Partial and General Equilibrium Measures of Trade

Restrictiveness

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Abstract

New partial equilibrium forms of the Trade Restrictiveness Index and the Mercantilist Trade Restrictiveness Index have recently been used by the World Bank and others. In this paper we examine the bias in the partial equilibrium forms due to the neglect of general equilibrium effects. We propose “semi-general equilibrium” measures that capture those general equilibrium effects due to vertical input-output relations without the need for a cge model. These measures also incorporate ntms. Australian data are used to compute the semi-general equilibrium measures. These estimates indicate that the partial equilibrium forms underestimate the true value of the indices, and by a large margin in some cases.
In the theory of trade restrictions, a major breakthrough was made by Anderson and Neary (1994 and 2005) with the development of the concept of the Trade Restrictiveness Index (TRI). For one country, the TRI is the uniform tariff rate that yields the same utility as a differentiated structure of tariffs. It is an index of the average levels of restrictions that is a true (utility-constant) index and a general equilibrium measure which takes account of input-output relations and all other inter-relationships across markets in both demand and supply.

As the index is a general equilibrium measure, a computable general equilibrium (cge) model of the economy is required to calculate its value. This is a severe limitation as it makes the computation complex and, in the absence of a time series of cge models associated with historical social accounting matrices and protection databases, it precludes the computation of a time series of the TRI. The complexity involved in estimating the index has limited the attempts to compute TRIs. Estimates of the TRI have been made for one or two years for the US (see Anderson and Neary, 2005) and a few other countries.

Feenstra (1995, p. 1562) derived a special case of the Trade Restrictiveness Index, on the assumption that tariffs are the only form of trade restrictions and all import functions are linear functions of own price alone. The restriction on the import functions eliminates all cross-market demand and supply effects of tariffs but, on the other hand, it is an index which can be readily calculated without the use of a computable general equilibrium model. Anderson and Neary (2005) developed the analogous partial equilibrium form of the Mercantilist Trade Restrictiveness Index (MTRI). The MTRI is the uniform tariff rate that yields the same level of imports in the country as the differentiated structure of restrictions. It is an alternative measure of the average height of trade restrictions that is appropriate if
one is concerned with the effects of trade restrictions on the volume of trade rather than on welfare.

Recently, a group of economists at the World Bank has used these forms to calculate new measures of the TRI and the MTRI for 88 countries in the 1990s (Kee, Nicita and Olarreaga, 2008 and 2009). This is an audacious but inspired approach to the measurement of the indices. A number of others have followed this method: Irwin (2007) has calculated a time series of TRI for the US economy over the period from 1859 to 1961, Lloyd and MacLaren (2008) have calculated a 31 year times series of TRI for Australia, and Lloyd, Croser and Anderson (2010) have calculated TRI and MTRI for agricultural products in 75 countries using World Bank data. These estimates result in measures which are a substantial improvement over standard measures of the average level of trade restrictions. However, they do neglect general equilibrium effects. Given the growing popularity of the partial equilibrium forms of the TRI and MTRI, it is important to compare them with the general equilibrium forms of the same concepts.

Section I derives the general and partial equilibrium forms of the TRI and the MTRI under the assumptions that the import demand functions are linear in their price arguments. Section II examines the difference between the partial equilibrium and the general equilibrium forms of the TRI. If the maintained hypothesis that the cross market effects are all zero is false, there is a bias resulting from the use of the partial equilibrium forms of the index. Section III advances the analysis by splitting the consumption and production responses and at the same time introduces possible differences between the rate of consumer and producer price distortion for each good. It proposes semi-general equilibrium measures of the TRI and the MTRI that capture some of the general equilibrium effects without
the use of a general equilibrium model. These results are illustrated using
Australian data in Section IV. The findings are summarised in Section V.

I

Consider first the TRI. Following Anderson and Neary (2005), let the trade
expenditure function for a small open but tariff-distorted economy be

\[ B(p, p^*, v, u) = e(p, u) - g(p, v) - (p - p^*)'m \]

where: \( p^* \) and \( p = p^*(1+t) \) are vectors of world and domestic prices, respectively, \( t \)
is the vector of ad valorem tariff rates, and \( (p - p^*) \) is a vector of tariff wedges.
\( e(p, u) \) and \( g(p, v) \) are the national expenditure function and the national product
function respectively. The vector \( m = e_p(p, u) - g_p(p, v) \) is the vector of quantities
of imports and exports with \( m_i > 0 \) for an importable and \( m_i < 0 \) for an exportable.
\( v \) is the vector of endowments of primary factors, and \( u \) is the utility level of the one
household. The technology, which permits the use of intermediate inputs, is given.
Thus \( B \) measures the value of transfers to the household which is required to sustain
a chosen level of utility, given the factor income received by the household and net
tariff revenue that is assumed to be returned lump-sum to the household. Following
the convention in trade theory, the vector of endowments is held constant, the
number of goods is fixed. We assume that the only distortions are border tariffs.
This assumption is relaxed in Section II.

