



**INDUSTRY  
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**Two Small Extensions to SALTER**

by

Robert McDougall

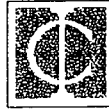
**SALTER Working Paper No. 12**

MAY 1993

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SALTER working papers document work in progress on the development of the SALTER model of the world economy. They are made available to allow scrutiny of the work undertaken but should not be quoted without the permission of the author(s). Comments on the papers would be most welcome.

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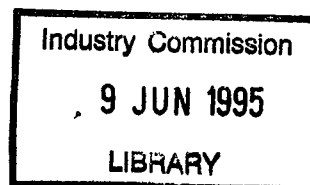
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## TWO SMALL EXTENSIONS TO SALTER

This paper describes two small extensions to the theoretical structure of the SALTER general equilibrium model of the world economy:

- to allow for quantitative trade targets; and
- to analyse changes in terms of trade.

These extensions were made in the course of work for a paper (Dee, Jomini, and McDougall, 1992) for a conference on ‘Regionalism in the World Economy: The North American Free Trade Agreement and the Australian Response’.

The extensions to the model affect only the theoretical structure; no additions are required to the database. The extensions are implemented as additions to the TABLO source code for the model (for an introduction to TABLO, see Codsì and Pearson, 1989).

For a description of the original model structure, see Jomini, Zeitsch, McDougall, Welsh, Brown, Hambley and Kelly (1991).

In presenting the additions to the theoretical structure, we follow the convention that, unless otherwise stated, variables in the model represent percentage changes in underlying theoretical variables.

### **Quantitative trade targets**

The extension described in this section is designed to model quantitative trade interventions, including both quantitative import restrictions and quantitative export targets. The main motivation for its development was the need to model assistance to agriculture in the European Communities (EC), particularly the variable import levies. Another consideration was the need to model voluntary export restraints.

The extension is intended primarily for use in simulations in which quantitative interventions are maintained at initial levels while other policy settings are changed. For instance, it could be used to simulate the maintenance of quantitative interventions in agricultural trade by the EC at a time when other regions are pursuing agricultural trade liberalisation. Other approaches may be more appropriate for simulating the removal of quantitative trade interventions.

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In modelling the EC's agricultural assistance policies, the extension enables users to treat voluntary import levies as instruments for enforcing quantitative restrictions on imports. Likewise it enables users to treat the EC's agricultural export subsidies as instruments for achieving quantitative export targets. This could be appropriate where policy mechanisms insulate agricultural producers from changes in export prices. Finally, the extension enables users to treat voluntary export restraints, such as the Multifibre Arrangement or restraints on motor vehicle exports to various destinations, as quantitative export targets.

Quantitative trade targets may be either bilateral or global. A bilateral target applies to imports from or exports to an individual trading partner; a global target applies to imports from or exports to all trading partners. The EC's voluntary import levies and agricultural export subsidies may be regarded as instruments for achieving global targets. On the other hand, voluntary export restraints represent bilateral targets. The extension enables users to model either bilateral or global targets.

With global targets a question arises concerning the adjustment of tariff equivalent rates or export subsidy equivalent rates applying to different trading partners. If an adjustment in rates is needed to maintain the global target, we want the adjustment to be uniform across trading partners. But if the rates applying to different trading partners are not uniform initially, it is not clear what constitutes a uniform adjustment. In the quantitative trade targets module, we assume that rates applying to different trade partners are adjusted proportionally.

Another question concerns the treatment of intra-region trade. The structure of the database accommodates intra-region trade flows, and tariffs and export subsidies on those flows. In developing the quantitative trade targets module, we assume that regions applying quantitative trade restrictions exclude intra-region trade from any global trade targets. Similarly we assume that, where regions adjust tariff or export subsidy rates to maintain global trade targets, these adjustments do not affect tariff or export subsidy rates on intra-region trade. These assumptions enable us to model the EC's variable import levies as instruments for enforcing quantitative restrictions on imports from outside the EC, without restricting trade within the EC.

The first set of equations in the quantitative trade restrictions module determines the power of the tariff in terms of new shift variables:

$$d(i,z,s) = RTPWRTDTRCS(i,z,s)*fddc(i,z) + fddcs(i,z,s),$$

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where:

- $d(i,z,s)$  denotes the power of the tariff,
- $fddc(i,z)$  a source-generic tariff shift variable,
- $fddcs(i,z,s)$  a source-specific shift variable, and
- $RTPWRTDTRCS(i,z,s)$  the ratio of the tariff rate to the power of the tariff,

applying to imports of commodity  $i$  from region  $s$  into region  $z$ . The presence of the parameter  $RTPWRTDTRCS$  as the coefficient on the variable  $fddc$  means that source-generic tariff shifts generate tariff changes that are proportional across sources of imports.

To ensure that source-generic tariff shifts do not affect tariffs on intra-region trade, we adjust the definition of  $RTPWRTDTRCS$  so that components corresponding to intra-region trade flows are equal to zero:

$$\begin{aligned} RTPWRTDTRCS(i,z,s) &= DR(i,z,s)/VALIMP(i,z,s), & s \neq z, \\ RTPWRTDTRCS(i,z,s) &= 0, & s = z, \end{aligned}$$

where:

- $DR(i,z,s)$  denotes duty on imports of commodity  $i$  from region  $s$  into region  $z$ , and
- $VALIMP(i,z,s)$  denotes the basic value of imports of commodity  $i$  from region  $s$  into region  $z$ .

