Kinked Terms of Trade in GE Modelling

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A Contributed Paper at the 39th Annual Conference of the
Australian Agricultural Economics Society
Perth WA, 14-16 February 1995

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A standard assumption used in C.G.E. modelling is that the price of two goods can be represented by a single ratio. This simplifying assumption is often untrue and using it may produce a misleading result. Many countries benefit from preferential access to protected markets for a specified quantity of particular goods, they therefore face two (or more) prices for those goods. By modifying the terms of trade line to reflect these differentiated prices it is possible to show that the welfare maximising mix of production differs from that calculated using the standard, undifferentiated, approach to C.G.E. modelling

1. Introduction

The standard approach to general equilibrium modelling is to represent the terms of trade between two goods as a single ratio. This approach is appropriate when the exporter receives an undifferentiated price for the goods sold However, it produces an incorrect result when the prices received are differentiated.

By representing the terms of trade as a single ratio the modeller is, implicitly, assuming that the quantity of goods sold is too small to influence the price and that there are no barriers to trade. Although the first assumption is usually reasonable the second is often incorrect. Many countries erect barriers to trade and it is common for them to exempt some imports from "preferred" countries. These exempt imports earn the exporter a premium above the open market price but are usually subject to some form of quantitative restriction. In effect the exporter is a price taker in two (or more) separate markets one of which also imposes a limit on how much can be sold.

If differentiated prices are combined with quota restrictions the terms of trade can no longer be represented by a single ratio. The correct representation requires two (or more) price ratios one (or more) of which is bounded by an exogenous

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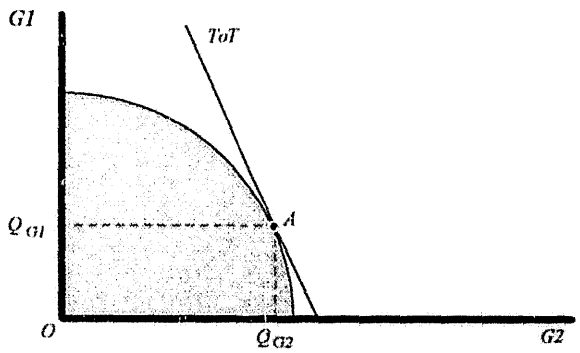
quantitative restriction, hence the term used in the title of this paper, *kinked* terms of trade in G.E. modelling.

Incorporating the effects of price differentiation and quantitative restrictions into computable general equilibrium models enables the welfare maximising mix of production to be estimated properly. A method for doing this is outlined in this paper.

2. Terms of Trade with Open Market Prices

When the exporter is small, in relation to total world trade, and does not have preferential access to a protected market, the general equilibrium mix of output can be represented as the point at which an unbounded terms of trade line is tangential to the production possibility frontier. In Figure 1 the general equilibrium is shown as point *A* where the mix of production is Q_{G1} and Q_{G2}.

Figure 1: Terms of Trade with Open Market Prices



Where:

ToT	=	Terms of trade (undifferentiated prices)
Q_{G1}	=	Quantity of good one
Q_{G2}	=	Quantity of good two

The terms of trade line, *ToT*, is described in equation 1. The open market prices are treated as exogenous and unaffected by the quantity sold hence, P_{G1} equals x, the open market price for *G1* and P_{G2} equals y, the open market price for *G2*.

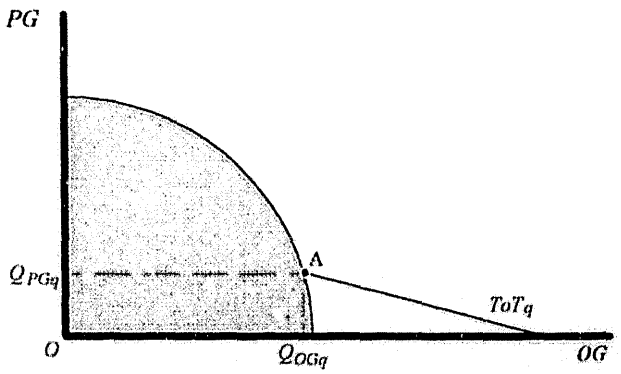
$$ToT = {}^{P_{ex}}\!/_{P_{im}} \qquad \text{where. } P_{ex} = x \text{ , } P_{im} = y \text{ and } 0 < Q_{ex}, Q_{im} < \infty \quad (1)$$