We are interested in the welfare effects of varying the levels of the tariff
rates that create wedges between the (fixed) world prices and the domestic prices of
the goods. As we wish to compare the welfare of distorted trade situations with that
in the free trade situation, \( u \) is held constant at the free trade level. As tariffs and
domestic prices are varied, \( B \) is a compensation function that provides a money metric to measure changes in welfare.

Allow tariff rates on the \( n \) importable goods to vary from zero, where the \( n \) importables are a subset of the tradeable goods.\(^1\) Then, relative to free trade, the change in welfare is given by totally differentiating equation (1)

\[
dB = -(\mathbf{p} - \mathbf{p}^*)' \mathbf{M} \mathbf{dp}
\]

where \( \mathbf{M} = [\partial m_i / \partial p_j] \) is an \( n \times n \) symmetric and negative semi-definite matrix of the partial derivatives of the income-compensated import demand functions, \( \mathbf{m}(\mathbf{p}, u) \).

Assume that the import demand functions are linear in all prices. Then the diagonal elements of the matrix \( \mathbf{M} \) are the constant slopes and the off-diagonal terms are the intercept shifters of these functions. Let there be a set of discrete (non-small) ad valorem tariffs \( t = (t_1, t_2, \ldots, t_n) \) which in turn generate discrete changes in domestic prices, \( \Delta \mathbf{p} = (p_1^t, p_2^t, \ldots, p_n^t) \). From equation (1), the change in welfare is

\[
\Delta B = -\frac{1}{2} (\Delta \mathbf{p})' \mathbf{M} (\Delta \mathbf{p}) = -\frac{1}{2} (\mathbf{p}^* t)' \mathbf{M} (\mathbf{p}^* t)
\]

If the demand functions are not linear, this expression is an approximation only. The exact expression is given by line integrals that measure the areas under the import demand curves.

The TRI is defined as the single, uniform scalar tariff rate, \( T \), that yields the same loss of welfare, \( \Delta B \), as does the vector \( t \), i.e.,

\[
-\frac{1}{2} (\mathbf{p}^* t)' \mathbf{M} (\mathbf{p}^* t) = -\frac{1}{2} (\mathbf{p}^* T)' \mathbf{M} (\mathbf{p}^* T)
\]

Solving for \( T \), we have

\[
T = \left[ \sum_i \sum_j t_i t_j w_{ij} \right]^{\frac{1}{2}}
\]
where \( w_{ij} = \frac{p_i^* p_j^* (\partial m_i / \partial p_j)}{\sum_i \sum_j p_i^* p_j^* (\partial m_i / \partial p_j)} \) and \( \sum_i \sum w_{ij} = 1 \).

Equation (5) is the general equilibrium form of the trade restrictiveness index for linear import demand functions. Calculation of this measure of trade restrictiveness would require econometric estimation of the \( (n/2)(n+1) \) distinct elements of \( M \) – a substantial task at any reasonable degree of disaggregation of goods even if \( m(p, u) \) were observable.

As a special case, suppose that the cross-price effects are zero, i.e., \( M \) is replaced by the diagonal matrix, \( M = \frac{\partial m_i}{\partial p_i} \). Then equation (5) reduces to

\[
T^F = \left[ \sum_i t_i^2 w_i \right]^{1/2}
\]

(6)

\( w_i = \frac{p_i^* (\partial m_i / \partial p_i)}{\sum_i p_i^* (\partial m_i / \partial p_i)} \) and \( \sum w_i = 1^{2} \). This is the form introduced by Feenstra (1995). It will be referred to as the Feenstra partial equilibrium form of the trade restrictiveness index in order to distinguish it from other partial equilibrium forms. \( T^F \) is the mean of order 2. In general, a mean of order \( r \) is defined as

\[
\left( \sum_{i=1}^n t_i w_i \right)^{1/r}.
\]

Consider now the MTRI. The loss of the value of imports from the free trade situation is, for a small country,

\[
\Delta I = (p^*)' \Delta m(p, u)
\]

The MTRI, \( M \), is defined implicitly by the equation

\[
(p^*)' \Delta m(p, u) = (p^*)' \Delta m([1 + M]p^*, u)
\]

(7)

Assuming all import demand functions are linear in all prices, the solution for \( M \) is

\[
M = \left[ \sum_i \sum_j t_i w_{ij} \right]
\]

(8)
where \( w_{ij} = p_i^* p_j^* \left( \frac{\partial m_i}{\partial p_j} \right) / \sum_i \sum_j p_i^* p_j^* \left( \frac{\partial m_i}{\partial p_j} \right) \) and \( \left( \frac{\partial m_i}{\partial p_j} \right) = \text{const.} \) for each pair \((i, j)\) though they may differ between pairs. The weights sum to unity.

