

Factor Market Flexibility and the Implications of Trade Policy Reforms

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1. Introduction

Analyses of trade policy reforms between developed and developing regions using global CGE models often conclude that while the absolute gains for developed economies outweigh the absolute gains for developing countries the relative gains for developing countries are larger. However analyses of the results typically demonstrate that the extent of structural change in developing countries is many times greater than in developed economies; in previous studies the authors have found that the proportions of factors reallocated to different activities in developing economies can be in excess of one hundred times the proportions reallocated in developed economies. Moreover explorations of the properties of these simulation exercises demonstrate that the factor reallocations are often a critical determinant of the results; for instance if factor use by activities is fixed, an extreme assumption, then typically there are no gains in developing economies.

In the majority of global CGE models it is commonly assumed that factors are perfectly mobile across activities irrespective of whether full employment or excess supplies of factors are assumed. Such an assumption implicitly assumes that each factor is perfectly homogenous and that differences in the marginal productivities of a factor across activities are solely attributable to activity specific differences. Consequently factors are assumed to be perfectly mobile and reallocations across activities are costless. Furthermore it is assumed that factors in different segments, e.g., skilled and unskilled labour, cannot be reallocated across segments. Arguably these assumptions are relatively poor representations of the operation of actual labour markets.

An alternative assumption, used in the GTAP model among others, is that factor reallocations are 'sluggish' and that constant elasticity of transformation (CET) functions control factor reallocations: most frequently it is used for land and the authors know of no cases where it has been applied to labour factors. This assumption evidently impedes factor reallocations and thereby reduces the flexibility of factor markets. But it is not without limitations. In particular the limitations imposed on price definitions/linkages by CET functions are known and the units with which factors are measured, and hence that are used to clear factor markets, are opaque.

This study adapts a typical global CGE model, the GLOBE model, so as to increase the factor market segments and then to allow imperfect reallocation between related segments. Thus, for instance, unskilled labour can be segmented between groups of activities, e.g., agriculture, manufacturing and services, and then reallocations between the different unskilled labour segments are controlled by migrations functions where the elasticities of transformation are less than infinity and market clearing for unskilled labour is defined across the related segments. Within the segments the perfect mobility assumption is retained.

The simulations used to illustrate the implications of the changes in model formulation are stylised representations of a Doha development agenda (DDA) agreement. The choice of simulations is deliberately simple since they are a class of simulations for which the properties are well known and understood. The data are a twenty sector, five factor and fifteen region aggregation of GTAP 8 for 2007.

The preliminary results indicate that the potential gains from a stylised DDA decline for all regions when compared to results achieved when the ‘standard’ assumption of full factor mobility is imposed. This is an expected conclusion: any impediment to structural changes in response to changed incentives will, by definition, have negative implications. However the implications for developing and developed regions differ substantially. Developed countries continue to experience positive gains even with very low migration elasticities whereas developing countries, even when full employment is assumed, often lose all gains even at relatively high elasticities.

Additional simulations to explore the relative importance to the results of the extent of segmentation versus the migration elasticities are required to understand more fully the behaviour of the modified model.

2. Factor Market Operations in CGE Models

2.1 Perfect Mobility

2.2 Sluggish

3. Factor Market Segmentation and Imperfect Mobility

4. Data and Model

The data used in the model were derived from the GTAP database (see Hertel, 1997) using a three dimensional Social Accounting Matrix (SAM) method for organising the data. Details of the method used to generate a SAM representation are reported in McDonald and Thierfelder (2004a) while a variety of reduced form representations of the SAM and methods for augmenting the GTAP database are reported in McDonald and Thierfelder (2004b) and McDonald and Sonmez (2004) respectively. Detailed descriptions of the data are provided elsewhere so the discussion here is limited to the general principles.

Global Social Accounting Matrix

The Global SAM can be conceived of as a series of single region SAMs that are linked through the trade accounts; it is particularly valid in the context of the GTAP database to note that the ONLY way in which the regions are linked directly in the database is through commodity trade transactions although there are some indirect links through the demand and supply of trade and transport services. Specifically the value of exports, valued free on board (*fob*) from source x to destination y must be exactly equal to the value of imports valued *fob* to destination y from source x , and since this holds for all commodity trade transactions the sum of the differences in the values of imports and exports by each region must equal zero. However the resultant trade balances do not fully accord with national accounting conventions because other inter regional transactions are not recorded in the database (see McDonald and Sonmez, 2004). A description of the transactions recorded in a representative SAM for a typical region in the database is provided in Table 1.

A SAM is a transactions matrix; hence each cell in a SAM simply records the values of the transactions between the two agents identified by the row and column accounts. The selling agents are identified by the rows, i.e., the row entries record the incomes received by the identified agent, while the purchasing agents are identified by the columns, i.e., the column entries record the expenditures made by agents. As such a SAM is a relatively compact form of double entry bookkeeping that is complete and consistent and can be used to present the National Accounts of a country in a single two-dimensional matrix (see UN, 1993, for a detailed explanation of the relationship between conventional and SAM presentations of National Accounts). A SAM is complete in the sense that the SAM should record ALL the transactions within the production boundary of the National Accounts, and consistent in the sense that income transactions by each and every agent are exactly matched by expenditure

transactions of other agents. A fundamental consequence of these conditions is that the row and column totals of the SAM for each region must be identical, and hence the SAM provides a complete characterisation of current account transactions of an economy as a circular (flow) system. In the context of a global SAM the complete and consistent conditions need extending to encompass transactions between regions; this simply requires that each and every import transaction by a region must have an identical counterpart export transaction by another region. This is enough to ensure that the resultant global SAM provides a characterisation of current account transactions of the global economy as a circular (flow) system.