3. Terms of Trade at Preference Prices

There are two differences between a producer's terms of trade with an open market and the terms of trade the producer faces in a protected market. The prices received for sales to a protected market are higher than those to the open market, and the amount that can be sold to the protected market is usually limited by some form of quantitative restriction. In most cases the exporter is a price taker in the protected market so the quantity exported has no effect on the price received. The terms of trade can therefore be represented by a straight line which is bounded, at the upper limit, by the size of the quantitative restriction imposed by the importer. This situation is shown in Figure 2.

The difference between Figure 1 and Figure 2 is the way in which the terms of trade line is shown. In Figure 1 it is tangent to the production possibility frontier whereas in Figure 2 it intersects the production possibility frontier. This reflects the fact that there is no market constraint on the amount that can be sold to the open market whereas the amount that can be sold under the preferential access arrangements is limited by quota.

Figure 2: Terms of Trade at Preference Prices



The terms of trade line ToT_q is described in equation 2. As with the open market situation, the price paid for the preference good is exogenous and is not affected by the quantity sold and hence ToT_q can be drawn as straight line. However, unlike the open market situation, the amount that can be exported cannot exceed a specified quota so ToT_q is bounded, at the upper limit, by the size of the quota, Z. Hence ToT_q is shown as intersecting, rather than being tangent to, the production possibility frontier.

$$ToT_{PG} = P_{PG} / P_{OG}$$

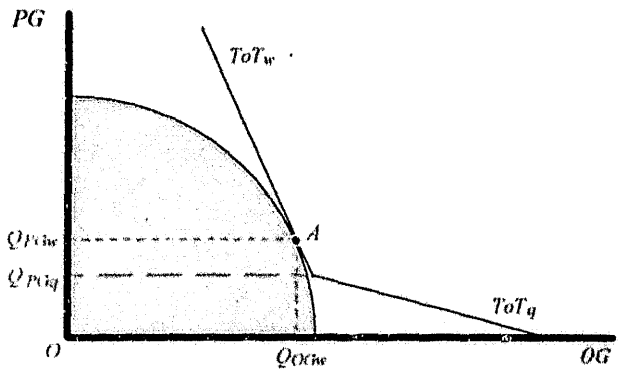
where $P_{PG} = z$, $P_{OG} = y$, $0 < Q_{PGq} \leq Z$ and $0 < Q_{OGq} < \infty$ (2)

The price of the preference good, P_{PG}, is the duty paid price, z, in protected market. The price of the other goods, P_{OG}, is the open market price, y, and is assumed to be exogenous and the quantity of other goods that can be sold, Q_{OGq}, is assumed to be unconstrained.

4. Kinked Terms of Trade

If the open market price and the price paid for the preference good are combined in the one graph the terms of trade must be drawn as a kinked line as shown in Figure 3. The ToT_w spline represents the ratio between the open market prices of both the preference good and the other goods. The ToT_q spline represents the ratio between the protected market price of the preference good and the open market price for the other goods. The ToT_w spline is unbounded whereas the ToT_q spline is bounded at it upper limit by the size of the import quota.

Figure 3: Kinked Terms of Trade with Open Market Exports



The equilibrium mix of output is represented by point *A* at which the terms of trade line is tangential to the production possibility frontier. In the situation depicted, the exporter would increase production until aggregate marginal costs equalled the open market price for the preference good. The total quantity of preference good produced would equal Q_{PGw} of which Q_{PGq} would be exported to the preference market and the balance, Q_{PGw} - Q_{PGq} would be exported to the open market.