If again we assume that the import demand functions are linear functions of own price alone, then the off-diagonal elements of \( M \) go to zero and \( M \) reduces to

\[
M^F = \left[ \sum_{i=1}^{n} w_{ii} \right] \text{ where } w_{ii} = p_i^* p_i^* \left( \frac{\partial m_i}{\partial p_i} \right) / \sum_i p_i^* p_i^* \left( \frac{\partial m_i}{\partial p_i} \right) \text{ and } \sum_i w_{ii} = 1
\]

Equation (9) is the partial equilibrium form of the import-constant MTRI. It is the same as the form obtained by Anderson and Neary (2005, p. 21) but, as it parallels the Feenstra form of the TRI, it is designated \( M^F \). Note that the weights in equation (9) are the same as those for the TRI in equation (6).

The derivation of the two indices explains why the expression for the TRI involves the squares of the tariff rates whereas the expression for the MTRI involves only the tariff rate. In equation (7), the change in the value of imports at constant prices for good \( i \) is the rectangle

\[
\Delta I_i = p_i^* \Delta m_i = p_i^* \left( \frac{\partial m_i}{\partial p_i} \right) t_i
\]

This change in the value of imports is proportional to the tariff rate. By contrast, in equation (3) the area of the Harberger triangle for good \( i \) is

\[
\Delta B_i = -\frac{1}{2} \Delta p_i \Delta m_i = -\frac{1}{2} p_i^* \left( \frac{\partial m_i}{\partial p_i} \right) t_i^2
\]

The loss of welfare is proportional to the square of the tariff rate because the tariff rate enters in both the base and the height of the triangle.

We can state an exact relationship between \( T^F \) and \( M^F \). If we regard the tariff rates as a random variable with a known distribution, we can write

\[
(T^F)^2 = E(t^2) \]

Using the definition of variance, \( Var(t) = E(t^2) - [E(t)]^2 \), we have

\[
T^F = \{ (M^F)^2 + Var(t) \}^{1/2}
\]
It follows immediately that $T^F > M^F$ if and only if $Var(t) > 0$. Thus the more dispersed are the tariff rates, the greater the difference between $T^F$ and $M^F$, and the greater the welfare loss induced by this dispersion, measured from free trade.

II

The partial equilibrium forms are a drastic simplification as they ignore all general equilibrium effects. We need to compare the Feenstra partial equilibrium forms of the TRI and the MTRI with the general equilibrium forms in order to know whether these partial equilibrium forms are reliable indicators of the average levels of trade restrictions.

Consider first the Feenstra form of the TRI. It is not obvious whether the partial equilibrium index (equation (6)) understates or overstates the general equilibrium index (equation (5)) because the cross-product terms, $p_i^* p_j^* \left( \partial m_i / \partial p_j \right)$, $i \neq j$, appear in equation (5) in both the numerator and denominator.

We need first to examine the left-hand side of the defining equation, equation (4). This is the aggregate welfare loss from the tariff regime. The own-price and cross-price effects can be separated:

$$-rac{1}{2} \sum_i \sum_j \left( \partial m_i / \partial p_j \right)(p_i^* t_i)(p_j^* t_j) = -\frac{1}{2} \sum_i \left\{ (\partial m_i / \partial p_j)(p_i^* t_i) + \sum_{j \neq i} \left( \partial m_i / \partial p_j \right)(p_i^* t_i)(p_j^* t_j) \right\}$$

(12)

This term is in fact a line integral. Over the path of the integration, the tariff rates on other goods are increased and consequently the demand curves as a function of own price shift. They will shift to the right (left) as $\partial m_i / \partial p_j > (<) 0$ for $j \neq i$; that is, as the goods $i$ and $j$ are trade substitutes (complements).
There are really two types of cross-market general equilibrium effects, which might be called horizontal and vertical effects. The first are the substitute/complement relations in demand and supply among final goods. The second arise in production because many goods use the products of other industries as intermediate inputs. The introduction of tariffs on inputs and the possibilities of fragmented production introduce additional costs of a tariff regime. For the horizontal effects, substitutability is normal and can be expected to dominate. For the vertical effects too substitutability will hold. An increase in the price of one good used as an intermediate in the production of another good will increase the latter's unit costs of production, reduce its output and increase imports. Pairs of goods that are substitutes in both demand and supply are trade substitutes. If all goods are trade substitutes, the cross-price effects reduce the aggregate deadweight loss.

Separating own-price and cross-price effects on both sides of the defining equation (4), the over(under)-statement of the loss affects the right-hand side of this equation too. In general, one cannot state that the omission of cross-market effects in equation (6) understates or overstates the true value of the index in equation (5). This conclusion holds even if all pairs of goods are trade substitutes. The result will depend on the magnitudes as well as the signs of the cross-price effects.