Table 1 Social Accounting Matrix for a Region in the Global Social Accounting Matrix

	Commodities	Activities	Factors	Households	Government	Capital	Margins	Rest of World	Totals
Commodities	0	Combined Intermediate Use Matrix	0	Private Consumption	Government Consumption	Investment Consumption	Exports Margins (fob)	Exports of Commodities (fob)	Total Demand for Commodities
Activities	Domestic Supply Matrix	0	0	0	0	0	0	0	Total Domestic Supply by Activity
Factors	0	Expenditure on Primary Inputs	0	0	0	0	0	0	Total Factor Income
Households	0	0	Distribution of Incomes	Factor0	0	0	0	0	Total Household Income
Government	Taxes on Commodities	Taxes on Production	on Direct Taxes	Income Direct Taxes	0	0	0	0	Total Government

			Taxes on Factor Use							Income
Capital	0	0	Depreciation Allowances	Household Savings	Government Savings	0	Balance Margins Trade	on Foreign Savings		Total Savings
Margins	Imports of Trade and Transport Margins	0	0	0	0	0	0	0		Total Income from Margin Imports
Rest World	Imports of Commodities (<i>fob</i>)	0	0	0	0	0	0	0		Total Income from Imports
Totals	Total Supply of Commodities	Total Expenditure on Inputs Activities	Total Factor Expenditure	Total Household Expenditure	Total Government Expenditure	Total Investment	Total Expenditure on Margin Exports	Total Expenditure on Exports		

Given these definitions of a SAM the transactions recorded in a SAM are easily interpreted. In Table 1 the row entries for the commodity accounts are the values of commodity sales to the agents identified in the columns, i.e., intermediate inputs are purchased by activities (industries etc.), final consumption is provided by households, the government and investment demand and export demand is provided by the all the other regions in the global SAM and the export of margin services. The commodity column entries deal with the supply side, i.e., they identify the accounts from which commodities are purchased so to satisfy demand. Specifically commodities can be purchased from either domestic activities – the domestic supply matrix valued inclusive of domestic trade and transport margins – or they can be imported – valued exclusive of international trade and transport margins. In addition to payments to the producing agents – domestic or foreign – the commodity accounts need to make expenditures with respect to the trade and transport services needed to import the commodities and any commodity specific taxes.

The GTAP database provides complete coverage of bi lateral transactions in commodities – these are valued free on board (*fob*) - but only provides partial coverage of transactions in trade and transport margins. Specifically the imports of trade and transport margins by each region are directly associated with the imports of specific commodities, hence for each commodity import valued *fob* the source and destination regions are identified and the value of each trade and transport margin service used is identified. The sum of the values of trade and transport services and the *fob* value of the commodity imports represent the carriage insurance and freight (*cif*) paid value of each imported commodity. But the source regions of the trade and transport services are NOT identified, and similarly the values of exports of trade and transport services by a region do NOT identify the destination regions. To overcome this lack of information an artificial region called Globe is included in the database. This region collects together all the exports of trade and transport services by other regions as its imports and then exports these to other regions to satisfy their demand for the use of trade and transport services associated with commodity imports. By construction the value of imports by Globe for each and every trade and transport margin service must exactly equal the value of exports for the corresponding trade and transport service. However this does not mean that the trade balance between Globe and each and every region must exactly balance, rather it requires that the sum of Globe’s trade balances with other regions is exactly equal to zero.

An important feature of the construction of a SAM can be deduced from the nature of the entries in the commodity account columns. By definition the column and row totals must

equate and these transaction totals can be expressed as an implicit price times a quantity, and the quantity of a commodity supplied must be identical to the quantity of a commodity demanded. The column entries represent the expenditures incurred in order to supply a commodity to the economy and hence the implicit price must be exactly equal to the average cost incurred to supply a commodity. Moreover since the row and column totals equate and the quantity represented by each corresponding entry must be same for the row and column total the implicit price for the row total must be identical to average cost incurred to supply the commodity. Hence the column entries identify the components that enter into the formation of the implicit prices in the rows, and therefore identify the price formation process for each price in the system. Typically a SAM is defined such that the commodities in the rows are homogenous and that all agents purchase a commodity at the same price.

Total income to the activity accounts is identified by the row entries. In the simple representation of production in the GTAP database each activity makes a single commodity and each commodity is made by a single activity, which means that the domestic supply matrix is a diagonal (square) matrix. The expenditures on inputs used in production are recorded in the activity columns. Activities use intermediate inputs, which in this version of the database are record as composites of domestically produced and imported commodities, primary inputs and pay taxes on production and factor use. For each region the sum of the payments to primary inputs and on production and factor use taxes by activity is equal to the activity's contribution to the value added definition of GDP while the sum over activities equals the region's value added measure of GDP.

The remaining accounts relate to the institutions in the SAM. All factor incomes are distributed to the single private household after making allowance for depreciation of physical capital and the payment of direct (income) taxes on factor incomes. Incomes from factor sales are also the sole source of income to the household account. Three categories of expenditures by the household account are recorded; direct (income) taxes, savings and consumption. The government receives incomes from commodity taxes, production taxes and direct taxes on factor and household incomes, and uses that income to pay for consumption and for savings. In the basic form of the database government savings are set to zero for all regions; this stems from the reduced form representation of intra institutional transactions provided by the GTAP database (see McDonald and Thierfelder, 2004b).¹ There are therefore five sources of savings

¹ McDonald and Sonmez (2004) demonstrate that it is straightforward to overcome this limitation of the database. The model described in this paper operates whether the government savings are zero or non-zero.

in each region: depreciation, household/private savings, government savings, balances on trade in margin services and balances on trade in commodities, but only a single expenditure activity – investment (commodity) demand.

As should be apparent from the description of the SAM for a representative region the database is strong on inter regional transactions but relatively parsimonious on intra regional transactions.

