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**The Doha Development Agenda and Africa: Taking
Armington Seriously**

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1. Introduction

A substantial proportion of the hope for beneficial trade reform from the perspective of developing countries has been centred upon the Doha Development Agenda (DDA) (WTO, 2001). While much of this hope foundered with the lack of agreement at the Trade Ministerial meeting at Cancun in late 2003, some hope has been rekindled by the proposals about how the Doha Work Programme might progress that emerged in July 2004 (WTO, 2004). These proposals have formed the basis of much of the empirical research that has emerged since, e.g., the volume by Hertel and Winters (2005), and the conclusions from these studies suggest that the global welfare gains and the extent of poverty alleviation from the DDA may be substantial, but that the distribution of benefits may be skewed to the extent that some countries and/or regions may see little or no net gain from the DDA, and that some of the countries that may lose out include developing countries. Such results are likely to exacerbate the concerns about the trade liberalisation agenda held by many policy makers and advisors, and thereby immediately raise the potential that subsequent negotiations will founder upon risk adverse responses by policy makers.

The implications of the DDA for developing and, especially, least developed countries are largely an empirical matter. Of particular concern are the implications for the world's poorest countries, which are disproportionately concentrated in sub Saharan Africa, and yet it is arguable that African regions have been relatively neglected in published studies of the DDA. This study uses a global computable general equilibrium (CGE) model that is calibrated using the GTAP database (version 6) to partly addresses this matter by using an aggregation of the GTAP that includes five African regions together with seven other regions.

Given that the implications are largely an empirical matter it is pertinent to consider the information from analyses that may or may not be available to policy makers. These analyses often include results from studies undertaken using some form of global CGE model and therefore depend at least partly, upon the behavioural characteristics built in to the models. However the specification of trade relationships as a two level nest following Armington's 'insight' (Armington, 1969), which is typical in global CGE models, e.g., the GTAP model, is questionable, as is the common assumption that the substitution elasticities are invariant across regions. It is argued in this paper that such a specification of trade relations can be interpreted as a contradiction of Armington's 'insight' since it implies that commodities are scarcely differentiated by source. In the context of a global CGE model this may have important implications since it contains an implicit presumption about market access – namely that market

access is not substantively influenced by differences in the ‘place of production’. This contains the inherent consequence that the pattern of any expansion of trade between regions as a consequence of liberalisation will be influenced by trade shares more than the elasticities of substitution, i.e., by current trade patterns.

This has interesting resonances with the literature on the Prebisch-Singer hypothesis and the (empirical) terms of trade literature. As clarified by Singer (1986) the Prebisch-Singer hypothesis was more complex than some of the literature suggests. The hypothesis, according to Singer, can be summarised under 4 headings: i) differences in price elasticities of demand for primary and manufactured commodities; ii) differences in income elasticities of demand for primary and manufactured commodities; iii) technological superiority in ‘developed’ economies; and v) market structure differences. The critical point to emerge from this, in the current context, is a view that the commodities produced by ‘developing’ countries are less differentiated than those produced by the ‘developed’ economies. Whether this view is correct or not, it is definitely a view of the nature of production and trade relationships that attracts substantial support.

The analyses reported in this paper addresses these concerns by using multi level CES and CET functions for modelling import demand and export supply. This more flexible structure is valuable since it allows for the degree of differentiation to be both commodity and region specific while at the same time recognising that the least developed regions may be producing commodities that are less differentiated than those produced by more developed regions. If this is the case the interesting question that emerges is what are the implications for the results of global trade liberalisation scenarios of such patterns of commodity differentiation.

In order to assess this question a series of simulations that are stylised representations of DDA proposals are implemented. As such the objective is not to conduct in-depth analyses of the DDA, rather it is, at this stage, intended to use the stylised representation of a liberalisation inspired by the DDA to address the issue of the impact of different behavioural assumptions inspired by the Armington ‘insight’.

The rest of the paper is organised as follows. The next section discusses the modelling of trade with reference to CGE models. Section three then provides an overview of the model and details about the aggregation of the GTAP database used in this study. The simulations and model closure rules are detailed in section four and this is followed by the results in section 5. The final section offers some concluding comments.

2. Modelling Trade

The basic, or standard, neoclassical trade model presumes that all commodities are tradeable and that all commodities are perfect substitutes and hence that a ‘law of one price’ must hold, i.e., all commodities should have the same price in all markets. Consequently it is possible to invoke a simple border price paradigm (see Timmer, 1986) whereby the domestic prices of all commodities, for a small open economy, are determined ultimately by world prices. The Salter-Swan (or Australian) trade model pointed up the extreme limitations imposed by a presumption that all commodities are tradable, and hence initiated a series of models within which a dichotomy between traded (tradables) and non-traded (non-tradables) commodities was imposed. This approach has much to recommend it, but in part the problem presented by the presumption that all commodities are traded remains; for the subset of commodities that are tradable a ‘law of one price’ must hold. Thus even in a Salter-Swan type model it would be expected that we would observe:

- prices of all traded commodities would be set by world prices;
- minor shifts in policy instruments periodically producing extreme fluctuations in trade patterns;
- complete specialisation; and
- no-cross hauling;

whereas even with extremely disaggregated trade data these features are rarely if every observed. Thus, when such trade models find ‘corner solutions’ (e.g., complete specialisation) and/or extreme fluctuations in relative prices, even when the Salter-Swan model is followed, the empirical validity of the models are seriously questionable.