III

To advance the analysis, we need to split the import responses into separate demand \( x \) and supply \( y \) responses. By definition, \( m_i(p) = x_i(p) - y_i(p) \). The demand and the supply for the good are functions of all prices and, consequently,

\[
\frac{\partial m_i}{\partial p_j} = \frac{\partial x_i}{\partial p_j} - \frac{\partial y_i}{\partial p_j}
\]

for all \( i \) and \( j \). At the same time, we take advantage of this split to make the treatment of instruments which restrict or distort trade more
general by separating consumer tax/subsidy rates from producer tax/subsidy rates. This is much more realistic as, for many goods, the use of subsidies and goods-specific tax concessions means that the rate of distortion of producer prices is different than the rate of distortion of consumer prices. $r_i$ and $s_j$ are the rates of distortion of consumer and producer prices of good $i$. If the tariff is the only border instrument for the good, then $r_i = s_i = t_i$. This split will allow us to examine the bias due to the production and consumption cross-price effects separately.

Using this split, the trade expenditure function in equation (1) has to be redefined as

$$ B(p^p, p^c, v, u) = e(p^c, u) - g(p^p, v) - (p^c - p^*)'x + (p^p - p^*)'y $$ (13)

where $p^p$ and $p^c$ are the vectors of producer and consumer prices respectively.

The derivation of the trade restrictiveness index follows in the same manner as in Section I. Differentiating $B$, setting the loss equal to that with a uniform tariff and solving, we have

$$ T^G = \left[ \left( \sum_i \sum_j r_i c_{ij}(a) + \left( \sum_i \sum_j s_j d_{ij}(b) \right) \right)^\frac{1}{2} \right] $$ (14)

where $c_{ij} = p^*_i p^*_j (\partial x_i / \partial p_j)$, $d_{ij} = p^*_i p^*_j (\partial y_i / \partial p_j)$, $a = \sum_i \sum_j p^*_i p^*_j (\partial x_i / \partial p_j) / \sum_i \sum_j p^*_i p^*_j (\partial m_i / \partial p_j)$, $b = -\sum_i \sum_j p^*_i p^*_j (\partial y_i / \partial p_j) / \sum_i \sum_j p^*_i p^*_j (\partial m_i / \partial p_j)$, and $\sum_i \sum_j c_{ij} = 1$, $\sum_i \sum_j d_{ij} = 1$, and $a + b = 1$.

This is the general equilibrium form of the trade restrictiveness index with the extension to encompass different consumer and producer distortion rates. It is designated as $T^G$. In this form the total consumption and total production effects
within the square brackets are weighted by the share of the consumption and production responses in total import responses respectively. All of the weights sum to unity as required in well-behaved indexes.

We can now consider special cases. The first special case is that in which there are zero cross-market effects. From equation (14), the expression for $T$ reduces in this case to

$$T^p = \left[ (\sum_i x_i^2 c_i(a) + (\sum_i s_i^2 d_i))(b) \right]^{\frac{1}{2}}$$

(15)

This is the partial equilibrium version, designated as $T^p$.

To establish bias, we need to compare equations (14) and (15). To do this, we consider an intermediate case in which the only general equilibrium effects are due to the vertical production effects but there are zero cross-market effects between final products. In this case, equation (14) reduces to

$$T^s = \left[ (\sum_i x_i^2 c_i(a) + (\sum_i \sum_j s_i s_j d_{ij}))(b) \right]^{\frac{1}{2}}$$

(16)

This is the second special case and it is called the semi-general equilibrium form of the index because it incorporates the vertical production relations but not the cross-price relationships between final products. It is designated as $T^s$.

Now the weights $(d_{ij})$ in the second term within the square brackets involve only vertical effects. In this term we separate own-price and cross-price effects

$$\sum_i \sum_j s_i s_j d_{ij} = [\sum_i s_i (p_i \partial y_i / \partial p_i + \sum_{j \neq i} s_j p_j \partial y_j / \partial p_i) / [\sum_i p_i \partial y_i / \partial p_i + \sum_{j \neq i} p_j \partial y_j / \partial p_i]]$$

$$= [\sum_i s_i (s_i - \sum_{j \neq i} \theta_i s_j) p_i \partial y_i / \partial p_i] / [\sum_i p_i \partial y_i / \partial p_i (1 - \sum_{j \neq i} \theta_i)]$$

(17)
where $\theta_y = -\frac{\partial y_i}{\partial p_j p_i^*}/\frac{\partial y_i}{\partial p_j}$ is the share of the $j$th intermediate input in the unit cost of producing good $i$ and $-\frac{\partial y_i}{\partial p_j}/\frac{\partial y_i}{\partial p_j}$ is the physical input-output coefficient. This interpretation of the right-hand side of the last equation follows because the change in the price of the intermediate input $j$ raises unit costs in proportion to the physical input-output coefficient. The sign changes because an increase in the price of the input $j$ decreases the output of good $i$ whereas an increase in the price of good $i$ increases its output. Substituting equation (17) into equation (16) and rearranging terms, we have

$$T^S = \left[ \sum_i \xi_i^2 c_{iy}(a) + \sum_i s_i g_i e_i(b) \right]^{\frac{1}{2}}$$