The second set of equations defines a new import volume index, representing the volume of imports of each commodity into each region, aggregating over sources, but excluding intra-region imports. We calculate the index using basic value (ie. duty-inclusive) weights; we prefer these to border value (duty-exclusive) weights, as giving a better measure of the ability of imports to displace domestic products in the market. The equations are

$$ivmdc(i,z) = \text{SUM}(s, SEC, SMPBVETDC\_S(i,z,s)*imps(i,z,s)),$$

where:

- $ivmdc(i,z)$  denotes a volume index for imports into region  $z$  of commodity  $i$ ,
- $imps(i,z,s)$  denotes the volume of imports into region  $z$  of commodity  $i$  from region  $s$ , and
- $SMPBVETDC\_S(i,z,s)$  denotes the share of imports from source  $s$  in the basic value of imports of commodity  $i$  into region  $z$ , excluding intra-region imports.

These two sets of equations enable us to model quantitative import restrictions flexibly using closure changes. In the absence of quantitative restrictions, the shift variables  $fddc$  and  $fddcs$  are exogenous, and global import volumes  $ivmdc$  endogenous. Where global

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restrictions apply, we exogenize global import volumes  $ivmdc$ , and endogenize source-generic tariff shifters  $fddc$ . Where bilateral restrictions apply, we exogenize bilateral import volumes  $imps$  and endogenize source-specific tariff shifters  $fddcs$ .

The treatment of quantitative export targets is similar. We express powers of export taxes in terms of new shift variables, by an equation

$$te(i,z,s) = RTPWRTXPRCS(i,z,s)*ftesc(i,z) + ftescd(i,z,s),$$

where:

- $te(i,z,s)$  denotes the power of the tax on exports,
- $ftesc(i,z)$  denotes a destination-generic export tax shift variable,
- $ftescd(i,z,s)$  denotes a destination-specific export tax shift variable, and
- $RTPWRTXPRCS(i,z,s)$  denotes the ratio of the export tax rate to the power of the export tax,

applying to exports from region  $z$  of commodity  $i$  into region  $s$ . To prevent destination-generic export tax shifts from affecting tax rates on intra-region trade, we adjust the definition of the parameter  $RTPWRTXPRCS$  so that components corresponding to intra-region trade flows are zero:

$$\begin{aligned} RTPWRTXPRCS(i,z,s) &= TER(i,z,s)/VALEXPS(i,z,s) & s \neq z, \\ RTPWRTXPRCS(i,z,s) &= 0, & s = z, \end{aligned}$$

where:

- $TER(i,z,s)$  denotes tax on exports of commodity  $i$  from region  $z$  to region  $s$ , and
- $VALIMP(i,z,s)$  denotes the basic value of exports of commodity  $i$  from region  $z$  to region  $s$ .

Finally, we define a global export volume variable as an index of exports of each commodity from each region over all destinations, excluding intra-region exports. We calculate the index using basic value weights; we prefer these to border value weights, as they give a better measure of the ability of exports to relieve domestic supply surpluses. The equation is

$$ivxsc(i,z) = SUM(s, SEC, SXPBVETSC\_D(i,z,s)*es(i,z,s));$$

where:

- $ivxsc(i,z)$  denotes the volume of exports from region  $z$  of commodity  $i$  to all regions, excluding intra-region exports,
- $es(i,z,s)$  denotes the volume of exports from region  $z$  of commodity  $i$  to region  $s$ , and

- 
- $SXPBVETSC\_D(i,z,s)$  denotes the share of destination  $s$  in the basic value of exports from region  $z$  of commodity  $i$ , excluding intra-region exports.

Normally the export tax shift variables  $ftesc$  and  $ftescd$  are exogenous, and the export volume index  $ivxsc$  is endogenous. But where global export targets apply, we exogenize global export volumes  $ivxsc$  and endogenize destination-generic export tax shifters  $ftesc$ . Where bilateral export targets apply, we exogenize bilateral export volumes  $es$ , and endogenize destination-specific export tax shifters  $ftescd$ .

The relevant additions to the TABLO source code are reproduced in Appendix A.

## Terms of trade

The extension described in this section is designed to assist in determining the sources of changes in each region's terms of trade. It is not meant to identify the mechanisms generating the terms of trade changes, but merely to assist in identifying the particular commodity price changes and the particular features of a region's international trade structures that contribute most to the observed changes. In short, it is designed to show not why but how the terms of trade change.

The terms of trade module provides a decomposition of the terms of trade into several different components. We present first an intuitive overview of the decomposition, and then a mathematical derivation.

### *Decomposition of the terms of trade: overview*

The objective is to identify the characteristics of a region's trade pattern and changes in border prices that contribute significantly to changes in the region's terms of trade.

In a perfect substitutes model, each commodity would have a single world price. Changes in a region's terms of trade in a simulation would arise from correlation between world price changes in the solution and net exports in the database. A positive would imply an improvement in the terms of trade, and a negative correlation a deterioration.

In SALTER, an imperfect substitutes model, changes in the terms of trade can also arise from changes in the relative prices of different source-specific varieties of the same commodity. A region's terms of trade will tend to improve if the varieties it exports rise in price relative to varieties exported by other regions. A region's terms of trade will tend to worsen if it imports source-specific varieties which rise in price relative to other varieties.