Other GTAP Data

In addition to the transactions data the GTAP database contains other data that can be used with this model, and/or variants of the model. The most obviously useful data are the import and primary factor elasticity data used in the GTAP model; the programme used to derive an aggregation of the SAM also contains a routine for aggregating these elasticities for use in this model. However, the GTAP elasticities are only a subset of the elasticities used in this model and it is therefore necessary to provide other elasticities even when using the GTAP elasticity data.

Other data of interest to modellers include estimates of energy usage and emissions and land use (carbon sinks). None of these data are used in this variant of the model.

Database Dimensions

The dimensions of the SAM are determined by the numbers of accounts within each aggregate group identified in Table 1, while the actual numbers of accounts in each group of accounts are defined for version 5.4 to 8.0 of the GTAP database in Table 2. Given the large number of accounts in the SAMs for each region and the relatively large number of regions the total number of cells in the global SAM is very large, although only slightly over 10 percent of the cells actually contain non zero entries; nevertheless this still means that the GTAP database contains some 4 million transaction values, which implies that there are some 8 million possible prices and quantities that can be deduced from the database. Even allowing for the implications of adopting the law of one price for transactions in the rows of each region's SAM and for other ways of reducing the numbers of independent prices and quantities that need to be estimated in a modelling environment, it is clear that the use of the GTAP database without aggregation is likely to generate extremely large models (in terms of the number of equations/variables). Consequently, except in exceptional circumstances all CGE models that use the GTAP data operate with aggregations of the database.

Table 2 Dimensions of the Global Social Accounting Matrix

Account Groups	Sets	Total Number of Accounts			
		GTAP 5.4	GTAP 6.0	GTAP 7.1	GTAP 8
Commodities	<i>C</i>	57	57	57	57
Activities	<i>A</i>	57	57	57	57
Factors	<i>F</i>	5	5	5	5
Taxes	$(2*r) + (1*f) + 3$	164	182	232	266
Other Domestic Institutions	3	3	3	3	3
Margins	$3*r$	234	261	336	387
Trade	<i>R</i>	78	87	112	129
Total		598	652	802	904
Total Number of Cells in the Global SAM		27,893,112	36,984,048	72,038,848	105,420,864

Overview of the Model

Behavioural Relationships

The within regional behavioural relationships are fairly standard in this variant of the model; it is easy to make them more elaborate but the focus in this variant of the model is upon international trade relationships. The activities are assumed to maximise profits using technology characterised by Constant Elasticity of Substitution (CES) and/or Leontief production functions between aggregate primary inputs and aggregate intermediate inputs, with CES production functions over primary inputs and Leontief technology across

intermediate inputs. The household maximises utility subject to preferences represented by a Stone-Geary utility function, i.e., a linear expenditure system, having first paid income taxes and having saved a fixed proportion of after tax income.²

The Armington assumption is used for trade. Domestic output is distributed between the domestic market and exports according to a two-stage Constant Elasticity of Transformation (CET) function. In the first stage a domestic producer allocates output to the domestic or export market according to the relative prices for the commodity on the domestic market and the composite export commodity, where the composite export commodity is a CET aggregate of the exports to different regions – the distribution of the exports between regions being determined by the relative export prices to those regions. Consequently domestic producers are responsive to prices in the different markets – the domestic market and all other regions in the model – and adjust their volumes of sales according relative prices. The elasticities of transformation are commodity and region specific. The CET functions across exports can be switched off so that export supplies are determined by import demands.³

Domestic demand is satisfied by composite commodities that are formed from domestic production sold domestically and composite imports. This process is modelled by a three-stage CES function. At the bottom stage one composite import commodity is a CES aggregate of imports from different regions with the quantities imported from different regions being responsive to relative prices and another composite import commodity is a Leontief aggregate of imports from different regions with the quantities being fixed proportions of the volume of import demand. This second composite commodity is introduced for the treatment of imports whose volumes are small and can, as a consequence have large terms of trade effects. The second level is a Leontief aggregate of the two composite commodities formed at the bottom level, which defines the volumes of composite imports. The top stage defines a composite consumption commodity as a CES aggregate of a domestic commodity and a composite import commodity with the mix being determined by the relative prices. The elasticities of substitution are commodity and region specific.⁴ Hence the optimal ratios of imports to domestic commodities and exports to domestic commodities are determined by first order conditions based on relative prices. The price and quantity systems are described in greater detail below

² With appropriate parameter specification the LES collapses to a Cobb-Douglas specification.

³ Switching off the CET function allows the model to function in a similar manner to the GTAP model.

⁴ This is different to the GTAP model where the elasticities are only commodity specific.

All commodity and activity taxes are expressed as *ad valorem* tax rates, while income taxes are defined as fixed proportions of household incomes. Import duties and export taxes apply to imports and exports, while sales taxes are applied to all domestic absorption, i.e., imports are subject to sequential import duties and sales taxes. Production taxes are levied on the value of output by each activity, while activities also pay taxes on the use of specific factors. Factor income taxes are charged on factor incomes after allowance for depreciation after which the residual income is distributed to households. Income taxes are taken out of household income and then the households are assumed to save a proportion of disposable income. This proportion is either fixed or variable according to the closure rule chosen for the capital account.

Government expenditure consists of commodity (final) demand, which is assumed to be in fixed proportions in real/volume terms. Hence government saving, or the internal balance, is defined as a residual. However, the closure rules for the government account allow for various permutations. In the base case it is assumed that the tax rates and volume of government demand are fixed and government savings are calculated as a residual. However, the tax rates can all be adjusted using various forms of scaling factors; hence for instance the value of government savings can be fixed and one of the tax scalars can be made variable thereby producing an estimate of the constrained optimal tax rate. If the analyst wishes to change the relative tax rates across commodities (for import duties, export taxes and sales taxes) or across activities (for production taxes) then the respective tax rate parameters can be altered via a second adjuster. Equally the volume of government consumption can be changed by adjusting the closure rule with respect the scaling adjuster attached to the volumes of government consumption. The patterns of government expenditure are altered by changing the parameters that controls the pattern of government expenditure (*qgdconst*).