2.1 The Armington ‘Insight’

The seminal contribution by Armington (1969) proposed a resolution to this problem through the assumption that imported and domestically produced commodities are imperfect substitutes, i.e., commodities are ‘semi-tradable’, which has also been extended to encompass the substitutability between exports and domestic supply (see Dervis *et al.*, 1982). This assumption now dominates the modeling of trade in CGE models and has become increasingly common in partial equilibrium models (see Francois and Hall, 1997). The properties of trade models that adopt the Armington assumption have been extensively analysed (e.g., de Melo and Robinson, 1981 and 1989), although there are questions about the universal appropriateness of the assumption (Alston, *et al.*, 1989; Brown, 1987).

Armington was primarily concerned with providing a theoretically consistent basis for the ‘modified-shares’ approach to modeling trade. This had largely originated with concerns about the results from trade models that presumed the trade shares by partners were approximately constant. This debate resulted in models that forecast trade patterns using a two-stage approach: in the first stage trade shares were forecast using the constant-shares method, in the form of a matrix of shares, and in the second stage the matrix was modified to reflect factors expected to cause changes in shares (see Taplin, 1967). It seems that, to a greater or lesser extent, the early applications of the modified-shares method involved somewhat ill-defined arguments to justify changes in the shares matrices.

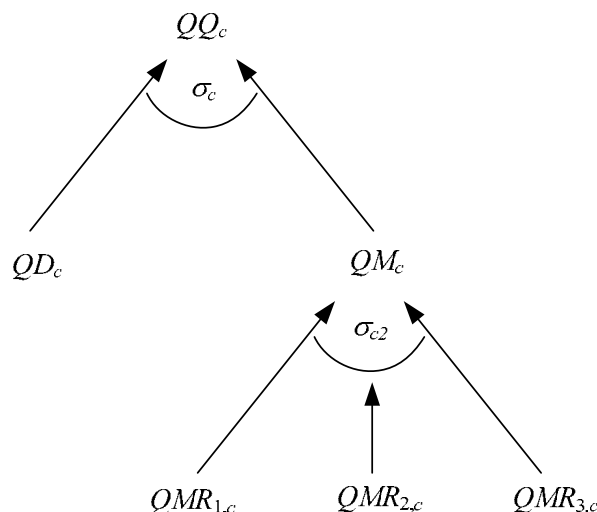
2.2 Modelling Imports and Exports in Global Models

In global CGE models, e.g., Hertel *et al.*, (1997), Rutherford (2005) and van der Mensbrugghe (2003), it is common¹ to find import demand modeled using a two stage CES nesting structure wherein the top level defines an imperfect substitution relationship between the domestically produced commodity demanded on the domestic market and an aggregate imported commodity, where the aggregate import is an aggregate of imperfect substitutes between the commodities imported from all potential trade partners.² This type of nesting structure is illustrated in Figure 1 for a case where there are three trading partners – 1, 2 and 3. At the bottom level the imports for commodity type c from the trade partners, $QMR_{r,c}$ are aggregated as imperfect substitutes to form the aggregated import, QM_c , that is then aggregated as an imperfect substitute for the domestic commodity, QD_c , to form the composite commodity supplied to the domestic market.

¹ As far as is known all global CGE models use the equivalent of a two stage nested structure; other characteristics of the modelling of trade across different models, e.g., with respect to elasticities of substitution, are not always clear in the available documentation.

² There are differences in the treatment between the cited models, e.g., the GTAP model allows agent specific substitution,

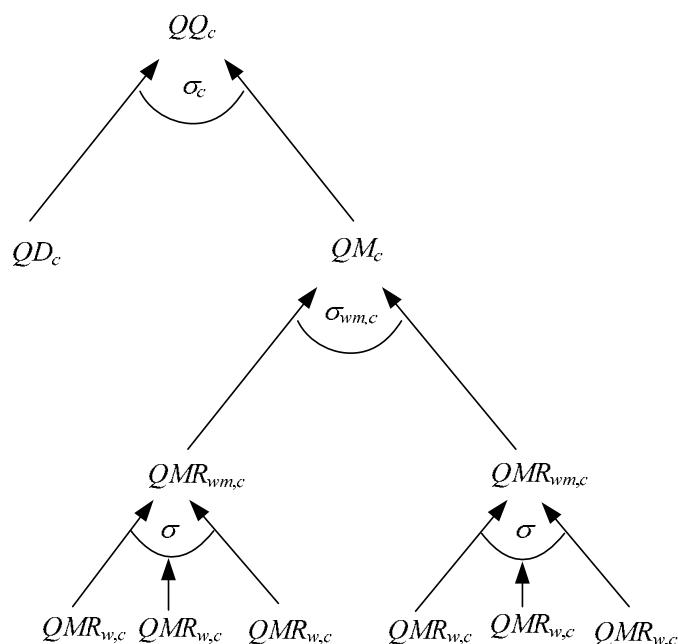
Figure 1 **Two Stage Nesting Structure**



This approach to the modelling of international trade is consistent with the simplification proposed by Armington (1969, pp 167-8), but does require, as Armington noted, the twin assumptions that “(a) the elasticities of substitution in each market are constant and (b) the elasticity of substitution between any two products competing in a market is the same as that between any other pair of products competing in the same market” (p 167).