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The terms of trade for each region are defined as the ratio of the region's export price index to its import price index:

$$tt(z) = \frac{epi(z)}{imppi(z)},$$

where

- $tt(z)$  denotes the terms of trade,
- $epi(z)$  the export price index, and
- $imppi(z)$  the import price index,

for region  $z$ . We can express the terms of trade as the sum of three components:

$$tt(z) = cttcr(z) + cttvxr(z) - cttvmr(z).$$

Here the first component  $cttcr$  represents the contribution to change in the terms of trade of changes in price relativities between commodities. It is equal to the covariance over all commodities between net exports and changes in world prices (we define the world price of each commodity as an index of border prices of exports from all regions). The term  $cttcr$  is positive for a region that exports commodities whose world prices are rising, and imports commodities whose world prices are falling.

In a perfect substitutes model,  $cttcr$  would fully account for the change in the terms of trade. Because *SALTER* is an imperfect substitutes model, the terms of trade change also includes components  $cttvxr$  and  $cttvmr$  arising from changes in price relativities between different varieties of the same commodity. Changes in price relativities between varieties can contribute to changes in the terms of trade through either export prices or import prices.

The term  $cttvxr(z)$  represents the contribution to change in the terms of trade of changes in price relativities between varieties on the export side. It is equal to the average over all commodities of divergences between export prices received by region  $z$  and world prices. The term  $cttvmr(z)$  represents the contribution to change in the terms of trade of changes in price relativities between varieties on the import side. It is equal to the average over all commodities of divergences between import prices paid by region  $z$  and world prices. These divergences in import prices can arise when for example region  $z$  sources a large share of its imports from regions exporting varieties that rise in price relative to varieties exported by other regions.

Each of these three components of the terms of trade change is calculated as the sum of commodity-specific components. Thus

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$$\begin{aligned}
cttcr(z) &= SUM(i, IND, cttcrc(i,z)), \\
cttvxr(z) &= SUM(i, IND, cttvxrc(i,z)), \\
cttvmr(z) &= SUM(i, IND, cttvmrc(i,z)).
\end{aligned}$$

These components are defined in the next section, which explains the mathematical basis of the terms of trade decomposition. The relevant additions to the TABLO source code are listed in Appendix B.

### *Decomposition of the terms of trade: derivation*

This section sets out the mathematical basis of the terms of trade decomposition.

Note that this section uses normal mathematical notation, rather than the restricted notation used in the previous sections and in the TABLO code. A concordance between the mathematical notation and the TABLO notation is provided at the end of the section.

Let  $P_{Xij}$  denote the border price of exports of commodity  $i$  from region  $j$ . Let  $S_i^{Xj}$  denote the share of commodity  $i$  in the border value of exports from region  $j$ . Then the change in the export price index for region  $j$ ,

$$P_{X\bullet j} = \sum_i S_i^{Xj} P_{Xij}$$

(note that we follow the convention of replacing a subscripted argument with the symbol ‘•’ to indicate summation or averaging over that argument).

Similarly, let  $P_{Mij}$  denote a price index for imports of commodity  $i$  into region  $j$ , and  $S_i^{Mj}$  the share of commodity  $i$  in the border value of imports into region  $j$ . Then the import price index for region  $j$ ,

$$P_{M\bullet j} = \sum_i S_i^{Mj} P_{Mij}$$

Then the terms of trade for region  $j$ ,

$$t_j = P_{X\bullet j} - P_{M\bullet j}$$

Let  $P_{Xi\bullet}$  denote a world export price index for commodity  $i$ ,

$$P_{Xi\bullet} = \sum_j S_j^{Xi} P_{Xij}$$

where  $S_j^{Xi}$  denotes the share of region  $j$  in exports of commodity  $i$ . Define an aggregate world export price index,

$$p_{X..} = \sum_i S_i^X p_{Xi.},$$

where  $S_i^X$  denotes the share of commodity  $i$  in aggregate world exports. Using these definitions, we can decompose the terms of trade as follows:

$$\begin{aligned} t_j &= \sum_i (S_i^{Xj} - S_i^{Mj})(p_{Xi.} - p_{X..}) \\ &\quad + \sum_i S_i^{Xj} (p_{Xij} - p_{Xi.}) \\ &\quad - \sum_i S_i^{Mj} (p_{Mij} - p_{Xi.}) \\ &= \sum_i C_{1ji} + \sum_i C_{2ji} - \sum_i C_{3ji} \\ &= C_{1j.} + C_{2j.} - C_{3j.}, \end{aligned}$$

where

$$\begin{aligned} C_{1ji} &= (S_i^{Xj} - S_i^{Mj})(p_{Xi.} - p_{X..}), \\ C_{2ji} &= S_i^{Xj} (p_{Xij} - p_{Xi.}), \\ C_{3ji} &= S_i^{Mj} (p_{Mij} - p_{Xi.}), \end{aligned}$$

and

$$\begin{aligned} C_{1j.} &= \sum_i C_{1ji}, \\ C_{2j.} &= \sum_i C_{2ji}, \\ C_{3j.} &= \sum_i C_{3ji}. \end{aligned}$$

Here the variable  $C_{1j.}$  can be interpreted as the contribution to the change in region  $j$ 's terms of trade of covariance between world price changes and region  $j$ 's net exports. If the commodities whose world prices rise most are those which region  $j$  exports, and the commodities whose world prices fall most are those which region  $j$  imports, then this contribution will be positive.

The variable  $C_{1ji}$  represents the contribution of commodity  $i$  to  $C_{1j.}$ . If (i) the world price of commodity  $i$  rises relative to the general world price level, and region  $j$  is a net exporter of commodity  $i$ , or (ii) the world price of commodity  $i$  falls relative to the general world price level, and region  $j$  is a net importer of commodity  $i$ , then this contribution will be positive.