Table 3 Behavioural Relationships for a Global CGE Model

	Commodities	Activities	Factors	Households	Government	Capital	Margins	Rest of World	Prices
Commodities	0	Leontief Input-Output Coefficients	0	Stone-Geary Utility Functions	Fixed Exogenously	Fixed Shares of Savings	Three-Stage CET Functions	Three-Stage CET Functions	Consumer Commodity Price
Activities		Total Supply from Domestic Production	0	0	0	0	0	0	Activity Prices
Factors	0	Two-stage CES Production Functions	0	0	0	0	0	0	Factor Prices
Households	0	0	Fixed of	Shares Factor	0	0	0	0	

	Income								
	Ad valorem								
Government	Ad valorem tax rates	Output and rates	Average tax rates	Average tax rates	0	0	0	0	
	Factor Use								
Capital	0	0	Shares of Factor Incomes	Shares of household income	of Government Savings (Residual)	0	Current Account 'Deficit' Margins Trade	Current onAccount 'Deficit'	
Margins	Fixed Technical Coefficients	0	0	0	0	0	0	0	
Rest of World	Three-Stage CES Functions	0	0	0	0	0	0	0	
Prices	Producer Prices	Value Added Prices							

	Domestic and World Prices for Imports	
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Table 4 Transactions Relationships for a for a Global CGE Model

	Commodities	Activities	Factors	Households
Commodities	0	$(PQD_c * QINTD_c)$	0	$(PQD_c * QCD_c)$
Activities	$(PDS_c * QDS_c)$	0	0	0
Factors	0	$(WF_f * FD_{f,a})$	0	0
Households	0	0	$\sum_f \left(\begin{matrix} hvash_{h,f} \\ *YF_f \end{matrix} \right)$	0
Government	$\left(\begin{matrix} TM_{w,c} * PWM_{w,c} \\ *QMR_{w,c} * ER \end{matrix} \right)$ $\left(\begin{matrix} TE_{w,c} * PWE_{w,c} \\ *QER_{w,c} * ER \end{matrix} \right)$ $(TS_c * PQS_c * QQ_c)$	$(TX_a * PX_a * QX_a)$ $\left(\begin{matrix} TF_{f,a,r} * WF_{f,r} \\ *WFDIST_{f,a,r} * FD_{f,a,r} \end{matrix} \right)$	$\left(\begin{matrix} TYF_{f,r} * \left(\begin{matrix} YF_{f,r} - \\ deprec_{f,r} \end{matrix} \right) \\ *YF_{f,r} \end{matrix} \right)$	$(TYH_h * YH_h)$
Capital	0	0	$(deprec_{f,r} * YF_{f,r})$	$\left(\begin{matrix} YH_{h,r} \\ *(1 - TYH_{h,r}) \end{matrix} \right) * (SHH_{h,r})$

Margins	$(PT_c * QT_{w,c})$	0	0	0
Rest of World	$\begin{pmatrix} PWMFOB_{w,c} \\ *QMR_{w,c} * ER \end{pmatrix}$	0	0	0
Total	$(PQD_c * QQ_c)$	$(PX_a * QX_a)$	YF_f	YH

Table 4 (cont) Transactions Relationships for a for a Global CGE Model

	Government	Capital	Margins	RoW
Commodities	$(PQD_c * QGD_c)$	$(PQD_c * QINVD_c)$	$\begin{pmatrix} PWE_{c,w} * QER_{c,w} \\ *ER \end{pmatrix}$	$\begin{pmatrix} PWE_{c,w} * QER_{c,w} \\ *ER \end{pmatrix}$
Activities	0	0	0	0
Factors	0	0	0	0
Households	0	0	0	0
Government	0	0	0	0
Capital	$(YG - EG)$	0	$(KAPREG * ER)$	$(KAPREG * ER)$

Margins	0	0	0	0
Rest of World	0	0	0	0
Total	<i>YG</i>	<i>INVEST</i>	0	0

Total savings come from the households, the internal balance on the government account and the external balance on the trade account. The external balance is defined as the difference between the value of total exports and total imports, converted into domestic currency units using the exchange rate. In the base model it is assumed that the exchange rates are flexible and hence that the external balances are fixed. Alternatively the exchange rates can be fixed and the external balances can be allowed to vary. Expenditures by the capital account consist solely of commodity demand for investment. In the base solution it is assumed that the shares of investment in total domestic final demand are fixed and that household savings rates adjust so that total expenditures on investment are equal to total savings, i.e., the closure rule presumes that savings are determined by the level of investment expenditures. The patterns of investment volume are fixed, and hence the volume of each commodity changes equiproportionately according to the total values of domestic final demand. It is possible to fix the volumes of real investment and then allow the savings rates, by households, to vary to maintain balances in the capital account, and it is possible to change the patterns of investment by changing the investment parameters (*qinvdconst*).

Price and Quantity Systems for a Representative Region

Price System

The price system is built up using the principle that the components of the ‘price definitions’ for each region are the entries in the columns of the SAM. Hence there are a series of explicit accounting identities that define the relationships between the prices and thereby determine the processes used to calibrate the tax rates for the base solution. However, the model is set up using a series of linear homogeneous relationships and hence is only defined in terms of relative prices. Consequently as part of the calibration process it is necessary set some of the prices equal to one (or any other number that suits the modeller) – this model adopts the convention that prices are

Figure 1 Commodity Price System for a Typical Region

Leontief aggregate of the prices from the source regions.⁵ The user can adjust the definition of a ‘small’ source region when configuring the model; the definition of a ‘large’ source region is then defined as the complement. The region specific import prices are expressed in terms of the domestic currency units after paying for trade and transport services and any import duties. Thus a destination region is assumed to purchase a commodity in a source economy where the price is defined in “world dollars” at the basket exchange rate and is valued free on board (*fob*), i.e., *PWMFOB*. The carriage insurance and freight (*cif*) price (*PWM*) is then defined as the *fob* price plus trade and transport margin services (*margcor*) times the unit price of margin services (*PT*). The *cif* prices are related to the domestic price of imports by the addition of any import duties (*TM*) and then converted into domestic currency units using the nominal exchange rate (*ER*).

