The use and limitations of computer models in assessing trade policy

by

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Introduction

In a dynamic and complex world where there are many trade policy options facing politicians and other decision makers, the use of models to assist in clarifying the potential trade-offs that are inherent within such complexities is becoming more routine. While this situation can potentially assist these decision makers, there is also considerable scope for the converse: the linkages between the actual ‘back room’ modeller and the decision maker can be less than direct and the lack of clear understanding of the implications of changes to policies on the part of decision makers caused by weaknesses in the policy advice chain can easily be accentuated by an inappropriate modelling base from where the initial advice came from.

The objective of this research is to try to demystify Computer General Equilibrium (CGE) trade models\(^1\) in general and the Global Trade Analysis Project (GTAP) model in particular\(^2\). This chapter will discuss model strengths and weaknesses, and shed some light on situations where a particular model may or may not be an appropriate tool for the task at hand. The emphasis will be on a ‘policy-maker friendly’ approach rather than a more technical framework directed at modelling practitioners. While of course a model can be any abstraction to represent and portray reality, the focus is entirely upon the narrow sub-set of models that seeks answers to implications directly relevant to changes in trade policy even though the implications and indeed the original premise may or may not be from a direct trade policy question. The emphasis will be upon South African and regional applications, although a more international perspective is given at times.

It is not the intention to develop this chapter as a tightly referenced academic paper, and the reader is referred to sources such as Piermartini and Teh (2005) for the primary sources from which the greater part of the technical base for this paper is drawn.

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\(^1\) Where the term ‘general equilibrium’ means that all players in the economy (and often global economy) can be brought onto the stage, ‘partial equilibrium model’ means that only the immediate and usually local actors are used. A CGE model can be, in effect, ‘closed down’ to simulate small or local programmes, but often this may be using a hammer to crack nuts where a smaller but more detailed model is more appropriate.

\(^2\) GTAP is a global network of researchers who conduct quantitative analyses of international economic policy issues, especially trade policy using at least some variant of a standard GTAP model. They cooperate to produce a consistent global economic database, covering many sectors and all parts of the world. This database contains bilateral trade patterns, production, consumption and intermediate use of commodities and services data. See the website at [www.gtap.agecon.purdue.edu](http://www.gtap.agecon.purdue.edu).
Computer trade models

The opening remarks in support of computerised trade models must stress that they are becoming extremely sophisticated in their linkages and reflections to economic theory, their data bases are enormous and their abilities to simulate complex questions involving a multitude of interactions cannot be replicated any other way. Their strength is undoubtedly the ability to handle these large and complex data sets and interactions within an economy that take place when a structural change is made and to report upon the implications of these changes. The weakness is that models only react to the assumptions made (including the so-called 'closure rules' on factors such as the response to employment being through changes in employment or wages or some combination of both), and the data used. In the final analysis models are, by definition, an abstraction from reality, and this must be kept in mind.

Firstly consider the sequence of events in the real world versus the model. A tariff is reduced for African exports to a certain market for a given product. The reaction of exporters is to consider sending more produce to that market, and the model is programmed to do just that. But by how much more? In the real world, that will depend upon a multitude of factors, such as the domestic availability of produce, the change in this one market vis à vis other markets, the degree of marketing power and distributional arrangements that the exporter has in place in this and other markets, influences of other factors such as exchange rate variations and other, often more restrictive barriers to trade in any given market, and, finally, the important and often overlooked reactions of competitors. True, the more sophisticated models are able to take many of these features into account, but there are many and often conflicting factors in play here.

The ideal research scenario (or what the model and modeller should tell you)

The starting point here should be to seriously consider if it is even appropriate to use CGE modelling in this particular instance. Often, for problems that are not very complex, a good spreadsheet presentation and analysis of the data may well provide many of the insights that a more sophisticated but perhaps inappropriate model may give. This is, in effect, known as the Occam’s (Ockham’s) razor principle³, which states that the explanation of any phenomenon should make as few assumptions as possible, eliminating (or ‘shaving off’) those that make no difference in the observable predictions of the explanatory hypothesis or

theory. In short, when given two equally valid explanations for a phenomenon, one should embrace the less complicated formulation. In modern parlance, this is the KISS principle (Keep It Simple, Stupid).