---

The variable  $C_{2j\bullet}$  is the contribution to region  $j$ 's terms of trade of changes in export prices received by region  $j$ , relative to changes in average world prices of the commodities which region  $j$  exports. If the varieties exported by region  $j$  rise in price relative to varieties exported by other regions, then this contribution will be positive. The variable  $C_{2ji}$  represents the contribution of commodity  $i$  to  $C_{2j\bullet}$ . If the price of exports of commodity  $i$  from region  $j$  rises relative to the world price of commodity  $i$ , then this contribution will be positive.

The variable  $C_{3j\bullet}$  represents the reduction in region  $j$ 's terms of trade attributable to changes in the average price of the mix of varieties of each commodity imported into region  $j$ , relative to average world prices for the same commodities. If the regions whose export prices rise have a larger share of the import market in region  $j$  than in the total world import market, then this variable will be positive (and the contribution to the terms of trade will be negative). The variable  $C_{3ji}$  represents the contribution of commodity  $i$  to  $C_{3j\bullet}$ . If the mix of varieties of commodity  $i$  imported into region  $j$  rises in price relative to the world price of commodity  $i$ , then this contribution will be positive (and the corresponding contribution to the terms of trade will be negative).

Before we can operationalise this scheme, we need to consider border prices more closely. For the relative price ( $p_{Mij} - p_{Xi\bullet}$ ) appearing in the coefficient  $C_{3ji}$  to be meaningful, both prices  $p_{Mij}$  and  $p_{Xi\bullet}$  must refer to a common pricing point. A convenient common point is the border of the exporting country. But the import price variables in the standard model refer to prices at the border of the importing country. For primary products and manufactures, these differ from prices at the border of the exporting country, the difference arising from international freight margins. We therefore add new import price variables to the model, for use in the terms-of-trade analysis module.

Let  $V_{Xijk}$  denote the value of non-margin exports of commodity  $i$  from region  $j$  to region  $k$ . Define the at-source value of imports of commodity  $i$  from region  $k$  into region  $j$ ,

$$V_{Mijk} = V_{Xikj}.$$

Let  $V_{MTj}$  denote total freight margins on imports into region  $j$ . Define the at-source value of imports of commodity  $i$  into region  $j$ ,

$$V_{Mij\bullet} = \begin{cases} \sum_k V_{Mijk} & \text{if } i \text{ is a non-margin commodity,} \\ \sum_k V_{Mijk} + V_{MTj} & \text{if } i \text{ is the margin commodity.} \end{cases}$$

Then we can define an at-source price index for imports of commodity  $i$  into region  $j$ ,

$$P_{Mij} = \begin{cases} \sum_k S_k^{Mij} P_{Xikj}, & \text{if } i \text{ is a non-margin commodity,} \\ \sum_k S_k^{Mij} P_{Xikj} + S_T^{Mij} P_T, & \text{if } i \text{ is the margin commodity.} \end{cases}$$

Here  $S_k^{Mij}$  denotes the share of source  $k$  in the at-source value of imports of commodity  $i$  into region  $j$ ,

$$S_k^{Mij} = V_{Mijk} / V_{Mij\bullet},$$

and  $S_T^{Mij}$  denotes the share of freight on imports in the at-source value of imports into region  $j$  of the margin commodity,

$$S_T^{Mij} = V_{MTj} / V_{Mij\bullet}.$$

The coefficients  $V_{Mij\bullet}$  are also used in calculating the share coefficients  $S_i^{Mj}$  appearing in the equations for  $C_{1ji}$  and  $C_{3ji}$ :

$$S_i^{Mj} = V_{Mij\bullet} / V_{M\bullet j\bullet},$$

where  $V_{M\bullet j\bullet}$  denotes aggregate imports into region  $j$ ,

$$V_{M\bullet j\bullet} = \sum_i V_{Mij\bullet}.$$

The following table relates the mathematical notation used in this section to the TABLO notation.

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**Table 1: Notational concordance for the terms of trade extension**


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<i>Mathematical notation</i>	<i>TABLO notation</i>	<i>Description</i>
<b>Variables</b>		
$P_{Xiz}$	$pxrc(i,z)$	Price index for exports of commodity $i$ from region $z$
$P_{X\bullet z}$	$epi(z)$	Price index for exports from region $z$
$P_{Miz}$	$pmrc(i,z)$	Price index for imports of commodity $i$ into region $z$ (valued at source)
$P_{M\bullet z}$	$imppi(z)$	Price index for imports into region $z$
$t_z$	$tt(z)$	Terms of trade for region $z$
$P_{Xi\bullet}$	$pxc(i)$	World price index for commodity $i$
$P_{X\bullet\bullet}$	$wepi$	World export price index
$C_{1zi}$	$cttcr(i,z)$	Contribution of world price of commodity $i$ to terms of trade of region $z$
$C_{2zi}$	$cttvxrc(i,z)$	Contribution of deviation of price of exports of commodity $i$ from region $z$ from world price index for commodity $i$ , to terms of trade of region $z$
$C_{3zi}$	$ctvmrc(i,z)$	Contribution of deviation of price of imports of commodity $i$ into region $z$ from world price index for commodity $i$ , to terms of trade of region $z$
$C_{1z\bullet}$	$cttcr(z)$	Contribution of covariance between world export prices and net exports from region $z$ , to terms of trade of region $z$
$C_{2z\bullet}$	$cttvxr(z)$	Contribution of deviations of prices of exports from region $z$ from world prices, to terms of trade of region $z$
$C_{3z\bullet}$	$ctvmr(z)$	Contribution of deviations of prices of imports into region $z$ from world prices, to terms of trade of region $z$
<b>Coefficients</b>		
$S_i^{Xz}$	$S\_XPBDC\_R(i,z)$	Share of exports from region $z$ in world trade in commodity $i$
$S_i^{Xz}$	$S\_XPBDR\_C(i,z)$	Share of commodity $i$ in exports from region $z$
$S_i^{Mz}$	$S\_MPSCR\_C(i,z)$	Share of commodity $i$ in imports into region $z$ (valued at source)
$S_s^{Miz}$	$S\_MPSCRC\_S(s,i,z)$	Share of source $s$ in imports of commodity $i$ into region $z$ (valued at source)
$S_T^{Miz}$	$S\_MPSCRC\_T(i,z)$	Share of freight in value of imports into region $z$ (for $i$ the margin commodity)