However during the first three sections of Armington’s paper a general approach is adopted; namely products are “distinguished not only by their kind – e.g., machinery, chemicals – but also by their place of production” (p 159). It was a response to the practical problem of dealing with very large numbers of differentiated products that Armington made the twin assumptions that allow a major simplification of the problem. However there are no compelling or absolute reasons to believe that either or both of these simplifying assumptions are always, if ever, appropriate. In particular it is arguable that the assumption of common elasticities between competing products supplied from different regions may be particularly restrictive. For instance while it may be reasonable to assume common substitution elasticities between products supplied by developed countries the substitution elasticities between products supplied by developed and least developed economies may not be common, even if the substitution elasticities between products supplied by the least developed economies are common.

Figure 2 **Three Stage Nesting Structure**



One way to address this possibility is illustrated in Figure 2, for the case where there are 6 trading partners that fall into two groups within which the substitution elasticities are common but that the substitution elasticities differ between the two groups. At the bottom (third) level the imports for commodity type c from the trade partners, $QMR_{w,c}$, are aggregated as imperfect substitutes to form the aggregated imports from each group of regions, $QMR_{wm,c}$, which are then aggregated as imperfect substitutes at the second level to form an aggregated import, QM_c , that is then aggregated as an imperfect substitute for the domestic commodity, QD_c , to form the composite commodity supplied to the domestic market.

Clearly this is only one of many alternative approaches. For instance, it could be assumed that each commodity is differentiated by both source and destination and hence the sub-groups required for a three-level nest could be regarded as overly restrictive – this would be consistent with the general approach in sections II and III of Armington's original paper. Equally it might be argued that different functional forms may offer benefits, e.g., an AIDS function, although it is arguable that nested CES functions can adequately reflect the characteristics of more flexible functional forms (Perroni and Rutherford, 1995). Ultimately however the issue remains that addressed by Armington: how to define an appropriate simplification that provides a theoretically consistent method by which trade shares would be modified in response to defined economic signals.

3. Data and Model

3.1 GTAP data: aggregation and descriptive statistics

The data for this study are derived from the GTAP database version 6.0, which is benchmarked to the year 2001 (see McDougall and Dimanaran, 2005). The form of the database used for this study is a Social Accounting Matrix (SAM) representation of the Global Trade Analysis Project (GTAP) database version 5.4 (see McDonald and Thierfelder, 2004, for a detailed description of the core database). The GTA project produces the most complete and widely available database for use in global computable general equilibrium (CGE) modelling; indeed the GTAP database has become generally accepted as the preferred database for global trade policy analysis and is used by nearly all the major international institutions and many national governments. Hertel (1997) provides an introduction to both the GTAP database and its companion CGE model. The precise version of the database used as the starting point for this study is a reduced form global SAM representation of the GTAP data.

The aggregation used for this model is a 28 sector (commodities and activities) by 12 region, with 4 factors aggregation of the GTAP database. The accounts in the SAM are detailed in Table 1, and the aggregation mapping is provided in the Appendix. Because of the emphasis on food and agriculture in the DDA the aggregation seeks to provide a broad coverage of sectors with some bias to agriculture – 9 sectors – and food – 5 sectors – with a balanced coverage of the other trade sectors. The regional aggregation reflects more the specific objectives of this study; there are 5 African regions and 3 (broadly) OECD regions. The relatively large number of regions for Africa allow for deeper insights into the impacts upon those economies of variations in the number of nests in the behavioural modelling of trade relations.

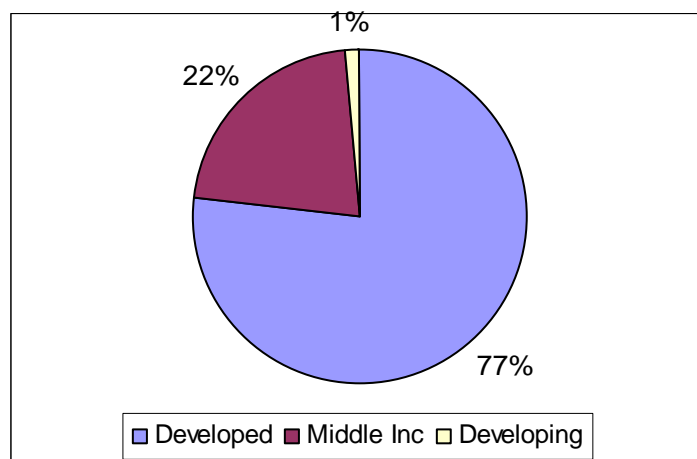
Table 1 **SAM and Model Accounts**

Sectors		Regions
Wheat	Dairy products	European Union
Other Cereals	Sugar	Rest of Europe
Vegetables fruits and nuts	Other food products	NAFTA
Oil seeds	Beverages and tobacco	South Africa
Sugar cane and beet	Textiles and apparel	Japan
Other crops	Wood products	Asia
Cattle sheep goats horses	Petroleum chemicals and minerals	Rest of the World
Other animal products	Metal products	Globe
Raw milk	Vehicles and transport	Rest of SACU
Forestry	Other manufactures	Rest of Africa
Fishing	Utilities	Rest of sub Saharan Africa
Coal oil and gas	Construction	Rest of SADC
Minerals	Trade and transport	Factors
Meat products	Services	Land and resources
		Unskilled labour
		Skilled labour
		Capital