To place the role of a trade model firmly in perspective it is imperative to have a framework for outlining exactly what a client should be seeking and a researcher in turn should be offering. The following would seem to be the key points (hopefully as reflected in tralac work):

- The problem statement – what exactly the issue is and what key information the client is seeking if the work has been commissioned, or what questions the researcher is endeavouring to answer if it is spontaneous research.
- The background – more information about the setting for this particular issue and events leading to the core issue(s) is necessary. This should include the background data and a review of applicable research, including models and modelling work that has been used. Often, a clear presentation here of the relevant data will assist in results interpretation later.
- An introduction to the model to be used – why it is the best option for advancing the research. If it is an established model (such as GTAP), a short review of it and the data being used is presented; and here the provision of footnotes, references or even annexes with more details may be useful. If it is a new model or an established one with major modifications, this needs to be clearly outlined with consideration given to the use of an Annex.
- The model results and interpretation of these results – this is the key part of the research, with an easily understood presentation of what is often crucial technical data. Start with ‘big picture’ outcomes and move sequentially through to details as deemed necessary. Careful consideration must be given to the presentation re graphs, tables and jargon-free wording to balance the often technical nature of the results on one hand with the non-technical inclination of the policy maker on the other. Also be careful not to imply an exaggerated sense of precision in your results.
- Review – often overlooked is the need to come back to the first part of this outline and place the results in the perspective of the original problem.
- Limitations of the model – discuss the limitations of the research/model and how these may influence the results. The use of scenarios based around alternative key parameters and assumptions implemented is often used to show what is important and what is possibly not in generating results. These limitations may include data problems.
• Summary – finally, there must either be a concise summary or a set of key points (or even both). With key points, you have ten minutes to brief the busy CEO/Minister on your work. What exactly will you tell him/her in those ten minutes?

At all times care must be taken to provide this information as jargon-free as possible to enable the client to fully understand what is going on, with any necessary technical information to be put into an annex.

The short history of CGE trade models

While the theoretical concepts for a sophisticated model have been around since the 1960s, it was only during the 1980s that computer availability and power coupled with associated software developments led to an upsurge in the field. Several individual contributions were made, of which possibly the most important were the Michigan University team and the Australian group based at Monash University. Both were influential in policy analysis in the US and Australia respectively, but it has been the Australian team that contributed the most during that period in that the modern GTAP has evolved via their so-called SALTER model. The key catalyst for transforming this international scene was Tom Hertel who, during a Fulbright Scholarship to Melbourne in 1990, worked closely with the Melbourne team to extend their work to the current GTAP programme⁴. Prior to that time modellers were often working in isolation with little or no quality control possible on their work. Since that time international cooperation through GTAP has ensured that research is based upon a similar foundation in that the database is now almost universally used, model development is shared and research can be duplicated and critiqued for the betterment of all. Thus, a solid salute to both the Melbourne team and Tom Hertel is in order.

Limitations of trade models

Models cannot think and only faithfully do exactly as told. Thus, the old GIGO (garbage in, garbage out) adage holds true, although the almost universal usage of GTAP and the constant scrutiny and development of its database and structure ensure that this is being minimised and restricted to GIGO from individual users and their associated assumptions and applications. One cannot protect against that other than by peer review and relying upon the market working for the purchase of research as in any other commodity! Thus, modellers must be certain that their understanding and specification of the particular problem are

⁴ https://www.gtap.agecon.purdue.edu/about/history.asp.
correct, as unfortunately sometimes those commissioning work are themselves not certain as to what they actually want. A sub-set of the latter is cases where work is commissioned from a ‘tame’ researcher in order to confirm positive outcomes from a particular policy change that a government wants to implement. This is unfortunately not uncommon, but it is a fault that needs to be laid at the feet of the modeller and commissioning patron rather than the model. The seminal note on this is from Rob McDougall (1993) who outlines the use and abuse of models from his earlier experiences, and concludes with: ‘If you can provide a study that does justice to what your audience knows already about the situation, and which provides one clear insight that they didn’t have already, then you are likely to make a sale.’ This is a classic application of the KISS principle, a principle that too often has been ignored.