(18)

where

$$g_i = (t_i - \sum_j \theta_{iy}) / (1 - \sum_j \theta_j)$$

$$e_i = p_i^2 \frac{\partial y_i}{\partial p_i} (1 - \sum_j \theta_{iy}) / \sum_i p_i^2 \frac{\partial y_i}{\partial p_i} (1 - \sum_j \theta_j)$$

and the other variables are as defined above. $g_i$ is the standard measure of the effective rate of protection of good $i$, under the assumption that the intermediate input-output coefficients are fixed. This measure is the percentage deviation of value added per unit of output under protection from its free trade value. In the expression for this version of the semi-general equilibrium $T^S$ (equation (18)), the weights $c_{iy}$ and $a$ and $b$ are the same as those in the partial equilibrium expression for $T^p$ (equation (15)), but the weights $e_i$ differ from the weights $d_i$ in equation (15). The latter involve shares in the value of production whereas the former involve shares in value added.

Thus, $T$ has been written in a form which involves the squares of the nominal consumer tax rates as determinants of the consumption component of the
index and the product of the nominal and effective producer rates for each good as
determinants of the production component. The economic explanation of the
production component is that, in general equilibrium, the vector of gross outputs (=
et outputs + intermediate usage) is supported by the vector of effective prices, not
the vector of nominal prices, while the vector of net outputs is supported by the
vector of nominal prices (see, for example, Vousden, 1990, chapter 2.9).
Consequently, effective rates of protection are predictors of changes in gross
outputs.6

The third special case is that in which the only general equilibrium effects
are the horizontal production effects. This yields the same results as the previous
case, with the important difference that the $\theta_p = -(\partial y_i / \partial p, p^*_j) / (\partial y_i / \partial p, p^*_j)$ no
longer have the interpretation of input-output coefficients. Instead they represent
the ratio of cross-price final output effects to own-price final output effects.

The fourth and final special case is that in which the only general
equilibrium effects are the horizontal consumption effects. This is isomorphic to
the third case with the $x$’s replacing $y$’s.

We are now in a position to establish the bias from the use of partial
equilibrium measures. Suppose that some at least of the cross-market effects are
not zero but the empirical researcher uses the partial equilibrium measure of the
trade restrictiveness index ($T^p$). That is, the hypothesis that the cross-price effects
are zero is maintained falsely.

Then the welfare loss due to a regime of trade restrictions when measured
by the partial equilibrium measure in equation (15) will tend to understate the true
loss in (14) for two reasons.
First, in many countries, the tariff rates on intermediate imported inputs are generally lower than tariff rates on outputs, either because the substantive rates on pure intermediate inputs are lower or because there is a provision that allows reduced rates when imports are used as inputs. In such cases, the vertical input-output relations across markets mean typically that effective rates of protection of value added per unit of output are greater than the nominal rates of assistance to producers. This increases production losses and we have shown that it increases the value of $T$. The necessary and sufficient condition for a downward bias in the production component of the partial equilibrium measure is that

\[(\sum_i s_i g_i e_i) > (\sum_i s_i^2 d_i)\]  

(19)  

(Compare equations (15) and (18)). This inequality will be satisfied for many countries because $g_i > s_i$ for all or most $i$, even though the weights $e_i$ may differ from the weights $d_i$ in some cases.

Second, there is substitutability between pairs of goods in final demand and in final output. Relationships of substitutability can be expected to dominate those of complementarity and also the own price effects can be expected to be generally stronger than cross-price effects. This will make the $g_i$ in equation (18) (with the appropriate interpretation) again larger than the nominal rates $s_i$.

A similar line of argument applies to the partial equilibrium form of the MTRI. We follow the same steps as in the derivation of the various cases for the TRI. Splitting the import responses in equation (7) into demand and supply responses and distinguishing between the consumer and producer distortion rates, this equation can be rewritten as
\[ M^G = \left[ \left( \sum_i \sum_j r_i c_{ij} \right)(a) + \left( \sum_i \sum_j s_i d_{ij} \right)(b) \right] \quad (20) \]

where the weights are the same as in equation (14). This is the general equilibrium form of the Mercantilist Index with the extension to encompass different consumer and producer distortion rates. It is designated as \( M^G \).

When all cross-price effects are zero, this reduces to

\[ M^p = \left[ \left( \sum_i r_i c_{ij} \right)(a) + \left( \sum_i s_i d_{ij} \right)(b) \right] \quad (21) \]

This is the partial equilibrium form of the MTRI.