Descriptive Statistics

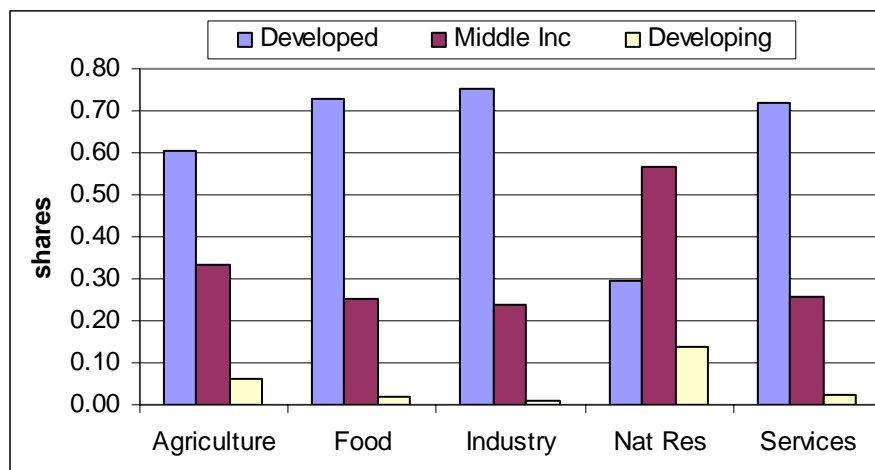
The developed countries, an aggregate of the regions EU, Rest of Europe, North America, and Japan, account for 77% of global GDP (see figure 3). In contrast, the developing countries (Rest of Africa, Rest of Sub-Saharan Africa, and Rest of SADC), account for 1% of global GDP and the middle income countries (South Africa, Rest of SACU, Asia, and Rest of World) account for 22% of global GDP.

Figure 3 **Global GDP Shares**



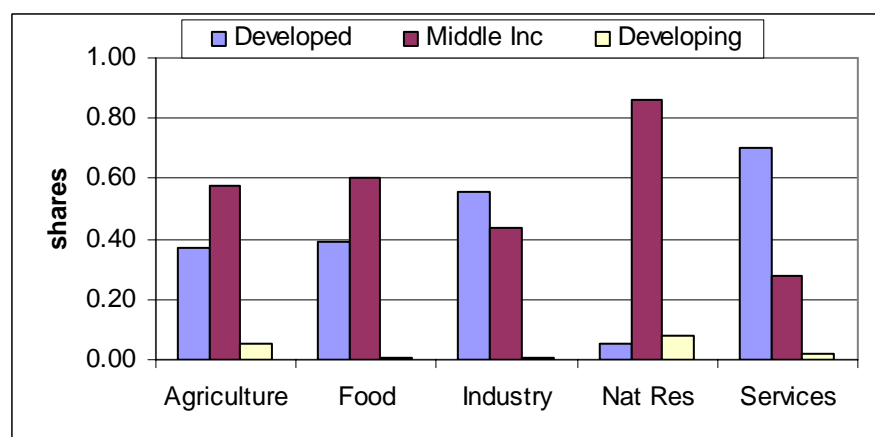
World trade is primarily with the developed countries. For example the developed countries import 60 percent of their agriculture and between 70 and 75 percent of food, industry and services from other developed countries. Natural resources are imported primarily from middle income countries.

Figure 4 **Import Shares, Developed Countries**



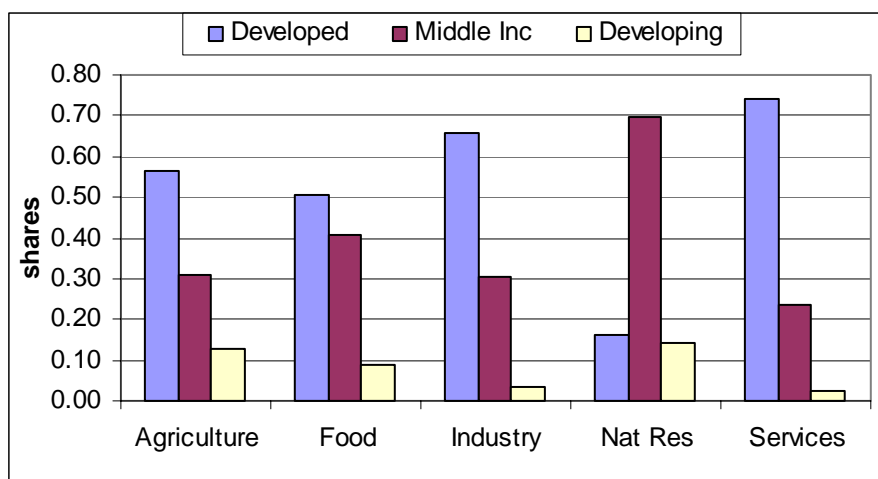
Middle income countries depend more upon other middle income countries for agriculture, food, and natural resource imports. They rely on developed countries for imports of services and industry.

Figure 5 **Import Shares, Middle Income Countries**



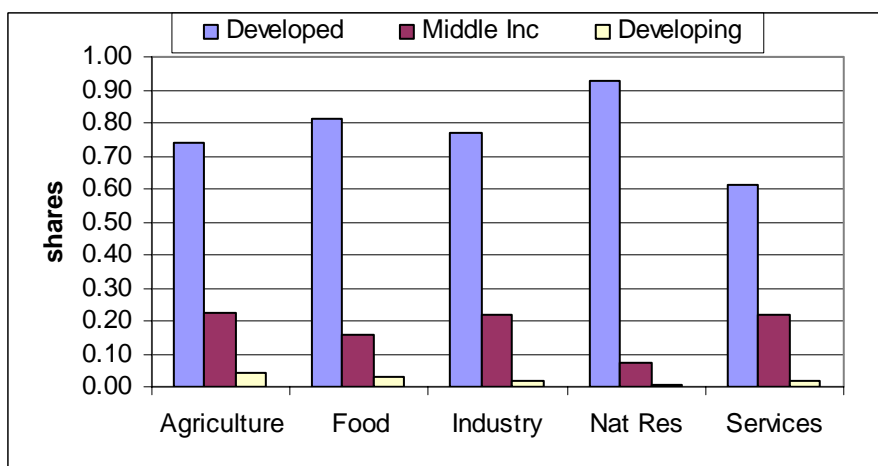
Developing countries follow the same import pattern as developed countries: they rely on the developed countries for imports of all goods except natural resources, which come from middle income countries. The import shares from other developing countries are quite low, ranging from three percent in industry and services to 14 percent in natural resources.