Models are only as good as the data that is being used. Few modellers are actually developing their own databases now, as the GTAP database has become the standard source. This, in turn, has benefited immensely from cooperative developments that have grown in collaboration with the GTAP groups such as the MacMaps and Agricultural Market Access Database (AMAD) and the increasing availability of much trade and tariff data online. Unfortunately, the availability, timeliness and reliability of this data vary considerably. Other than for South Africa, the absence and general unreliability even then of trade-related data are particularly acute in the SACU/SADC region. While this can be overcome by the use of ‘mirror’ data (i.e., for example the use of the Africa Growth and Opportunity Act (AGOA) website to find African imports into the US in the absence of primary export data), there are still major data reconciliation problems. In the final analysis, one has to go with the best available data at times knowing it is deficient. This, in turn, severely limits the precision which can be given to results and therefore policy advice.

One technical problem for models and modellers is the aggregation problem. The latest GTAP version contains data on and linkages between 57 sectors (42 for the production of goods and the remaining 15 for service sectors) and the option of 96 country/regional possibilities. While this sounds impressive, it is not really adequate for anything more than indicative results at an aggregated level. For example, nestled in the productive sectors there are two of relevance to the fruit sector: (a) vegetables, fruit and nuts, and (b) food products not elsewhere classified. The former is largely primary unprocessed products, while the latter is processed products. We are, literally, mixing fresh apples and processed apples here, thus an important change in the market access conditions for, say, fresh apples may often make a miniscule change to the overall picture that can just not be identified by a GTAP analysis. This is not to decry or degrade the use of a GTAP model; rather, it is to point out that such an aggregate model loses it richness when detail is important.
Another well-known weakness of a trade model is that it is not able to provide any insights into potential new areas of trade that may develop from a Free Trade Agreement (FTA), and this development of new trade has been shown to be an important part of the potential gains from an FTA. This is the notion of ‘trade chilling’. Finally, and equally importantly, trade models are not forecasting tools; they provide an indication of the likely outcome at the margin from a single change in policy, all other things held equal (this is known as comparative statistics).

**Strengths of models**

There is really no other way of bringing many different relationships together into one concise box, albeit sometimes a black one, to assess what is important and what is not, and to place all of these in perspective. In a world where everything is connected, some surprising insights are the result, and these insights are backed by economic theory in a disciplined linkage to that theory. What a model can tell you is a good indication of the changes at the margin that initiating a particular policy change will make.

**Some common and often confusing terms explained**

**Variables** used in a model are divided into two broad classes: (a) exogenous variables or information that is fed into the model from outside and taken as a given and (b) endogenous variables or information that is generated within the model. Examples of exogenous variables in trade are the tariff and quota rates and endowments or available resources such as land and capital stock, while the endogenous variables are the ones such as production and trade that change within the model in response to given changes in the exogenous variables. Depending upon the model, there is room for variation as sometimes an exogenous variable can be made endogenous as is the case in a dynamic model where capital accumulation and technological change can take place internally.

The concept of **elasticity** is a key one to economics. It represents the percentage change in one variable resulting from the percentage change in another. For example, the demand or own-price elasticity for wheat is the percentage change in the demand for wheat resulting from a one percent change in the price of wheat, while a substitution elasticity might be the percentage change in the demand for maize (a substitute good) resulting from a one percent change in the price of wheat. These elasticities abound in the base part of a model, although many of them are merely ‘guesstimates’. A sub-set of these is the so-called Armington
elasticities, named after the economist who pointed out that imports from different countries are not all the same and some method is needed to assess just how different they actually are. Different values for these ‘Armingtons’ are often at the heart of disputes over different results from what looks like similar models and assumptions.

**Sensitivity analysis** is the usual way in which the importance of a particular variable or assumption can be tested. This is the ‘what if?’ way of asking, for example, how important a particular elasticity is. In the example above, we can change the own price elasticity of wheat and see how robust our results are. When the results start changing as you change a particular number, then you know that number is important and you should focus on it. Many trees and electronic particles have given their lives so that disputes on the correct values of variables such as the Armington elasticities can be resolved, but at least a sensitivity analysis where you change them slightly tells you how important they actually are in this particular application.