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## References

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- Dee, P., Jomini, P., and McDougall, R. (1992), *Alternatives to Regionalism — Uruguay and APEC*, paper prepared for conference 'Regionalism in the World Economy: The North American Free Trade Agreement and the Australian Response', Adelaide, 19-21 July.
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APPENDIX A: THE QUANTITATIVE TRADE TARGET MODULE: TABLO  
SOURCE CODE

```
!*****!  
!                SETS                !  
!*****!
```

```
!**** ALL SETS ARE SHARED WITH THE ORIGINAL MODEL ****!
```

```
SET                                SEC  
  # regions #;  
  
                                IND  
  # sectors (commodities/industries);
```

```
!*****!  
!                VARIABLES            !  
!*****!
```

```
!**** VARIABLES SHARED WITH THE ORIGINAL MODEL ****!
```

```
VARIABLE  
  (ALL, i, IND) (ALL, z, SEC) (ALL, s, SEC)          d(i,z,s)  
  ! Power of the tariff on imports of commodity i from region s into region z !;  
  
  (ALL, i, IND) (ALL, v, SEC) (ALL, s, SEC)          imps(i,z,s)  
  # imports of commodity i from region s into region z #;
```

```
!**** NEW VARIABLES ****!
```

```
VARIABLE  
  (ALL, z, SEC) (ALL, i, IND)          fddc(i,z)
```



---

# import duty rate shift by destination and commodity #;

(ALL, z, SEC) (ALL, i, IND) (ALL, s, SEC) fddcs(i,z,s)  
# import duty rate shift by destination, commodity, and source #;

(ALL, z, SEC) (ALL, i, IND) ivmdc(i,z)  
# import volume index, basic value weights #;  
! excluding intra-region imports !

(ALL, z, SEC) (ALL, i, IND) ftesc(i,z)  
# export tax shift by source and commodity #;

(ALL, z, SEC) (ALL, i, IND) (ALL, s, SEC) ftescd(i,z,s)  
# export tax shift by source, commodity, and destination #;

(ALL, z, SEC) (ALL, i, IND) ivxsc(i,z)  
# import volume index, basic value weights #;  
! excluding intra-region exports and margin exports !

!\*\*\*\*\*

COEFFICIENTS

\*\*\*\*\*!

!\*\*\*\* COEFFICIENTS SHARED WITH THE ORIGINAL MODEL \*\*\*\*!

! Note that this document does not supply reads, formulae or updates for these coefficients. !

COEFFICIENT (ALL, i, IND) (ALL, z, SEC) (ALL, s, SEC) DR(i,z,s)  
# Duty on imports of commodity i from region s into region z #;

(ALL, i, IND) (ALL, z, SEC) (ALL, s, SEC) VALIMP(i,z,s)  
# basic value of imports of commodity i from region s into region z #;

RECIP\_NSEC  
# reciprocal of the number of regions #;

---

COEFFICIENT (ALL, i, IND) (ALL, z, SEC) (ALL, s, SEC)      TER(i,z,s)  
 # Tax on exports of commodity i from region z to region s #;

(ALL, i, IND) (ALL, z, SEC) (ALL, s, SEC)      VALEXPS(i,z,s)  
 # border value of exports of commodity i from region z to region s #;

(ALL, i, IND) (ALL, z, SEC) (ALL, s, SEC)      EXPNM(i,z,s)  
 # basic value of exports of commodity i from region z to region s #;

!\*\*\*\*    NEW COEFFICIENTS      \*\*\*\*!

ZERODIVIDE DEFAULT 0.0;  
 COEFFICIENT (ALL, z, SEC) (ALL, i, IND) (ALL, s, SEC)      RTPWRDTRCS(i,z,s)  
 # ratio of duty rate to power of duty on imports of i from s into z #;  
 FORMULA (ALL, z, SEC) (ALL, i, IND) (ALL, s, SEC)  
 RTPWRDTRCS(i,z,s)  
 = DR(i,z,s)/VALIMP(i,z,s);

! For intra-region trade, reset the ratio to zero. !  
 ! This is done to prevent changes in the variable fddc from affecting tariffs on  
 intra-region trade. !

