some extent by repeated applications of the procedures for different lengths of run. Too, paths of adjustment are also ignored in much econometric modelling.

Summary and Conclusions

There were two objectives in this paper. The first was to promote the use of EDM in analytical work in the area of price and policy analysis. This was because quite 'rich' results can be obtained with a minimum of effort. Cross-market effects are readily accommodated and these can be important in many problem settings.

The procedures involved were demonstrated by reproducing some important results obtained by Buse (1958) and investigating, in a partial way, an issue important in contemporary debate about Australia's agricultural marketing arrangements, namely the price-premium argument that has been advanced in favour of single-desk selling. That investigation reinforced the view that the benefits from single-desk selling may well be less than its costs.

While EDM is clearly a strong analytical tool, it can also be used as a substitute to econometric modelling to study the impacts of small, finite changes in exogenous variables. In using EDM in this way, it has to be remembered that it will provide only a first-order approximation to the true impacts (unless underlying functional forms are linear). Of

[2] The procedure provides exact results for finite changes if: (a) the underlying functions are linear and proportionate change (in any variable x) is measured as dx/x; or (b) the underlying functions are log-linear and proportionate change is measured as $d\ln x$ (Hurd 1992, pers. comm.).

course, econometric models also have the shortcoming of providing only approximations. As in static econometric modelling, EDM ignores paths of adjustment from one equilibrium position to another, although this could be overcome to some extent by repeated applications using elasticities corresponding to different lengths of run.

APPENDIX

Equilibrium conditions for the Buse model given by equation (1) in the text require that

$$\text{(A1)}\quad \begin{cases} D_1 \ (P_1,\ P_2,\ W) - D_1 = 0 \\ S_1 \ (P_1,\ P_2,\ X) - S_1 = 0 \\ D_2 \ (P_1,\ P_2,\ Y) - Q_2 = 0 \\ S_2 \ (P_1,\ P_2,\ Z) - Q_2 = 0 \end{cases}$$

where the endogenous variables (P_2, D_1, S_1 and Q_2) are measured at their equilibrium values.

To investigate the equilibrium displacement effects of a change in P_1, totally differentiate A(1) and set dW, dX, dY and dZ equal to zero to obtain:

$$\text{(A2)}\quad \begin{cases} (\partial D_1/\partial P_2)\ dP_2 - dD_1 = -\partial D_1/\partial P_1)\ dP_1 \\ (\partial S_1/\partial P_2)\ dP_2 - dS_1 = -\partial S_1/\partial P_1)\ dP_1 \\ (\partial D_2/\partial P_2)\ dP_2 - dQ_2 = -\partial D_2/\partial P_1)\ dP_1 \\ (\partial S_2/\partial P_2)\ dP_2 - dQ_2 = -\partial S_2/\partial P_1)\ dP_1. \end{cases}$$

Replace dP_1 with $P_1\ d\ ln\ P_1$ etc. and divide the first of the resulting equations by D_1, the second by S_1 and the third and fourth by Q_2 to obtain:

$$\text{(A3)}\quad \begin{cases} \eta_{12}\, d\ln P_2 - d\ln D_1 = -\eta_{11}\, d\ln P_1 \\ \varepsilon_{12}\, d\ln P_2 - d\ln S_1 = -\varepsilon_{11}\, d\ln P_1 \\ \eta_{22}\, d\ln P_2 - d\ln Q_2 = -\eta_{21}\, d\ln P_1 \\ \varepsilon_{22}\, d\ln P_2 - d\ln Q_2 = -\varepsilon_{21}\, d\ln P_1 \end{cases}$$

where $\eta_{ij}\,(\varepsilon_{ij})$ is the Marshallian price elasticity of demand (supply) of commodity i with respect to the price of commodity j.