The **interpretation of results** from a model is not straightforward. In the standard type of CGE model these results are expressed as welfare measures that express how much better off a country/region and the world would be as a result of the particular change. In the standard static model there is no indication of the time-path, so a welfare gain of $10 million to South Africa means that South Africa is $10 million better off at the final year than it otherwise would have been in the absence of that change. There is little said about the distributional aspects of these gains, although it is generally the case that there are a few (and vocal) losers versus numerous (and silent) winners embodied in these results. The results from a CGE model can help policy makers confront the losers although the ultimate decisions on implementing policy changes reside with policy makers and not trade modellers. There are also no guarantees that these gains will continue, though they are likely to, but with diminishing returns. In a dynamic model you are able to see the annual time-path of these gains, thus adding more information.

In any scientific experiment the concept of **replication** is crucial, and this potentially holds true for trade models. Are others able to come up with similar results using similar assumptions, and if not, then why not? This is a major contribution that the GTAP model has made, as discussed later.

**The GTAP model**

GTAP is supported by a fully documented, publicly available, global database and underlying software for data manipulation and implementing the model. The framework is a system of
multisector, country economy-wide models linked at the sector level through trade flows between commodities and factors of production. The latest GTAP database (Version 6) divides the global economy into 96 regions, with 57 sectors of economic activity in each region, and work is continually underway to expand this country/regional and commodity coverage. We must note that for SACU these regional aggregations are South Africa, Botswana and an amalgamation of Lesotho, Namibia and Swaziland into one ‘Rest of SACU country’. This latter is a severe limitation to examining regional impact in detail, as of course Lesotho, Namibia and Swaziland have three entirely different economies.

GTAP is a comparative static, general equilibrium model, which means that while it examines all aspects of an economy via its general equilibrium feature (as distinct from a partial equilibrium approach that examines only the sector under consideration), it is static in the sense that it does not specifically incorporate dynamics such as improved technology and economies of scale unless these are specifically built in. The economic agents of consumers, producers and government are modelled according to the neoclassical economic theory, with producers maximising returns to factor income and consumers maximising their utility, markets perfectly competitive, and all regions and activities linked. Thus, a small change in, say, a tariff into South Africa will have repercussions right through the world, but of course in practice those repercussions can be largely ignored in almost all of the full model and limited to key actors only. Results are measured as a change in welfare arising principally from the reallocation of resources within an economy and the resulting change in allocative efficiency and terms of trade effects\(^5\), which may be significant in many instances. This welfare is based upon a representative household, so unless this is modified it is not possible to examine the distributional aspects other than through the skilled/unskilled labour market closures. The standard GTAP model also does not address the time-path of benefits and capital flows over time. These changes are important as they allow consumers to borrow, which in turn allows consumption patterns to vary over time.

The interpretation of GTAP results

The standard GTAP model has gains from allocative efficiency and terms of trade if the standard closure rules are applied. In the model used by tralac there has been a capital

\(^{5}\) Where terms of trade are the relative changes in import and export prices following a change. Indeed, it is generally improved allocative efficiency within a country as it moves resources into more internationally competitive activities that leads to the outcome of greater welfare following a reduction in border protection. Thus, often the allocative efficiency pathway is providing most of the benefits to the ‘home’ country from reducing its own protection in a bilateral FTA rather than the exporter gaining better market access into foreign markets. This is an example of where a general equilibrium model is often able to counter the common mercantilist argument that a country needs protection to develop its own industrial sector.
accumulation closure and an employment closure added to the standard model. The model expresses the welfare implications of a modelled change in a country’s policy as the Equivalent Variation (EV) in income. The EV in income measures annual change in a country’s income (gains or losses) from having implemented, for example, an FTA scenario. The EV is simply defined as the difference between the initial pre-FTA scenario income and the post-FTA scenario income after implementation of the FTA, with all prices set as fixed at current (pre-FTA) levels.

$$EV = \text{post-FTA-Income} - \text{pre-FTA Income}$$

If a country’s EV in income increases due to a policy change, the country can increase its consumption of goods equal to the increase in income and thereby improve the national welfare in the country. The EV is a doubly effective measure for measuring global economic impacts of an FTA agreement between groups of countries. Firstly, the EV provides a monetary valuation of effects induced by FTA policy changes globally and at the country or regional level, so as to illuminate winners and losers. And secondly, the EV also facilitates comparisons of different policy scenarios, given that income changes are measured in initial base prices.

These total welfare gains/losses can be decomposed into contributions from improvements in allocative efficiency, capital accumulation, changes in the employment rate of the labour force and terms of trade.