FORMULA (ALL, z, SEC) (ALL, i, IND)      †  
 RTPWRDTRCS(i,z,z)  
 = 0.0;

COEFFICIENT (ALL, z, SEC) (ALL, i, IND) (ALL, s, SEC)      MPBVETDCS(i,z,s)  
 # imports at basic prices, excluding intra-region imports #;  
 FORMULA (ALL, z, SEC) (ALL, i, IND) (ALL, s, SEC)  
 MPBVETDCS(i,z,s)  
 = VALIMP(i,z,s);  
 FORMULA (ALL, z, SEC) (ALL, i, IND)  
 MPBVETDCS(i,z,z)  
 = 0.0;

COEFFICIENT (ALL, z, SEC) (ALL, i, IND)      MPBVETDC(i,z)  
 # imports at basic prices, by destination and commodity #;  
 FORMULA (ALL, z, SEC) (ALL, i, IND)  
 MPBVETDC(i,z)

---

= SUM(s, SEC, MPBVETDCS(i,z,s));

ZERODIVIDE DEFAULT RECIP\_NSEC;

COEFFICIENT (ALL, z, SEC) (ALL, i, IND) (ALL, s, SEC) SMPBVETDC\_S(i,z,s)

# share of source s in extra-region imports of commodity into region z #;

FORMULA (ALL, z, SEC) (ALL, i, IND) (ALL,s, SEC)

SMPBVETDC\_S(i,z,s)

= MPBVETDCS(i,z,s)/MPBVETDC(i,z);

ZERODIVIDE DEFAULT 0.0;

COEFFICIENT (ALL, z, SEC) (ALL, i, IND) (ALL, s, SEC) RTPWRTXPRCS(i,z,s)

# ratio of rate to power of export tax #;

FORMULA (ALL, z, SEC) (ALL, i, IND) (ALL, s, SEC)

RTPWRTXPRCS(i,z,s)

= TER(i,z,s)/VALEXPS(i,z,s);

! For intra-region trade, reset the ratio to zero. !

! This is done to prevent changes in the variable ftesc from affecting tariffs  
on intra-region trade. !

FORMULA (ALL, z, SEC) (ALL, i, IND)

RTPWRTXPRCS(i,z,z)

= 0.0;

COEFFICIENT (ALL, z, SEC) (ALL, i, IND) (ALL, s, SEC) XPBVETSCD(i,z,s)

# non-margin exports at basic prices, excluding intra-region imports #;

FORMULA (ALL, z, SEC) (ALL, i, IND) (ALL, s, SEC)

XPBVETSCD(i,z,s)

= EXPNM(i,z,s);

FORMULA (ALL, z, SEC) (ALL, i, IND)

XPBVETSCD(i,z,z)

= 0.0;

COEFFICIENT (ALL, z, SEC) (ALL, i, IND) XPBVETSC(i,z)

# exports at basic prices, by destination and commodity #;

! excluding margin exports and intra-region exports !

FORMULA (ALL, z, SEC) (ALL, i, IND)

XPBVETSC(i,z)

= SUM(s, SEC, XPBVETSCD(i,z,s));

---

ZERODIVIDE DEFAULT RECIP\_NSEC;  
 COEFFICIENT (ALL, z, SEC) (ALL, i, IND) (ALL, s, SEC) SXPBVETSC\_D(i,z,s)  
 # share of destination s in extra-region exports of commy i from regn z #;  
 FORMULA (ALL, z, SEC) (ALL, i, IND) (ALL, s, SEC)  
 SXPBVETSC\_D(i,z,s)  
 = XPBVETSCD(i,z,s)/XPBVETSC(i,z);

!\*\*\*\*\*

EQUATIONS

\*\*\*\*\*!

EQUATION

DUTY\_RATE

# duty rate #  
 (ALL, z, SEC) (ALL, i, IND) (ALL, s, SEC)  
 d(i,z,s)  
 = RTPWRDTRCS(i,z,s)\*fddc(i,z) + fddcs(i,z,s);

IMPT\_VOLE\_INDX

# import volume index, basic value weights #  
 (ALL, z, SEC) (ALL, i, IND)  
 ivmdc(i,z)  
 = SUM(s, SEC, SMPBVETDC\_S(i,z,s)\*imps(i,z,s));

EXPORT\_TAX\_RATE

# export tax rate #  
 (ALL, z, SEC) (ALL, i, IND) (ALL, s, SEC)  
 te(i,z,s)  
 = RTPWRTXPRCS(i,z,s)\*ftesc(i,z) + ftescd(i,z,s);

EXPT\_VOLE\_INDX

# export volume index, basic value weights #  
 (ALL, z, SEC) (ALL, i, IND)  
 ivxsc(i,z)  
 = SUM(s, SEC, SXPBVETSC\_D(i,z,s)\*es(i,z,s));

---

APPENDIX B: TERMS OF TRADE MODULE: TABLO SOURCE CODE

```
!*****!  
!                SETS                !  
!*****!
```

```
!**** ALL SETS ARE SHARED WITH THE ORIGINAL MODEL ****!
```

```
SET                                SEC  
  # regions #;
```

```
SET                                IND  
  # sectors (commodities/industries);
```

```
SET                                TRADE  
  # the international margin commodity #;  
SUBSET TRADE IS SUBSET OF IND;
```

```
SET                                NONTRD  
  # commodities other than the international trade margin commodity #;  
SUBSET NONTRD IS SUBSET OF IND;
```

```
!*****!  
!                VARIABLES                !  
!*****!
```

```
!**** VARIABLES SHARED WITH THE ORIGINAL MODEL ****!
```

```
VARIABLE  
  (ALL, z, SEC)                                epi(z)  
  # export price index for region z #;
```

---

(ALL, z, SEC) er(z)  
# exchange rate for region z #;

(ALL, z, SEC) imppi(z)  
# import price index for region z #;

(ALL, i, IND) (ALL, z, SEC) (ALL, s, SEC) pes(i,z,s)  
# border price of exports of commodity i from region z to region s #;

(ALL, i, IND) (ALL, z, SEC) pd(i,z)  
# basic price of domestically produced commodity i in region z #;

pt  
# price of international trade margin #;

!\*\*\*\* NEW VARIABLES

\*\*\*\*!