5. Terms of Trade with Pooled Prices

If a model is to be estimated using a single price ratio it is first necessary to calculate a weighted average price for each set of goods, in the following this is described as a pooled price. Typically, an equation similar to the one defined in equation 3 would be used to calculate a weighted average price of all sales.

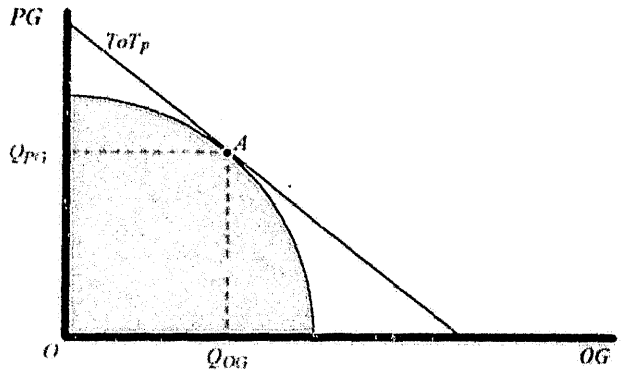
$$P_P = \frac{(P_{PG} * Q_{PG}) + (P_W * Q_W)}{(Q_{PG} + Q_W)} \qquad (3)$$

Where:

P_P	=	Pooled price of preference good (weighted average price)
P_{PG}	=	Preference price
P_W	=	Open market price
Q_W	=	Quantity sold to open market
Q_{PG}	=	Quantity sold to protected market

Figure 4 shows a general equilibrium with pooled prices where, at point A, the production mix comprises Q_{PG} of the preference good and Q_{OG} of the other goods.

Figure 4: Terms of Trade with Pooled Prices



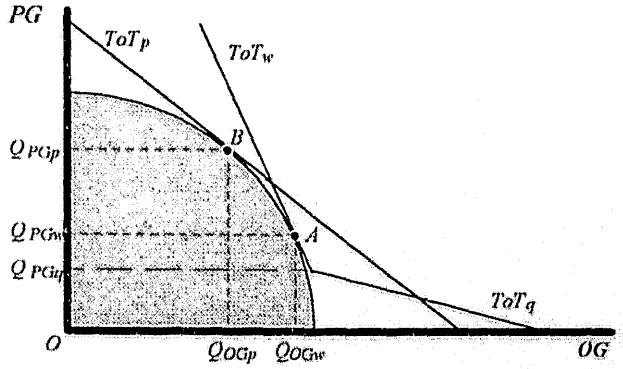
The terms of trade ratio is defined in equation 4.

$$ToT_p = P_p / P_{OG} \qquad \text{Where: } P_{OG} = y,\ 0 < Q_{PG}, Q_{OG} < \infty \quad (4)$$

6. Kinked versus Pooled Terms of Trade

By overlaying a pooled price terms of trade line, ToT_p, on the kinked terms of trade line(s), ToT_w: ToT_q, it can be shown that the kinked terms of trade approach results in a better welfare outcome than the pooled price approach.

Figure 5: Pooled Price - Differentiated Terms of trade



This conclusion can be fairly easily proved if the domestic consumption of the preference good is assumed to be zero[2]. It then becomes possible to treat the OG axis as a locus of indifference curves and thereby interpret the intersection of terms of trade lines with the axis as relative measures of national welfare[3]. The further the intersection is from the origin the greater the welfare achieved. Given that the pooled price terms of trade line must intersect the OG axis inside the kinked terms of trade spline the diagram shows that a modelling approach which differentiates prices gives a better welfare outcome.

Proving that ToT_p must intersect the OG axis inside the ToT_q intersection is also fairly straight forward. In equation 4 the pooled price is shown to be the weighted average of the preference sales and sales to the open market.