Gains from **allocative efficiency** arise from improved reallocation of productive resources (such as labour, capital and land) from less to more productive uses. For instance, when import tariffs are abolished, resources shift from previously protected industries towards other sectors which are more in line with the country’s comparative advantage, producing an increase in economic welfare.

**Terms of trade** effects are consequences of changing export and import prices facing a country. So, when a country experiences an increase in its export price relative to its import price (e.g. due to improved market access), it may finance a larger quantity of imports with the same quantity of exports, thus expanding the supply of products available to the country’s consumers. Whereas allocative efficiency contributes to increases in global welfare gains, the terms of trade affect the distribution of global welfare gains across countries; essentially, one country’s terms of trade gain is another country’s terms of trade loss. The global total must therefore add to zero, and if a large proportion of the benefits to South
Africa from an FTA is derived from terms of trade effects, this implies transfers to South Africa from the Rest of the World.

Capital accumulation summarises the long-term welfare consequences of changes in the stock of capital due to changes in net investment. A policy shock affects the global supply of savings for investment as well as the regional distribution of investments. If a trade agreement has a positive effect on income through improvements in efficiency and/or terms of trade, a part of that extra income will be saved by households, making possible an expansion in the capital stock. At the same time, rising income will increase demand for produced goods, pushing up factor returns and thus attracting more investments. Generally, economies with the highest growth will be prepared to pay the largest rate of return to capital, and will obtain most of the new investments. Therefore we will see that the long-term welfare gains from capital accumulation reinforce the short-term welfare gains deriving from allocative efficiency and terms of trade.

The welfare effects of changed employment rates are consequences of changes in the amount of unskilled labour force employed due to changes in the real wage. In a situation where the demand for labour increases and thereby the real wage, the amounts of labour employed increase, reducing the relative raise in the real wage and thereby increasing the competitiveness of the country’s industries (increasing EV in income).

Examples of GTAPs’ recent usage in global trade liberalisation

A notable feature of the December 2005 WTO Hong Kong Ministerial was the use and citation of models. More recent models are showing a considerable reduction in global welfare gains from trade liberalisation, and in particular a virtual disappearance of the gains to developing countries. Why are the gains shrinking? Part of the answer is that some of the assumptions are being revisited, while the newer version of the GTAP model and its associated database enable analysts to use better trade and tariff data and incorporate both the EU expansion and China’s WTO accession into their now updated base work. Importantly, the new Version 6 of the GTAP database has for the first time incorporated the MacMaps database of bilateral applied tariffs, including preferential market access given to many countries, whereas the Version 5 database used MFN rates for all imports. Therefore the initial tariff bases are sometimes lower for beginning the liberalisation and the introduction of preferences has reduced the calculated gains. These combinations are making a huge difference, and it is only by using Version 6 of the GTAP database that we now can get a better idea of these more accurate gains from liberalisation.
A good place to review this is the paper by Frank Ackerman (2005) (see also Van der Mensbrugghe, 2005) that details how the gains are becoming both smaller and skewed towards the developed countries rather than addressing poverty alleviation in the developing world. In another work widely cited at Hong Kong the highly-respected World Bank team of Kym Anderson, Tom Hertel and others are revising their benefits downwards to a miserly $3.13 per head in the developing world (in contrast to the $79.04 per head in the developed world)\(^6\). Note that these gains are not repeatable gains, but rather a once-only step upwards.

Some of the more optimistic models (as discussed by Ackerman) employ what is known as dynamic and economies of scale assumptions that extend the scope and range of these gains (see also OECD, 2006). The channels through which trade and Foreign Direct Investment (FDI) affect productivity levels and growth rates are linked are still not well understood. This makes modelling the dynamic effects of trade difficult and an important area for future research. For example, it may well be that dynamic productivity gains are much more important in the long term for developing countries than, say, preferences. Also important from a developing country perspective is that the latest models are able to incorporate both loss of tariff preference and loss of tariff revenues into their basic framework - and for many countries this is crucial.

Added to this is the realisation that ‘free trade’ is an overly optimistic and somewhat mercurial concept in consequence of which modellers may be better served by assuming a more realistic outcome to assist policy makers. In essence this is realism versus idealism.