The prices for commodities by activities (*PXC*) are determined by the domestic prices (*PD*) and the composite export prices (*PE*). The composite export prices are a CET aggregates of the export prices received by the source economy for exports to specific destinations (*PER*). The prices of the composite exports are determined as aggregates of the domestic prices paid for exports by all those regions that demand exports from this economy under the maintained assumption that exports are differentiated both by their destination region and the ‘regional’ group that the destination region is part of; hence there is a two-stage sub aggregation process whereby exports to like groups so regions are aggregated to form intermediate aggregates of exported commodities, which are then aggregated to form the composite export commodities. This allows for a degree of differentiation by both destination and commodity. The prices paid by the destination regions (*PWE*) are net of export taxes (*TE*) and are expressed in the currency units of the model’s reference region by use of the nominal exchange. Notice how the export prices by region of destination (*PER*), and the intermediate aggregates, are all normalised on 1, but the seeming counterpart of normalising import prices by source region (*PMR*) are not normalised on 1. The link between the regions is therefore embedded in the identification of the quantities exchanged rather than the normalised prices and is a natural consequence of the normalisation process. The CET function can be switched off so that the domestic and export commodities are assumed to be perfect substitutes; this is the assumption in the GTAP model and is an option in this model.

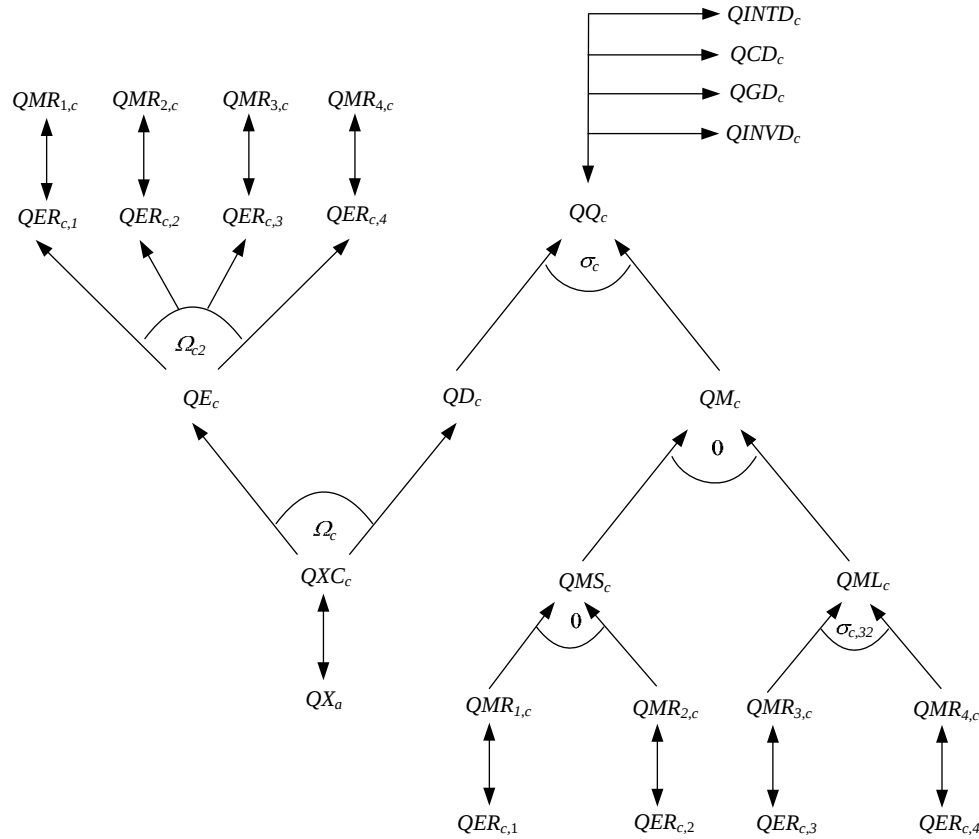
⁵ The impact of adding an additional level of nesting is explored in McDonald and Thierfelder (2006).

The price system also contains a series of equilibrium identities. Namely the *fob* export price (*PWE*) for region x on its exports to region y must be identical to the *fob* import price (*PWMFOB*) paid by region y on its imports from region x . These equilibrium identities are indicated by double headed arrows.

Quantity System

The quantity system for a representative region is somewhat simpler. The composite consumption commodity (QQ) is a mix of the domestically produced commodity (QD) and the composite import commodity (QM), where the domestic and imported commodities are imperfect substitutes, and the imported commodities are differentiated by their source region via a two-stage sub aggregation process whereby imports are differentiated by reference to their shares in the imports of that commodity by the destination region. The composite imported commodity is a Leontief aggregate of the composite imports from regions with ‘small’ (QMS) and ‘large’ (QML) import shares. QMS is a Leontief aggregate of the imports from source regions with ‘small’ import share while QML is a CES aggregate of imports from source regions with ‘large’ import shares. The equilibrium conditions require that the quantities imported from different regions (QMR) are identical to the quantities exported by other regions to the representative region (QER).

Figure 2 Quantity System for a Typical Region



The composite consumption commodity is then allocated between domestic intermediate demands ($QINTD$), private consumption demand (QCD), government demand (QGD) and investment demand ($QINVD$).