In the special case in which the only cross-price effects are the vertical input-output effects, equation (20) reduces to

\[ M^s = \left[ \left( \sum_i r_i c_{ij} \right)(a) + \left( \sum_i g_i e_{ij} \right)(b) \right] \quad (22) \]

where the weights are the same as in equation (18). This has the same form as the standard MTRI in equation (21) (or (9)) but the nominal rates of producer distortion are replaced by effective rates and, as with the TRI, in this version the weights \( e_i \) differ from the weights \( d_{ii} \) in equation (21).

The partial equilibrium measure will again understate the true general equilibrium measure if either tariff rates on inputs are generally lower than tariff rates on outputs or relationships of substitutability dominate those of complementarity and the own price effects are generally stronger than cross-price effects.

To assist the reader to keep track of and to compare the various versions of the TRI and the MTRI, Table 1 tabulates the various forms of the indexes. In the rows, we separate the forms when there are tariffs only from those when the
markets are distorted by combinations of tariffs and ntms which lead to different degrees of distortion of consumer and producer prices for some goods at least. In the columns, we separate each form of the TRI from the corresponding form of the MTRI. Note that in all rows the expression for the MTRI is the same as that for the TRI except that it is a mean of order 1.

<table>
<thead>
<tr>
<th>Table 1: The Forms of the TRI and the MTRI</th>
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<tbody>
<tr>
<td><strong>With tariffs only</strong></td>
</tr>
<tr>
<td>Full general equilibrium</td>
</tr>
<tr>
<td>TRI</td>
</tr>
<tr>
<td>$T = \left[ \sum_i \sum_j t_i t_j w_{ij} \right]^{\frac{1}{n}}$</td>
</tr>
<tr>
<td>MTRI</td>
</tr>
<tr>
<td>$M = \left[ \sum_i \sum_j t_i w_{ij} \right]$</td>
</tr>
<tr>
<td><strong>Partial equilibrium (Feenstra forms)</strong></td>
</tr>
<tr>
<td>TRI</td>
</tr>
<tr>
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<tr>
<td>$M^{F} = \left[ \sum_i t_i w_{ij} \right]$</td>
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</tr>
<tr>
<td>$T^{P} = \left[ \left( \sum_i r_i c_i(a) + \left( \sum_i s_i d_i(b) \right) \right]^{\frac{1}{n}}$</td>
</tr>
<tr>
<td>MTRI</td>
</tr>
<tr>
<td>$M^{P} = \left[ \left( \sum_i r_i c_i(a) + \left( \sum_i s_i d_i(b) \right) \right]^{\frac{1}{n}}$</td>
</tr>
<tr>
<td>Semi-general equilibrium</td>
</tr>
<tr>
<td>TRI</td>
</tr>
<tr>
<td>$T^{S} = \left[ \left( \sum_i r_i c_i(a) + \left( \sum_i s_i g_i e_i(b) \right) \right]^{\frac{1}{n}}$</td>
</tr>
<tr>
<td>MTRI</td>
</tr>
<tr>
<td>$M^{S} = \left[ \left( \sum_i r_i c_i(a) + \left( \sum_i s_i g_i e_i(b) \right) \right]^{\frac{1}{n}}$</td>
</tr>
</tbody>
</table>

The comparison of the partial and general equilibrium forms of the TRI and MTRI indicates the way in which the partial equilibrium measures used to date may be extended. $T^{S}$ and $M^{S}$ are better than the partial equilibrium Feenstra forms (equations (6) and (8)) that are currently used because they incorporate the vertical input-output effects as well as ntms in the theoretically correct way. They do not require a computable general equilibrium model. Yet they do incorporate in a simple way the general equilibrium effect of vertical input-output relations into the
“partial equilibrium” measure of average levels of trade restrictions. These are probably the most important cross-market effects.

The innovation in these semi-general equilibrium measures is the combination of nominal and effective rates. The nominal rates are measures of the distortions of prices to consumers and the effective rates are measures of the distortions of prices to producers. Trade economists have known for some time that the nominal rates are relevant to the deadweight consumer losses and the effective rates are relevant to the deadweight producer losses but we have not known how to combine them. Our results show that these semi-general equilibrium measures are weighted averages of the levels of distortions of consumer prices and of producer prices. For the TRI, the appropriate average is a mean of order two and, for the MTRI, the average is the arithmetic mean.

IV

In this section we provide estimates for partial equilibrium and semi-general equilibrium measures using annual data for the Australian economy for the ten-year period 1996–07 to 2005–06. We make use of the 109 sector input-output table for 2001–02 to calculate the effective rates of assistance. For each sector, we have time series data for: (A) outputs – (i) the assisted value of production and (ii) the gross subsidy equivalents; (B) on inputs – (iii) domestically produced intermediate products, (iv) imported intermediate products, (v) the tax equivalents on domestically produced intermediate products, and (vi) the tax equivalents on imported intermediate inputs; and (C) the consumer tax equivalents (in constant 2001–02 dollars). In the data for the variables listed above (A, B and C), assistance and taxation include forms
of intervention in addition to tariffs. These are budgetary assistance and agricultural pricing and regulatory assistance (Productivity Commission, 2008).  