Finally, divide throughout by d ln P_1 to obtain:

$$\text{(A4)}\quad \begin{cases} \eta_{12}\, G(P_2, P_1) - G\,(D_1, P_1) = -\eta_{11} \\ \varepsilon_{12}\, G(P_2, P_1) - G\,(S_1, P_1) = -\varepsilon_{11} \\ \eta_{22}\, G\,(P_2, P_1) - G\,(Q_2, P_1) = -\eta_{21} \\ \varepsilon_{22}\, G\,(P_2, P_1) - G\,(Q_2, P_1) = -\varepsilon_{21} \end{cases}$$

where (for example):

$$\text{(A5)}\quad \begin{cases} G(P_2, P_1) = d\ln P_2/d\ln P_1 \\ \qquad\qquad\;\; = (dP_2/P_2)/(dP_1/P_1) \\ \qquad\qquad\;\; = \text{general equilibrium point elasticity} \\ \qquad\qquad\quad\;\; \text{of } P_2 \text{ with respect to } P_1\,. \end{cases}$$

We now have a system of four linear equations that can be solved for the four general equilibrium elasticities $G(D_1, P_1)$, $G(S_1, P_1)$, $G(Q_2, P_1)$ and $G(P_2, P_1)$.

In matrix form the system is:

$$\text{(A6)} \qquad \begin{bmatrix} -1 & 0 & 0 & \eta_{12} \\ 0 & -1 & 0 & \varepsilon_{12} \\ 0 & 0 & -1 & \eta_{22} \\ 0 & 0 & -1 & \varepsilon_{22} \end{bmatrix} \begin{bmatrix} G(D_1, P_1) \\ G(S_1, P_1) \\ G(Q_2, P_1) \\ G(P_2, P_1) \end{bmatrix} = \begin{bmatrix} -\eta_{11} \\ -\varepsilon_{11} \\ -\eta_{21} \\ -\varepsilon_{21} \end{bmatrix}$$

and the solutions for the general equilibrium elasticities can be found by successive application of Cramer's rule.

Buse was interested in $G(D_1, P_1)$ and $G(S_1, P_1)$ which he termed the total elasticities of demand and supply, respectively. The solutions to these are:

$$\text{(A7)} \qquad G(D_1, P_1) = \eta_{11} + \eta_{12} (\varepsilon_{21} - \eta_{21})/(\eta_{22} - \varepsilon_{22})$$

and

$$\text{(A8)} \qquad G(S_1, P_1) = \varepsilon_{11} + \varepsilon_{12} (\varepsilon_{21} - \eta_{21})/(\eta_{22} - \varepsilon_{22}) .$$

However, it is also the case that:

$$\text{(A9)} \qquad G(P_2, P_1) = (\varepsilon_{21} - \eta_{21})/(\eta_{22} - \varepsilon_{22})$$

and, hence, alternative expressions for the total elasticities of demand and supply are

$$\text{(A10)} \qquad G(D_1, P_1) = \eta_{11} + \eta_{12}\, G(P_2, P_1)$$

and

$$\text{(A11)} \qquad G(S_1, P_1) = \varepsilon_{11} + \varepsilon_{12}\, G(P_2, P_1) .$$

These results are identical to those obtained by Buse using his explicit log-linear model. As indicated by Buse, the results extend to models involving more than two commodities.

A further result not covered by Buse is that

$$\text{(A12)} \qquad \begin{cases} G(Q_2, P_1) & = (\varepsilon_{21}\eta_{22} - \varepsilon_{22}\eta_{21})/(\eta_{22} - \varepsilon_{22}) \\ & = [\varepsilon_{21} (\eta_{22} - \varepsilon_{22}) + \varepsilon_{22} (\varepsilon_{21} - \eta_{21})]/(\eta_{22} - \varepsilon_{22}) \\ & = \varepsilon_{21} + \varepsilon_{22}\, G(P_2, P_1) . \end{cases}$$

Alternatively,

$$\text{(A13)} \qquad \begin{cases} G(Q_2, P_1) & = (\varepsilon_{21}\eta_{22} - \varepsilon_{22}\eta_{21})/(\eta_{22} - \varepsilon_{22}) \\ & = [\eta_{21} (\eta_{22} - \varepsilon_{22}) + \eta_{22} (\varepsilon_{21} - \eta_{21})]/(\eta_{22} - \varepsilon_{22}) \\ & = \eta_{21} + \eta_{22}\, G(P_2, P_1). \end{cases}$$

One can obtain other total elasticities with respect to changes in P_1 by appropriate combination of the total elasticities already derived. These include, for example, the total elasticity of revenue earned in market 2 given by:

$$\text{(A14)} \qquad G(R_2, P_1) = G(P_2, P_1) + G(Q_2, P_1);$$

and the total elasticity of stocks of commodity 1 given by:

$$\text{(A15)} \qquad G(K, P_1) = [G(S_1, P_1)S_1 - G(D_1, P_1)D_1]/K$$

where $R_2 = P_2Q_2$; and

$K = S_1 - D_1$.