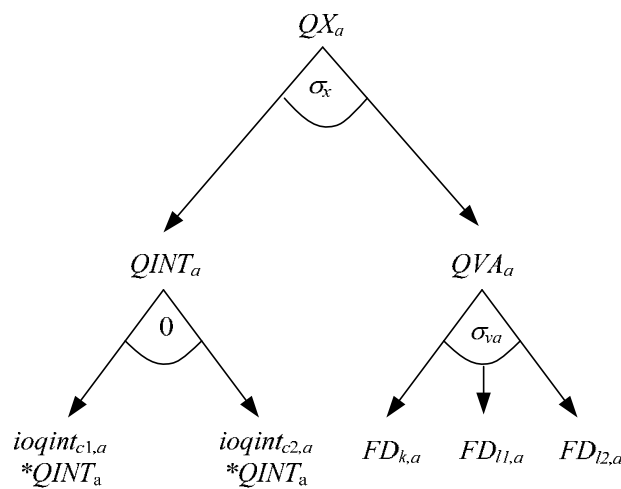
On the output side, domestic output by activity (QX) is identical to domestic commodity output (QXC). Domestically produced commodities are then allocated between the domestic market (QD) and composite export commodities (QE) under the maintained assumption of imperfect transformation. Exports are allocated between the different destination regions (QER) under the maintain assumption of imperfect transformation.

Production System

The production system is set up as a two-stage nest of CES production functions. At the top level aggregate intermediate inputs ($QINT$) are combined with aggregate primary inputs (QVA) to produce the output of an activity (QX). This top level production function can take either CES or

Leontief form, with CES being the default and the elasticities being activity **and** region specific.⁶ Aggregate intermediate inputs are a Leontief aggregation of the individual intermediate inputs where the input-output coefficients (*ioqint*) are defined in terms of input quantities relative to the aggregate intermediate input. The value added production function is a standard CES function over all primary inputs, with the elasticities being activity **and** region specific. The operation of this aggregator function can, of course, be influenced by choices over the closure rules for the factor accounts.

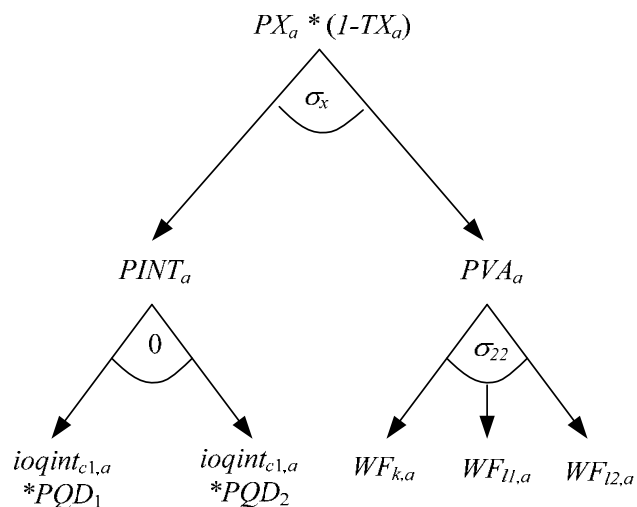
Figure 4 Production Quantity System for a Typical Region



In the price system for production the value added prices (*PVA*) are determined by the activity prices (*PX*), the production tax rates (*TX*), the input-output coefficients (*ioqint*) and the commodity prices (*PQD*). The activity prices are a one to one mapping of the commodity prices received by activities (*PXC*); this is a consequence of the supply matrix being a square diagonal matrix.

Figure 5 Production Price System for a Typical Region

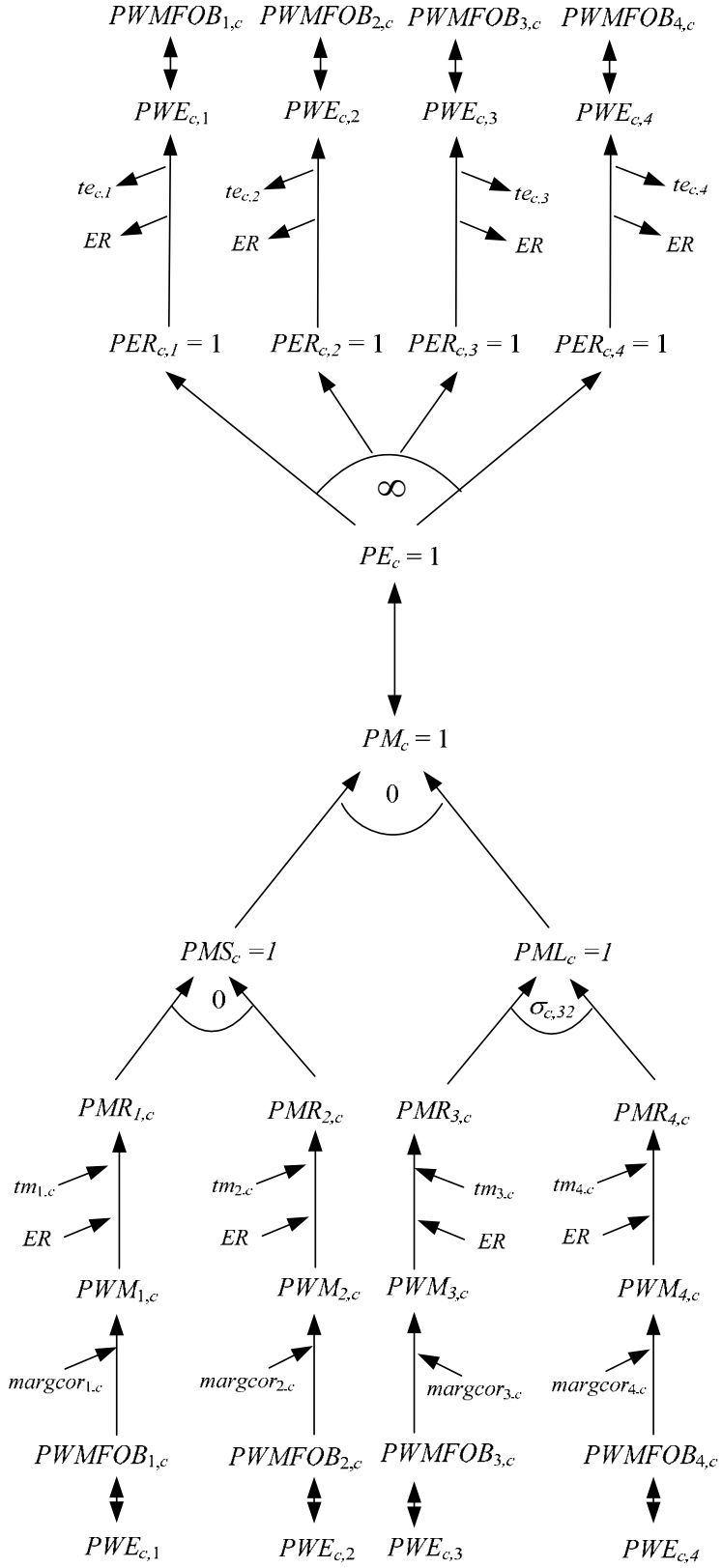
⁶ The model allows the user to specify the share of intermediate input cost in total cost below which the Leontief alternative is automatically selected.