Figure 6 **Import Shares, Developing Countries**



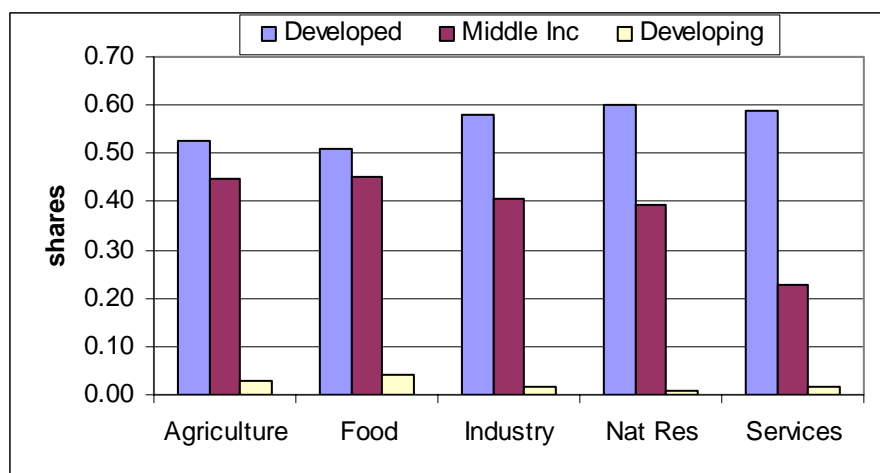
As seen in figure 7, developed countries export primarily to other developed countries, with very little exports to middle income countries and less to developing countries.

Figure 7 **Export Shares, Developed Countries**



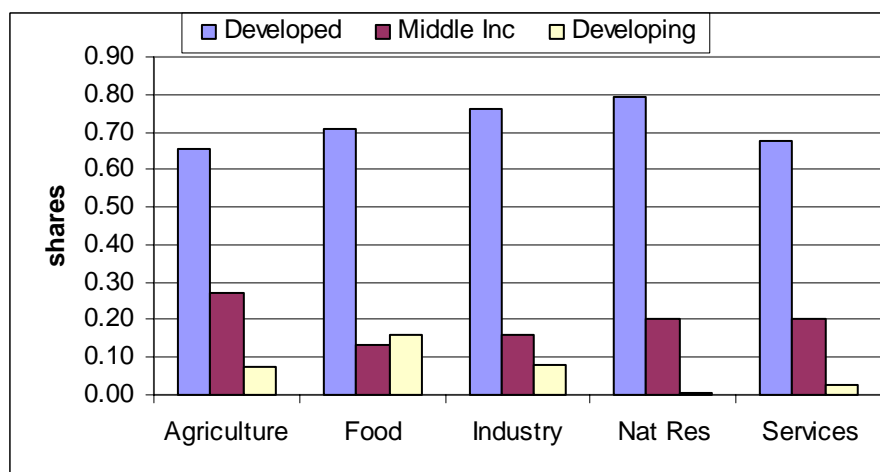
Middle income countries also export the most to developed countries; however, they are more diversified than developed countries and have more trade with other middle income regions.

Figure 8 **Export Shares, Middle Income Countries**



Developing countries rely on developed countries to sell their exports. This suggests that trade policies in developed countries matter more for developing countries than do trade policies in other regions.

Figure 9 **Export Shares, Developing Countries**



3.2 Globe CGE Model

This model is a member of the class of computable general equilibrium (CGE) models that are descendants of the approach to CGE modeling described by Dervis *et al.*, (1982). The implementation of this model, using the GAMS (General Algebraic Modeling System) software, is a direct descendant and development of the single country models devised in the late 1980s and early 1990s, particularly those models reported by Robinson *et al.*, (1990), Kilkenny (1991) and

Devarajan *et al.*, (1990), and the multi-country model developed by Robinson and co-workers to analyse NAFTA in the early 1990s (see Lewis *et al.*, 1995, for a later application).

The model is a SAM based CGE model, wherein the SAM serves to identify the agents in the economy and provides the database with which the model is calibrated. Since the model is SAM based it contains the important assumption of the law of one price, i.e., prices are common across the rows of the SAM. The SAM also serves an important organisational role since the groups of agents identified by the SAM structure are also used to define sub-matrices of the SAM for which behavioural relationships need to be defined. As such the modeling approach has been influenced by Pyatt's 'SAM Approach to Modeling' (Pyatt, 1987).

3.2.1. Trade

Trade is modelled using a treatment derived from the Armington 'insight'; namely domestically produced and consumed commodities are assumed to be imperfect substitutes for both imports and exports. Import demand is modelled via a series of nested constant elasticity of substitution (CES) functions, see Figure 2; imported commodities from different source regions are assumed to be imperfect substitutes for each other and are aggregated to form composite import commodities that are assumed to be imperfect substitutes for their counterpart domestic commodities. The composite imported commodities and their counterpart domestic commodities are then combined to produce composite consumption commodities. These are the commodities demanded by domestic agents as intermediate inputs and for final demand by households, the government, and for investment.