These data enable us to calculate the semi-general equilibrium measure of the TRI, \( T^S \) (equation (18)) and of the MTRI, \( M^S \) (equation (22)).

From the definitions of the weights \( c_{ii}, d_{ii} \) and \( e_i \), we need to know the slopes of the domestic demand and supply functions, functions that are assumed to be linear. These slopes are not known but, by making some simplifying assumptions, we can calculate approximations of the TRI and MTRI measures.

The weight \( c_{ii} = \frac{p_i^{c2}(\partial x_i / \partial p_i)}{\sum_j p_i^{c2}(\partial x_i / \partial p_j)} \) can be converted into elasticity form as \( c_{ii} = \frac{\rho_i^c p_i^c x_i}{\sum_i \rho_i^c p_i^c x_i} \) where \( \rho_i \) is the own-price elasticity of domestic demand for good \( i \). Similarly,

\[
d_{ii} = \frac{p_i^{c2}(\partial y_i / \partial p_i)}{\sum_j p_i^{c2}(\partial y_i / \partial p_j)} = \frac{\sigma_i y_i}{\sum_i \sigma_i y_i} \]

elasticity of domestic supply of good \( i \), and

\[
e_i = \frac{\partial y_i}{\partial p_i} \frac{1 - \sum_j \theta_j}{\sum_j} \frac{\sum_j}{\sum_j} \frac{\partial y_i}{\partial p_i} \frac{1 - \sum_j \theta_j}{\sum \theta_j} = \frac{\sigma_i y_i (1 - \sum_j \theta_j)}{\sum_i \sigma_i y_i (1 - \sum_j \theta_j)}
\]

In the absence of econometric estimates of the own-price elasticities of demand, we assume they are all the same. (Clements (2008) proposed that for aggregates of goods, a value of –0.5 is a reasonable approximation.) We also make the assumption that all elasticities of supply are equal, though not necessarily the same as the elasticities of demand. This allows the elasticity terms to be cancelled and the weights, \( c_{ii}, d_{ii} \) and \( e_i \) to be expressed as consumption weights, production weights and value-added weights, respectively. The constants \( a \) and \( b \) are each set at 0.5. In any case, all of the weights and the consumption component of the TRI are
the same in the full general equilibrium and the semi-general equilibrium forms, and the same holds for the MTRI. The differences between the partial equilibrium forms and the semi-general equilibrium forms are driven entirely by the substitution of effective rates for nominal rates in the semi-general equilibrium forms. This changes the production components of these indices.

The calculated values for $T^S$, $T^P$, $M^S$ and $M^P$ are shown in Figure 1. The average rate of assistance to the Australian economy has continued to decline over the period according to both measures (the TRI and the MTRI). This is because the Australian Government has cut tariffs and also reduced some forms of budgetary assistance.\textsuperscript{10} The horizontal portion of each of the four series arises because the tariff structure and the consumer tax equivalents were unchanged between the years 1999–2000 and 2003–04.

The main result to emerge from the Figure is the importance of including the general equilibrium, value-added effects on the production side when measuring the welfare and trade effects of the distribution of rates of assistance across the sectors of the economy, i.e., the comparison of $T^S$ with $T^P$, and $M^S$ with $M^P$. For example, in the years 1996–97 and 2005–06, the TRIs with effective rates were 3.8 per cent and 2.2 per cent respectively, whereas with nominal rates the corresponding numbers were 3.1 per cent and 1.7 per respectively. These comparisons confirm the conjecture made in section III above that including the vertical linkages, \textit{ceteris paribus}, would increase the welfare loss and the trade loss from the distorted prices of final outputs and intermediate inputs. The partial equilibrium forms have a downwards bias. This holds because the effective rates of assistance to producers are uniformly higher than the nominal rates of assistance to producers.\textsuperscript{11}
In order to assess the sensitivity of the results to the assumption that $a = b = 0.5$, we took two other sets of values, namely $a = 0.25$, $b = 0.75$ and $a = 0.75$, $b = 0.25$. However, the value $T^S$ changes very slightly in response to changes in the values of $a$ and $b$ and the results are not reported here. What matters more, as shown in Figure 1, is the effect of using the product of the nominal and effective rates of assistance in the semi-general equilibrium forms of the index, $T^S$, rather than squared nominal rate in $T^P$.

**Figure 1: Partial and Semi-General Equilibrium Measures of Trade Restrictiveness**

![Graph](image)

**Note:** In the legend, TS is the TRI as defined in equation (18) using the effective rates of assistance; MS is the MTRI as defined in equation (22) using the effective rates of assistance; TP is the TRI as defined in equation (15) calculated using the nominal rates of assistance; and MP is the MTRI as defined in equation (21) using the nominal rates of assistance. The weights $a$ and $b$ each take the value 0.5.
The aim of this paper was to compare the partial and the general equilibrium forms of the trade restrictiveness indices and, in particular, to ascertain the direction of the bias in the indices if the hypothesis of zero cross-price effects is maintained when it is not true. In general, the bias may be positive or negative.