The Globe Region

An important feature of the model is the use of the concept of a region known as Globe. While the GTAP database contains complete bilateral information relating to the trade in commodities, i.e., in all cases transactions are identified according to their region of origin and their region of destination, this is not the case for trade in margins services associated with the transportation of commodities. Rather the GTAP database identifies the demand, in value terms, for margin services associated with imports by all regions from all other regions but does not identify the region that supplies the margin services associated with any specific transaction. Consequently the data for the demand side for margin services is relatively detailed but the supply side is not. Indeed the only supply side information is the total value of exports of margin services by each region. The Globe construct allows the model to get around this shortage of information, while simultaneously providing a general method for dealing with any other transactions data where full bilateral information is missing.

Figure 6 Price System for the Globe Region



The price system for the Globe region is illustrated in Figure 6. On the import side Globe operates like all other regions. The commodities used in trade and transport services are assumed to be differentiated by source region and the proportion of imports accounted for by the source region. Thus a two-level Leontief and CES aggregation nest is used. It is assumed that imports of trade and transport services can *potentially* incur trade and transport margins (*margcor*) and face tariffs (*TM*); in fact the database does not include any transport margins or tariff data for margin services in relation to the destination region, although they can, and do, incur export taxes levied by the exporting region.

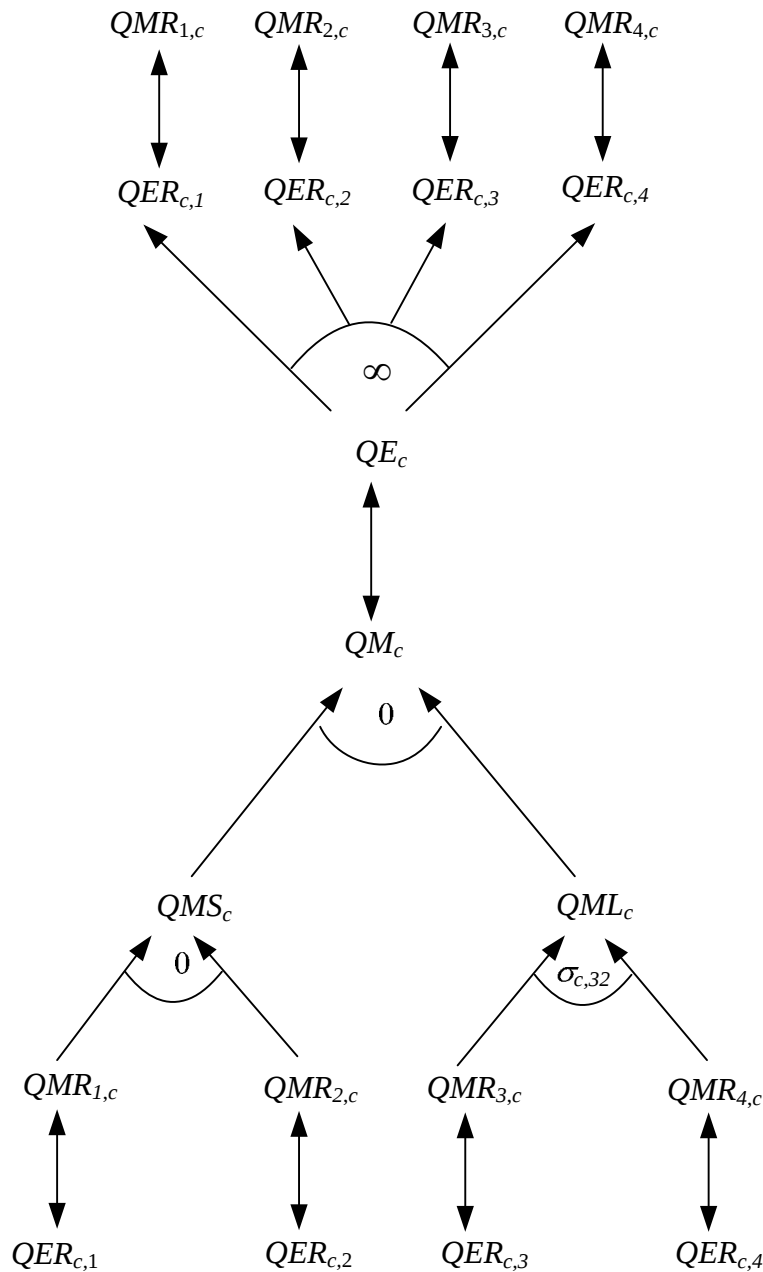
The export side is slightly different. In effect the Globe region is operating as a method for pooling differentiated commodities used in trade and transport services and the only differences in the use of trade and transport services associated with any specific import are the quantities of each type of trade service used and the mix of types of trade services. Underlying this is the implicit assumption that each type of trade service used is homogenous, and should be sold therefore at the same price. Hence the export price system for Globe needs to be arranged so that Globe exports at a single price, i.e., there should be an infinite elasticity of substitution between each type of trade service exported irrespective of its destination region. Therefore the average export price (*PE*) should equal the price paid by each destination region (*PER*), which should equal the export price in world currency units (*PWE*) and will be common across all destinations (*PT*).