Export supply is modelled via a series of nested constant elasticity of transformation (CET) functions; the composite export commodities are assumed to be imperfect 'substitutes' for domestically consumed commodities, while the exported commodities from a source region to different destination regions are assumed to be imperfect 'substitutes' for each other. The composite exported commodities and their counterpart domestic commodities are then combined to produce composite production commodities. The properties of models using the Armington 'insight' are well known (see de Melo and Robinson, 1989; Devarajan *et al.*, 1990), but it is worth noting here that this model differs from the GTAP model through the use of CET functions for export supply; this ensures that domestic producers will adjust their export supply decision in response to changes the relative prices of exports and domestic commodities, which help to moderate the magnitude of the terms of trade effects in this class of model.

3.2.2. Production

The production structure is a two stage nest. Intermediate inputs are used in fixed proportions per unit of output – Leontief technology. Primary inputs are combined as imperfect substitutes, according to a CES function, to produce value added.

3.2.3. Final Consumption

Final demand by the government and for investment is modelled under the assumption that the relative quantities of each commodity demanded by these two institutions are fixed – this reflects the absence of a clear theory that defines an appropriate behavioural response by these agents to changes in relative prices. For the household there is however a well developed behavioural theory; hence the model contains the assumption that households are utility maximisers who respond to changes in relative prices and their incomes. In this version of the model the utility functions for the private households are assumed to be Stone-Geary, which yields linear expenditure systems that allow for subsistence consumption, and reduce to Cobb-Douglas utility functions where minimum levels of consumption are not specified.

4. Policy Experiments and Model Closure

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.

4.1. Policy Experiments

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 – this part involves reducing export taxes and tariffs.
 - a. Export taxes – elimination of all export taxes by all regions.
 - b. Import duties – 40 percent reduction in import duty by the non rich regions and by 60 percent for other (rich) regions.
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.

These simulations were run for all commodities and for two subsets of commodities – agriculture and food commodities and activities and for NON agriculture and food commodities and activities, to separate out the broad effects of liberalisation over food and non food sectors.

4.2 Model Closure

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 exchanges 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 to exchange rates were fixed for African regions.

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

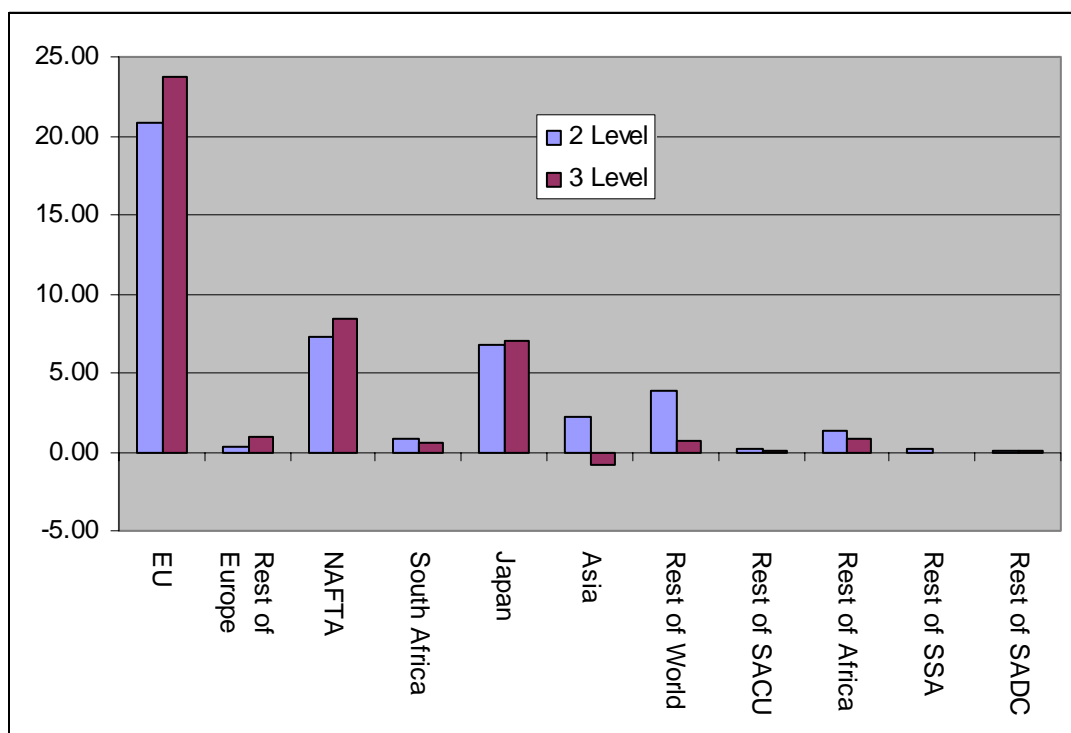
5. Results

The discussion of the results begins with the macroeconomic results/summary statistics and then goes behind these numbers to shed some light on the reasons for the results.