We next developed semi-general equilibrium forms of the TRI and the MTRI. These include the vertical input-output relations but not the horizontal relations of substitutability/complementarity between final products. At the same time we also introduced a more general specification of the model which allows the rate of distortion of the consumer price of a good to be different than that of the producer price. These semi-general equilibrium indices are a combination of nominal and effective rates. The nominal rates are measures of the distortions of prices to consumers and the effective rates are measures of the distortions to producers. Our modelling shows how to combine these two into trade restrictiveness indices that are appropriate to measure the welfare and the trade effects of trade-restricting regimes.

We showed that the partial equilibrium (Feenstra) forms will understate the true general equilibrium measures in most economies for two reasons. Both the neglect of vertical input-output relations and the neglect of cross-price relations of substitutability between final products will understate the values of the indices in most situations.

Partial and semi-general equilibrium indices were calculated for the Australian economy, using data that are disaggregated and which include a wide variety of ntms as well as tariff rates. We found that there is a substantial difference
between the numerical values of the partial and the semi-general equilibrium forms of the TRI. A similar conclusion holds for the MTRI.

For most countries, tariff rates on intermediate inputs are generally lower than those on competitive outputs. Hence, the Australian data are broadly representative. Thus, we conclude that the partial equilibrium forms of the two trade restrictiveness indices do result in a general understatement of the true (full general equilibrium) magnitude of these indices, and possibly by a large margin in cases where effective rates of assistance to producers are higher than nominal rates.
REFERENCES


Notes

1 The method can be readily extended to cover distortions of export trade (see Lloyd, Croser and Anderson, 2010).

2 The double subscript is retained to emphasise that only the non-diagonal elements are zero.

3 This integration is not path-dependent because the import demand functions are income-compensated.

4 Alternatively, we can accommodate ntms in the Feenstra forms of the indices by substituting tariff-equivalent rates for the tariff rates when ntms are present. However, these rates have to be calculated. They are not equal to the rates of distortion of producer prices, as commonly assumed, and for each good where \( r_i \neq s_i \), the equivalent rate to be used in the calculation of \( T^S \) in equation (18) below is different than the rate to be used in the calculation of \( M^S \) in equation (20).

5 Note that here \( T \) may be written as \( T = [R^2(a) + S^2(b)]^{1/2} \) where \( R = \left[ \sum_{i=1}^{n} c_i^c c_i^p \right]^{1/2} \) and \( S = \left[ \sum_{i=1}^{n} d_i^c d_i^p \right]^{1/2} \) are themselves indices of the average level of distortion of consumer and producer prices respectively. In fact, \( R \) and \( S \) are also means of order two.

6 Strictly speaking this prediction requires the existence of a value added function. One assumption that ensures this is the usual assumption in input-output theory that all intermediate input coefficients are fixed.

7 This measure of the TRI is the equivalent, for the partial equilibrium form, to the decomposition of the general equilibrium form of the TRI noted by Anderson and Neary (2005, p. 207) with the difference that the distortions of producer prices are represented by effective rates in place of nominal rates.

8 We gratefully acknowledge the assistance given to us by Paul Gretton and his colleagues at the Productivity Commission in making available the necessary time series data and the I-O table.

9 Budgetary assistance is in the form of direct financial assistance, e.g., grants and subsidies, and the funding of activities such as research and development, and business services (see Productivity Commission, 2008, pp. 19–38 for further details). However, there are some policy instruments that are not included in the calculations undertaken by the Productivity Commission. These include restrictions on international trade in services, anti-dumping and countervailing duties and assistance provided by State governments (Productivity Commission 2008, p. 10). For the agricultural sector, to the extent that sanitary and phytosanitary measures are more trade-restricting than necessary to achieve the desired level of risk, then these measures also provide assistance to the sector. However, these are not included by the Productivity Commission in its calculation of assistance to the sector.

10 Kee, Nicita and Olarreaga (2008, Table 2) estimated the TRI for Australia to be 4.97, using tariffs as the only form of assistance. This estimate was based on data at the HS6 level for the period 1988–2001. Our estimate of the TRI, using nominal rates of assistance, was 3.1 per cent in 1996–97 declining to 1.7 per cent in 2005–06. Given the substantial reduction in assistance to Australian Manufacturing and Australian Agriculture over the period used by Kee, Nicita and Olarreaga, it would be expected that their estimate would be greater than ours.

11 For each of the 109 sectors of the economy in financial year 2001-2002, the effective rate exceeded the nominal rate (calculated from data and the 109 sector I-O Table provided by Productivity Commission).