The linked quantity system contains the same asymmetry in the treatment of imports and exports by Globe (see Figure 7). The imports of trade and transport commodities are assumed to be differentiated by region and the proportion of imports accounted for by the source region, hence the elasticity of substitution is greater than or equal to zero but less than infinity, while the exports of trade and transport commodities are assumed to be homogenous and hence the elasticities of transformation are infinite.

One consequence of using a Globe region for trade and transport services is that Globe runs trade balances with all other regions. These trade balances relate to the differences in the values of trade and transport commodities imported from Globe and the value of trade and transport commodities exported to Globe; however the sum of Globe's trade balances with other regions must be zero since Globe is an artificial construct rather than a real region. But the demand for

trade and transport services by any region is determined by technology, i.e., the coefficients *margcor*, and the volume of imports demanded by the destination region. This means that the prices of trade and transport commodities only have an indirect effect upon their demand – the only place these prices enter into the import decision as a variable is as a partial determinant of the difference between the *fob* and *cif* valuations of other imported commodities. Consequently the primary market clearing mechanism for the Globe region comes through the quantity of trade and transport commodities it chooses to import.

Figure 7 Quantity System for the Globe Region



The Globe concept has other potential uses in the model. All transactions between regions for which there is an absence of full bilateral information can be routed through the Globe region. While this is not a ‘first best’ solution, it does provide a ‘second best’ method by which augmented versions of the GTAP database can be used to enrich the analyses of international trade in a global model prior to availability of full bilateral transactions data (see McDonald and Sonmez (2006) for an application).

normalised at the level of the CES and CET aggregator functions PQS , the supply price of the domestic composite consumption commodity and PXC , the producer price of the composite domestic output. The price system for a typical region in a 4-region global model is illustrated by Figure 1 – note that this representation abstracts from the Globe region.

5. Experiments

The policy experiments are designed to provide a stylised representation of the DDA trade reforms with respect to market access, export subsidies and domestic support programmes. In line with the basic principles of the DDA, the guiding presumption for market access is that the greater the degree of protection the greater the degree of reduction in the distortion, while export subsidies are removed in their entirety and domestic support programmes are reduced substantially.

The ‘full’ DDA simulation involves the following policy changes.

1. Export subsidies - elimination of all export subsidies where export subsidies are defined as negative export tax rates.
2. Market access – reduce export taxes and tariffs.
 - a. Export taxes – elimination of all export taxes by all regions.
 - b. Import duties – 40 percent reduction in import duties by the non rich regions (Rest of Europe, South Africa, Asia, Rest of the World, Rest of SACU, Rest of Africa, Rest of sub Saharan Africa, and Rest of SADC) and by 60 percent for other (rich or developed) regions (the European Union, NAFTA and Japan).
3. Domestic support programmes – 30 percent reduction in rates of domestic support by the non rich regions and by 70 percent for other (rich) regions.

To illustrate the effects of the trade nesting structure on the model results, the scenarios were run for the model with three-level nested CES and CET functions for trade in which regions were grouped into either Developed, Middle Income, or Developing. Elasticities of substitution are derived from the values in the GTAP database. In the three level nest, it is assumed that goods from developed countries are more differentiated than goods from developing countries. To represent this, the regions in the developed countries aggregate have a lower elasticity of substitution than the regions in the developing countries aggregate. In addition, the scenarios were run in a version of the model with two-level nested CES and CET functions for trade in which the elasticity of substitution was the same for imports from and exports to all regions.

The model closures adopted for this study are simple. The basic closure is a full employment balanced macroeconomic closure with unemployed unskilled labour in some regions wherein:

- the exchange rates are flexible;
- the shares of (the value of domestic) absorption by government and investment are fixed;
- the government deficits are fixed and the government budgets are cleared by varying the household income tax rates;
- all factors are fully employed and mobile except for unskilled labour in African economies where surplus unskilled labour is assumed; and
- the regional numéraires are the region specific consumer price indices and the regions in the global numéraire are the EU, NAFTA and Japan.

Two variants on the closure rules were run for purposes of identifying the impact of key assumptions:

- to assess the effect of assuming unemployed unskilled labour in Africa a full employment variant was run; and
- to assess the effect of assuming a flexible exchange rate on African regions, exchange rates were fixed for African regions, and the balances on the trade accounts for each region were flexible.

The effects of varying these assumptions are identified in the text.

When constructing the three level nested CES import demand function, it is assumed that it is more difficult to substitute among aggregate import groups (developed, middle income, and developing). To test the sensitivity of the assumption that goods from developed countries have lower elasticity of substitution than goods from developing countries, i.e. goods from developing countries are more differentiated than goods from developed countries, a version of the model was run in which this is not the case; i.e. in a three level nest, the elasticity of substitution within each aggregate category is the same, only the elasticity of substitution among the aggregate groups differs.

6. Concluding Comments

The preliminary results indicate that the potential gains from a stylised DDA decline for all regions when compared to results achieved when the ‘standard’ assumption of full factor

mobility is imposed. This is an expected conclusion: any impediment to structural changes in response to changed incentives will, by definition, have negative implications. However the implications for developing and developed regions differ substantially. Developed countries continue to experience positive gains even with very low migration elasticities whereas developing countries, even when full employment is assumed, often lose all gains even at relatively high elasticities.

Additional simulations to explore the relative importance to the results of the extent of segmentation versus the migration elasticities are required to understand more fully the behaviour of the modified model.

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