The immediately striking feature of the welfare results – Figure 3 – is the concentration of welfare gains among the relatively rich regions, with a pronounced bias towards the EU, while the gains for African regions are all relatively small. Moreover when a three level nest is applied to both imports demand and export supply functions the welfare gains to the rich regions increase while the already small gains to developing country regions decline. However the absolute

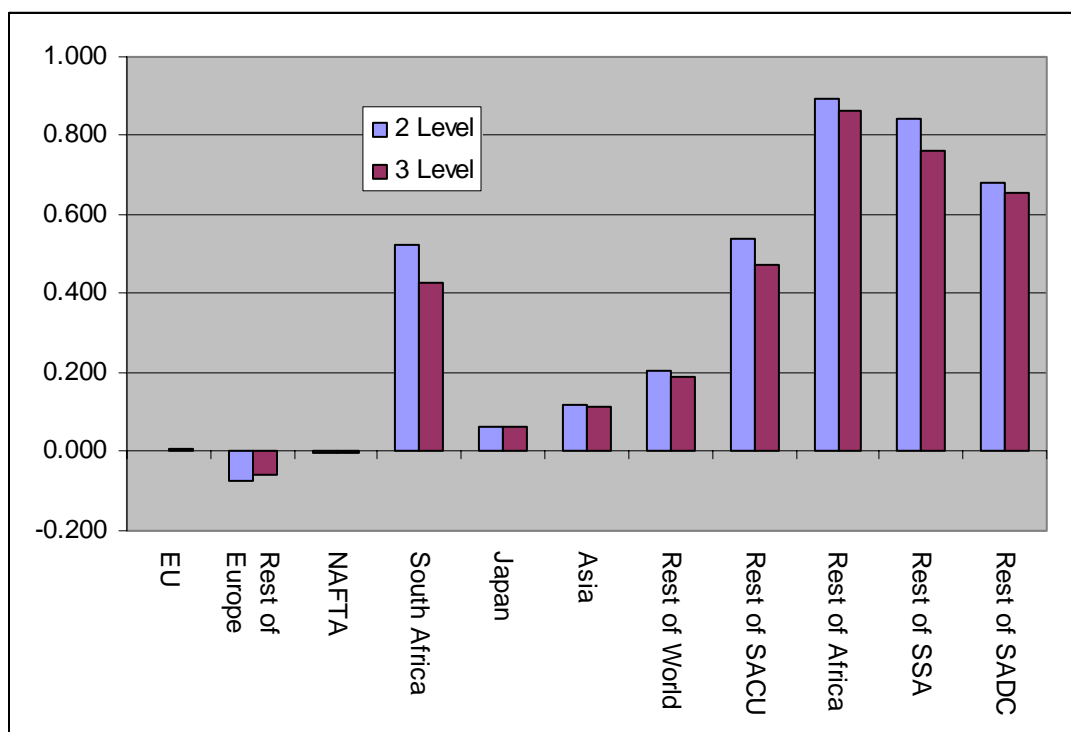
changes in regional welfare do not take account of population and are somewhat misleading as the percentage changes in GDP – Figure 4 – indicate; clearly the stylised DDA simulations do suggest that in relative terms the African regions stand to benefit more from the proposed liberalisation but the impact of the three level nest is to reduce the benefits accruing to the developing regions and increase those to the more developed regions.

Figure 3 **Regional Welfare – Equivalent Variation (\$US billions)**



Source: Model simulations.

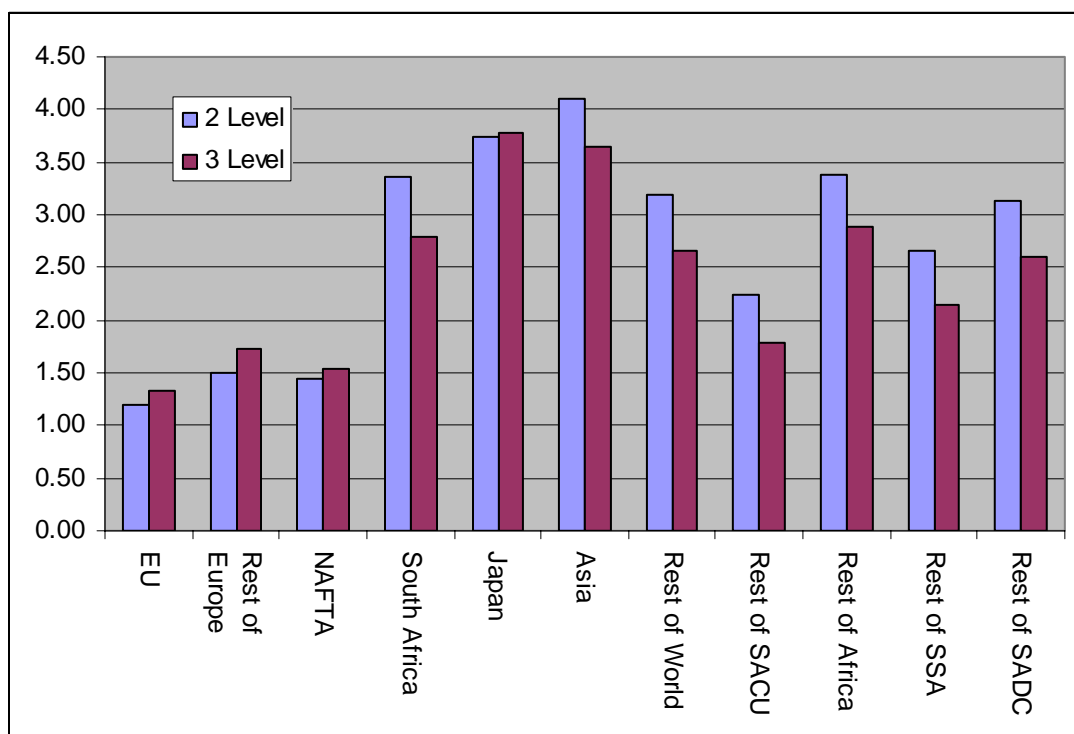
Figure 4 GDP (value added basis) – (% change)



Source: Model simulations.