VARIABLE

(ALL, z, SEC) tt(z)  
# terms of trade #;

(ALL, z, SEC) (ALL, i, IND) pxrc(i,z)  
# price index for exports, by source and commodity #;

(ALL, i, IND) pxc(i)  
# world price index for exports, by commodity #;

wepi  
# world export price index #;

(ALL, z, SEC) (ALL, i, IND) cttcrc(i,z)  
# contribution to cttcr of commodity i #;

(ALL, z, SEC) cttcr(z)  
# contribution to terms of trade of price variation between commodities #;

(ALL, z, SEC) (ALL, i, IND) cttvxc(i,z)  
# contribution to cttvxc of commodity i #;

---

(ALL, z, SEC) cttv<sub>xr</sub>(z)  
# contribution to terms of trade of export variety price variation #;

(ALL, z, SEC) (ALL, i, IND) pmrc(i,z)  
# price index for imports of commy i into regn z, at-source weights #;

(ALL, z, SEC) (ALL, i, IND) cttvmrc(i,z)  
# contribution to cttvmr of commodity i #;

(ALL, z, SEC) cttvmr(z)  
# contribution to terms of trade of export variety price variation #;

!\*\*\*\*\*  
COEFFICIENTS  
\*\*\*\*\*!

!\*\*\*\* COEFFICIENTS SHARED WITH THE QUANTITATIVE TRADE  
RESTRICTIONS MODULE OR THE ORIGINAL MODEL \*\*\*\*!

! Note that this document does not supply reads, formulae or updates for  
these coefficients. !

COEFFICIENT

(ALL, i, IND) (ALL, z, SEC) (ALL, v, SEC) SES(i,z,v);  
! Share of destination v in border value of exports of commodity i from  
region z. !

(ALL, i, IND) (ALL, z, SEC) SESM(i,z);  
! Share of margin exports in border value of exports of commodity i from  
region z. !

(ALL, i, IND) (ALL, z, SEC) VALEXP(i,z)  
# border value of exports of commodity i from region z #;

(ALL, z, SEC) ECRT(z)  
# exchange rate for region z, relative to the common currency #;

---

(ALL, z, SEC) EXPFOB(z)  
# border value of exports from region z #;

(ALL, i, IND) (ALL, z, SEC) (ALL, s, SEC) VALEXPS(i,z,s)  
# border value of exports of commodity i from region z to region s #;

(ALL, i, IND) (ALL, z, SEC) (ALL, s, SEC) FREIGHT(i,z,s)  
# freight on imports of commodity i from region s into region z #;

!\*\*\*\* NEW COEFFICIENTS

\*\*\*\*!

COEFFICIENT (ALL, z, SEC) (ALL, i, IND) XPBDRC(i,z)  
# exports of commodity i from region z, in common currency #;  
FORMULA (ALL, z, SEC) (ALL, i, IND)  
XPBDRC(i,z)  
= VALEXP(i,z)/ECRT(z);

COEFFICIENT (ALL, i, IND) XPBDC(i)  
# world exports of commodity i #;  
FORMULA (ALL, i, IND)  
XPBDC(i)  
= SUM(z, SEC, XPBDRC(i,z));

ZERODIVIDE DEFAULT RECIP\_NSEC;  
COEFFICIENT (ALL, z, SEC) (ALL, i, IND) S\_XPBDC\_R(i,z)  
# share of region z in world exports of commodity i #;  
FORMULA (ALL, z, SEC) (ALL, i, IND)  
S\_XPBDC\_R(i,z)  
= XPBDRC(i,z)/XPBDC(i);

COEFFICIENT (ALL, z, SEC) XPBDR(z)  
# exports from region z, expressed in common currency #;  
FORMULA (ALL, z, SEC)  
XPBDR(z)  
= SUM(i, IND, XPBDRC(i,z));



---

COEFFICIENT XPBD  
# exports from all regions #;

FORMULA  
XPBD  
= SUM(z, SEC, XPBDR(z));

COEFFICIENT (ALL, z, SEC) (ALL, i, IND) S\_XPBDR\_C(i,z)  
# share of commodity i in exports from region z #;

FORMULA (ALL, z, SEC) (ALL, i, IND)  
S\_XPBDR\_C(i,z)  
= VALEXP(i,z)/EXPCFB(z);

COEFFICIENT (ALL, z, SEC) (ALL, i, IND) (ALL, s, SEC) MPSCNMRC(s,i,z)  
# imports of commodity i from region s into region z, computed at source, non-margin #;

FORMULA (ALL, z, SEC) (ALL, i, IND) (ALL, s, SEC)  
MPSCNMRC(s,i,z)  
= VALEXPS(i,s,z)/ECRT(s);

COEFFICIENT (ALL, z, SEC) (ALL, i, IND) MPSCNMRC(i,z)  
# imports of commodity i into region z, computed at source, non-margin #;

FORMULA (ALL, z, SEC) (ALL, i, IND)  
MPSCNMRC(i,z)  
= SUM(s, SEC, MPSCNMRC(s,i,z));