For a preference premium to exist, the preference price must be greater than the open market price. Therefore the pooled price must be less than the preference price and greater than the open market price.

$$P_{W} \leq P_{P} \leq P_{PG} \tag{5}$$

Consequently the preference good/other good price ratio must be greater than the pooled price/other good price ratio. Hence ToT_p must intersect the OG axis inside the point at which ToT_q intersects the axis.

$$P_{PG}/P_{OG} \geq P_{P}/P_{OG} \tag{6}$$

At first glance it may not be obvious that the ToT_q intersection with the OG axis can be taken to represent gross domestic product. This relationship can be fairly easily proven if the following assumptions are made. a) there is zero domestic

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2 This assumption is not as heroic as might appear at first glimpse. In small open economies which specialise in producing one or two goods it is common for domestic consumption of these goods to be a small proportion of total production.

3 By assuming that national welfare equates with GDP, the intersection can also be interpreted as the relative size of GDP resulting from either pooled or differentiated price policies.

consumption of the preference good, b) all income is consumed and, c) there is no borrowing from overseas. These assumptions enable the consumption of other goods to be equated with gross domestic product.

$$Y = \alpha PG + (\beta - \alpha)Z + \varepsilon OG \tag{7}$$

where:

PG	=	Total quantity of preference good produced
Z	=	Preference good quota
OG	=	Total quantity of other goods produced
Y	=	Gross Domestic Product
a	=	Open market price for preference good
b	=	Preference price for preference good
e	=	Price of other goods

If OG is substituted for national income, Y, the equation becomes:

$$OG = \frac{\alpha}{\varepsilon}(PG - Z) + \frac{\beta}{\varepsilon}Z + \frac{\varepsilon}{\varepsilon}OG \tag{8}$$

The relationships are more clearly shown if the formula is reduced to its component parts as follows:

$$OG_1 = \frac{\alpha}{\varepsilon}(PG - Z) \tag{9}$$

Where: OG_1 equals the imports of OG which are financed by the sale of those preference goods that are sold to the open market.

$$OG_2 = \frac{\beta}{\varepsilon}Z \tag{10}$$

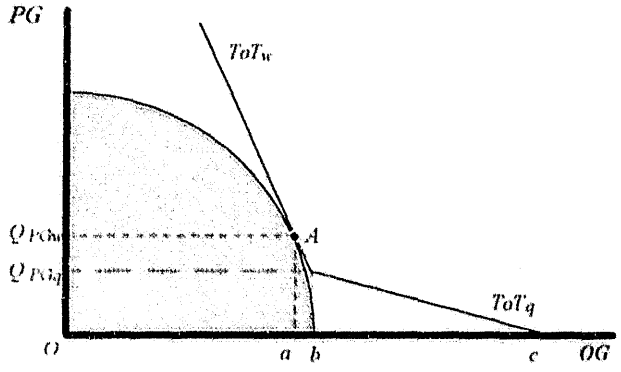
Where: OG_2 equals the imports of OG which are financed by the sale of those preference goods sold under the quota, and

$$OG_3 = \frac{\varepsilon}{\varepsilon}OG \tag{11}$$

Where: OG_3 equals the domestic production of OG

The ranges corresponding to these value are shown on Figure 6. Where Oa equals OG_3, ab equals OG_1 and bc equals OG_2

Figure 6: National Income defined in *Other Goods*



7. Summary

If price differentiation is incorporated into general equilibrium models the predicted equilibrium mix of production will be markedly different from that predicted if the model is based on undifferentiated prices. Similarly, the predicted national income and consequent national welfare outcome will also be greater than that predicted using pooled prices.

The approach is useful where the exported goods are sold to two (or more) separate and price differentiated markets. It has fairly wide application since there are numerous examples of price differentiation in international trade. For example, under the Lomé agreement, the ACP[4] group of countries receive preferential access to the EC[5] market for certain goods. The ACP exporters receive a premium price for the EC exports but are limited in the amount they can export to the EC by quota restrictions.

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4 African, Caribbean and Pacific countries that are signatories to the Lomé protocol.

5 European Community

When modelling policy option for small open economies economists should take explicit account of the pricing system facing these economies. This may require the use of kinked terms of trade in the formulation f the model.

References

Bhagwati, J.N and Srinivasan, T.N. (1983) *Lectures on International Trade*, The MIT Press, Cambridge Mass