Using similar procedures, one can derive general equilibrium elasticities for each of the endogenous variables with respect to any of the exogenous variables. Rather than doing this for the Buse model where P_1 is exogenous, it is useful to consider the case where both prices are endogenous. The matrix equation containing general equilibrium elasticities with respect to W (the demand shifter for commodity 1) is:

$$\text{(A16)} \qquad \begin{bmatrix} -1 & 0 & \eta_{11} & \eta_{12} \\ -1 & 0 & \varepsilon_{11} & \varepsilon_{12} \\ 0 & -1 & \eta_{21} & \eta_{22} \\ 0 & -1 & \varepsilon_{21} & \varepsilon_{22} \end{bmatrix} \begin{bmatrix} G(Q_1, W) \\ G(Q_2, W) \\ G(P_1, W) \\ G(P_2, W) \end{bmatrix} = \begin{bmatrix} -\eta_{1w} \\ 0 \\ 0 \\ 0 \end{bmatrix}$$

where η_{1w} is the partial elasticity of demand for commodity 1 with respect to W.

The solutions are

$$\text{(A17)} \qquad \left[\begin{array}{l} G(P_1, W) = \eta_{1w} (\eta_{22} - \varepsilon_{22})/d_2 \\ G(P_2, W) = \eta_{1w} (\varepsilon_{21} - \eta_{21})/d_2 \\ G(Q_1, W) = \eta_{1w} [(\varepsilon_{11} \eta_{22} - \varepsilon_{12} \eta_{21}) - (\varepsilon_{11} \varepsilon_{22} - \varepsilon_{12} \varepsilon_{21})]/d_2 \\ G(Q_2, W) = \eta_{1w} (\varepsilon_{21} \eta_{22} - \varepsilon_{22} \eta_{21})/d_2 \end{array} \right.$$

where d_2 is the determinant of the LHS matrix in (A16).

The expression for $G(Q_1, W)$ can be manipulated to show that:

$$\text{(A18)} \qquad G(Q_1, W) = \varepsilon_{11} G(P_1, W) + \varepsilon_{12} G(P_2, W)$$

and, hence,

$$\text{(A19)} \qquad G(Q_1, W)/G(P_1, W) = \varepsilon_{11} + \varepsilon_{12} [G(P_2, W)/G(P_1, W)].$$

Also the expression for $G(Q_2, W)$ can be manipulated to obtain

$$\text{(A20)} \qquad G(Q_2, W) = \varepsilon_{22} G(P_2, W) + \varepsilon_{21} G(P_1, W)$$

and hence,

$$\text{(A21)} \qquad G(Q_2, W)/G(P_1, W) = \varepsilon_{21} + \varepsilon_{22} [G(P_2, W)/G(P_1, W)].$$

Alternatively, it can be shown that:

$$\text{(A22)} \qquad G(Q_2, W) = \eta_{22} G(P_2, W) + \eta_{21} G(P_1, W)$$

and hence,

$$\text{(A23)} \qquad G(Q_2, W)/G(P_1, W) = \eta_{21} + \eta_{22} [G(P_2, W)/G(P_1, W)].$$

Note the similarity between (A8) which is the Buse total supply elasticity for commodity 1 and (A19) which, in a sense, can be interpreted as a supply elasticity one step removed so-to-speak from the initial source of change. In the case of (A8), the change in the price of P_1 is exogenous, whereas in (A19), P_1 changes because W changes.

The same comparisons can be made between (A12) and (A21), and between (A13) and (A23).

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