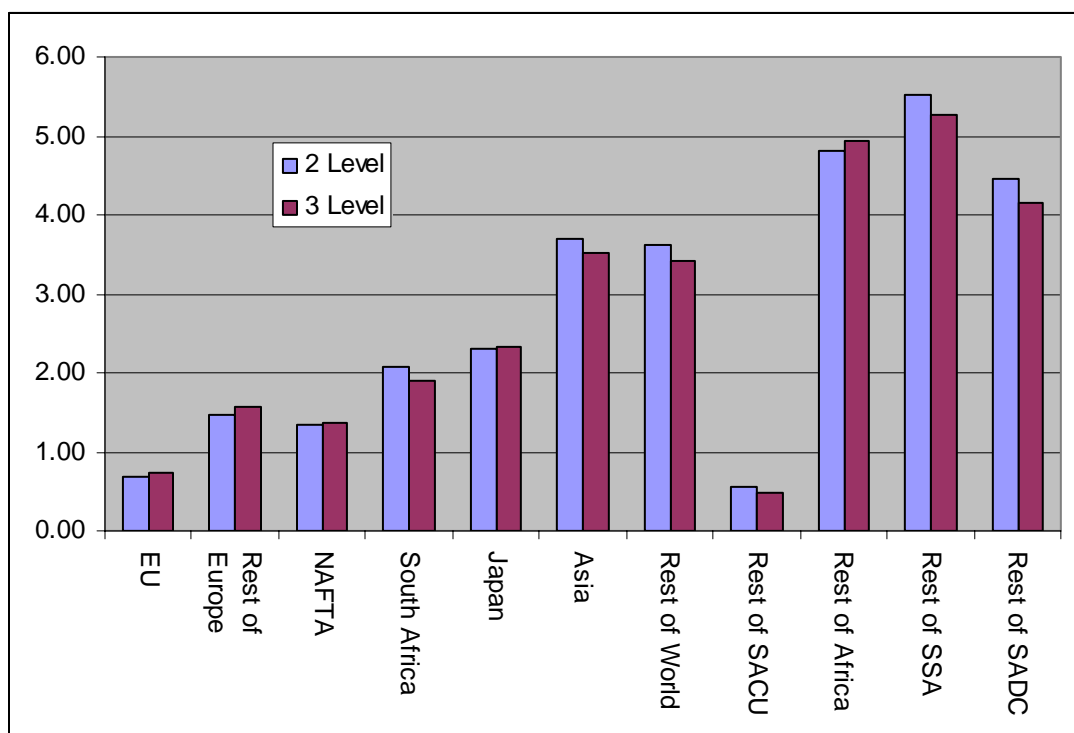
The fundamental cause for these differences is not hard to find. The effect of the three level nest is to markedly reduce the extent to which import demand and export supply increase for the African and developing regions while increasing the expansion of trade values for the developed regions. This is a substantive consideration since the underlying presumption behind the DDA is that trade expansion would be the driving force behind the generation of welfare gains for developing countries; if the degree of trade expansion diminishes then clearly the presumed benefits from the DDA for developing countries would also diminish and the incentives for those countries to support the DDA will decrease.

Figure 5 **Aggregate Imports (% change)**



Source: Model simulations.

Figure 6 **Aggregate Exports (% change)**



Source: Model simulations.

6. Concluding Comments

Understanding the causes that determine the results from these simulations is not hard: the adjustments in the trade shares due to changes in policy instruments induced by the model are relatively limited, consequently the relatively well off regions do relatively well out of the DDA scenario. While the less well off regions benefit irrespective of the nesting structure, this largely reflects the fact that the relative changes in incentives faced by those economies are greater in scenario examined. But the presumptions about the extent of product differentiation do impact upon the magnitude of the results; and if the hypothesis that the commodities produced by developing regions are relatively less differentiated than those produced by the more developed countries is correct, then the developing countries will not benefit as much from a DDA scenario as predicted in other models. Moreover it is reasonable to argue that if a DDA scenario were to induce a shift in the patterns of production in developing countries towards even less differentiated commodities, this would damp down even further the potential gains from such a scenario.

The use of imperfect substitution in aggregator (index number) functions runs throughout the CGE literature and has provided CGE models with a tractable and, arguably, theoretically elegant way to model trade relations, and there is little evidence of anything more acceptable on the horizon. But arguably the use of the method has become somewhat mechanical and unthinking and there seems to be a reluctance to address certain features of the method that do give rise to concern. This seems to be leading towards modeling actions that are questionable³, e.g., the use of high substitution elasticities to damp down terms of trade effects, and at the worst undermine the validity of the research method. Clearly the issue of the degree and nature of product differentiation between commodities and regions is ultimately an empirical matter. If the evidence indicates that the degree of product is sufficient to justify a more complex aggregation structure then that it may have relevance to the policy advice derived from global and single region CGE models.

This should not distract attention from the value of Armington's 'insight'; it still seems the best alternative available and remains intuitively attractive. Rather it should act as a spur to the development of an improved method for its implementation, be this in terms of functional form or otherwise, e.g., the use of complementary models that enhance the analytical content of the

³ This is similar to the use of 'ad factors' in macroeconometric models that seeks to counter the production of 'undesireable' results.

models. It still seems that Armington's objective of providing a theoretically consistent economic model that explains changes in trade patterns in response to economic signals is important: while the challenge of finding a better way to implement the 'insight' may be difficult it seems that taking the challenge Armington confronted seriously may be a worthwhile exercise.

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