COEFFICIENT (ALL, z, SEC) (ALL, i, TRADE) MPSCMGRC(i,z)  
# imports of commodity i into region z, computed at source, margin #;

FORMULA (ALL, z, SEC) (ALL, i, TRADE)  
MPSCMGRC(i,z)  
= SUM(j, IND, SUM(s, SEC, FREIGHT(j,z,s)));

COEFFICIENT (ALL, z, SEC) (ALL, i, IND) MPSCRC(i,z)  
# imports of commodity i into region z, computed at source #;

FORMULA (ALL, z, SEC) (ALL, i, TRADE)  
MPSCRC(i,z)  
= MPSCNMRC(i,z) + MPSCMGRC(i,z);

FORMULA (ALL, z, SEC) (ALL, i, NONTRD)  
MPSCRC(i,z)  
= MPSCNMRC(i,z);

---

---

ZERODIVIDE DEFAULT RECIP\_NSEC;  
 COEFFICIENT (ALL, z, SEC) (ALL, i, IND) (ALL, s, SEC) S\_MPSCRC\_S(s,i,z)  
 # share of source s in imports of commy i into regn z, compd at source #;  
 FORMULA (ALL, z, SEC) (ALL, i, IND) (ALL, s, SEC)  
 S\_MPSCRC\_S(s,i,z)  
 = MPSCNMRCs(s,i,z)/MPSCRC(i,z);

ZERODIVIDE DEFAULT 0.0;  
 COEFFICIENT (ALL, z, SEC) (ALL, i, IND) S\_MPSCRC\_T(i,z)  
 # share of freight in imports of commy i into regn z, compd at source #;  
 FORMULA (ALL, z, SEC) (ALL, i, TRADE)  
 S\_MPSCRC\_T(i,z)  
 = MPSCMGRC(i,z)/MPSCRC(i,z);  
 FORMULA (ALL, z, SEC) (ALL, i, NONTRD)  
 S\_MPSCRC\_T(i,z)  
 = 0.0;

COEFFICIENT (ALL, z, SEC) MPSCR(z)  
 # imports into region z, at common-currency prices #;  
 FORMULA (ALL, z, SEC)  
 MPSCR(z)  
 = SUM(i, IND, MPSCRC(i,z));

COEFFICIENT (ALL, z, SEC) (ALL, i, IND) S\_MPSCR\_C(i,z)  
 # share of commodity i in imports into region z (compd at source) #;  
 FORMULA (ALL, z, SEC) (ALL, i, IND)  
 S\_MPSCR\_C(i,z)  
 = MPSCRC(i,z)/MPSCR(z);

!\*\*\*\*\*!  
 EQUATIONS  
 \*\*\*\*\*!

EQUATION

TERMS\_OF\_TRADE

# terms of trade #  
 (ALL, z, SEC)  
 tt(z)  
 = (epi(z) - er(z)) - imppi(z);

---

EXPT\_PRICE\_REG\_COM

# price index for exports, by region and commodity #  
 (ALL, z, SEC) (ALL, i, IND)  
 pxrc(i,z)  
 = SUM(v, SEC, SES(i,z,v)\*pes(i,z,v)) + SESM(i,z)\*pd(i,z) - er(z);

EXPT\_PRICE\_COM

# world price index for exports, by commodity #  
 (ALL, i, IND)  
 pxc(i)  
 = SUM(z, SEC, S\_XPBDC\_R(i,z)\*pxrc(i,z));

WORLD\_EXPT\_PRINDEX

# world export price index #  
 XPBD\*wepi  
 = SUM(z, SEC, XPBDR(z)\*(epi(z) - er(z)));

CTTCR\_REG\_COM

# contribution to ctcr of commodity i #  
 (ALL, z, SEC) (ALL, i, IND)  
 ctterc(i,z)  
 = (S\_XPBDR\_C(i,z) - S\_MPSCR\_C(i,z))\*(pxc(i) - wepi);

CONTRN\_TTRADE\_COMMY

# contribution to terms of trade of price variation between commodities #  
 (ALL, z, SEC)  
 cttr(z)  
 = SUM(i, IND, ctterc(i,z));

CTTVXR\_REG\_COM

# contribution to cttvrx of commodity i #  
 (ALL, z, SEC) (ALL, i, IND)  
 cttvxrc(i,z)  
 = S\_XPBDR\_C(i,z)\*(pxrc(i,z) - pxc(i));

CONTRN\_TTRADE\_VAR\_X

# contribution to terms of trade of export variety price variation #  
 (ALL, z, SEC)  
 cttvxr(z)  
 = SUM(i, IND, cttvxrc(i,z));

---

IMPRINDEX\_NONTRD

# price index for imports of non-margin commies, by regn and commy #

(ALL, z, SEC) (ALL, i, IND)

pmrc(i,z)

= SUM(s, SEC, S\_MPSCRC\_S(s,i,z)\*(pes(i,s,z) - er(s))) + S\_MPSCRC\_T(i,z)\*pt;

CTTVMR\_REG\_COM

# contribution to cttvmr of commodity i #

(ALL, z, SEC) (ALL, i, IND)

cttvmerc(i,z)

= S\_MPSCR\_C(i,z)\*(pmrc(i,z) - pxc(i));

CONTRN\_TTRADE\_VAR\_M

# contribution to terms of trade of import variety price variation #

(ALL, z, SEC)

cttvmr(z)

= SUM(i, IND, cttvmrc(i,z));