**South Africa’s PROVIDE model**

A very good model that has been used extensively for domestic agricultural analysis within South Africa is the Provincial Decision-Making Enabling (PROVIDE) model\(^7\). This is an example of a single country CGE calibrated using a SAM. The linkage between PROVIDE and GTAP is that GTAP also has a Social Accounting Matrix (SAM) model of the South African economy with the same or similar theoretical structure as PROVIDE, but with GTAP this SAM is, by necessity, a smaller and more compact SAM that loses the South African detail available from PROVIDE but enables global analysis to be undertaken since all other

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\(^6\)Anderson and Martin (2005) and Hertel and Winters (2006).

\(^7\) At [http://www.eisenburg.com/provide/](http://www.eisenburg.com/provide/). This website contains the most recent applications of the PROVIDE model, as well as technical papers explaining the model itself. The project is an excellent example of a well documented model that is applied to relevant problems with the results written up in an extremely reader-friendly way.
countries/regions are represented by their SAMs. The two models can, in theory, be linked to combine the best features of both families of models. With the developments of both the modern computer and associated models this type of application will become the benchmark in the near future. An important feature of a SAM is that there are many more labour factors and associated households: PROVIDE has 162 South African households, while GTAP has one. This means that the two models have entirely different capacities to look at the distributional aspects of a policy change.

An excellent application of the PROVIDE model is its analysis of the implications of increasing the applied tariff rates on wheat imports into South Africa. Here the detailed model was able to focus specifically on the production effects this would have on winter cereals by region and the associated substitutions from other crops at a detailed level. The model was able to trace these effects right through to players such as millers and bakers and to the final implications on all 162 households in South Africa. The results showed that only seven of these 162 households were better off (five wheat growers in the Northern Cape and two in the Free State), while all others and the South African economy suffered (slightly) as final bread and bakery product prices increased. The detailed results available from this approach are exceedingly comprehensive should one want to explore the minute detail that is produced. In the final analysis, this research was used to justify a reduction in wheat tariffs rather than the hoped-for (by wheat farmers) increase, as unpublished simulation results that symmetrically decreased rather than increased tariffs showed enhanced welfare gains for both the economy and an overwhelming percentage of the general population as represented by the 155 households out of 162 who gained.

Can the GTAP and PROVIDE be used sequentially to examine the same question? The answer is yes: GTAP and PROVIDE models can be used complementarily by using GTAP to get the world price change and then using those world price changes to shock PROVIDE to get the distributional effect of those price changes in more detail for the South African economy. Careful attention has to be paid to a number of factors, however, but potentially the two could look at a proposed FTA or WTO outcome where GTAP derives some world price and quantity changes, and these changes are then fed into PROVIDE. Importantly, GTAP has only two labour groups (skilled and unskilled), but PROVIDE has labour categorised according to race, location and sector, which gives much more powerful information for the South African situation with previously disadvantaged groups.

**Final general thoughts**
Can the use of a model add value to researching an issue of concern to trade policy advisors and decision makers? Yes, provided that

- The model is an appropriate one for the clearly articulated problem statement;
- That problem statement is examined against the current policy setting;
- A clear enunciation of why the model is appropriate and how it may be expected to shed light on the issue at hand is given;
- The results are clearly and concisely articulated at a level for the intelligent layperson;
- Limitations of the model in particular, and possibly even the research itself, are also articulated.

A good place to end is with Rob McDougall's quote from above: ‘If you can provide a study that does justice to what your audience knows already about the situation, and which provides one clear insight that they didn’t have already, then you are likely to make a sale.’ We would add that if you merely provide incomprehensible academic mumbo-jumbo, you are unlikely to make a repeat sale. Be wary, as a generation of Americans were not, of ex-President Nixon’s famous ‘trust me, I know what I am doing’, assurance.

The GTAP model as used by tralac

Introduction

Model, database and scenarios

The potential gains to FTAs between South Africa and its leading trade partners have been assessed by tralac in this book, and the objective of this section is to discuss the model used in this analysis and how it predicts the overall welfare benefits to the respective parties. The analysis undertaken is based upon a variant of the GTAP model to simulate the impact of possible multilateral market access reforms resulting from an FTA between South Africa and the respective parties. Note that we also include the so-called BLNS SACU countries of Botswana, Lesotho, Namibia and Swaziland in the analysis and assess the welfare implications for them, as the new SACU agreement precludes South Africa from making unilateral trade agreements.

The database is the most recent Version 6 GTAP database with the base year 2001 (Dimaranan et al., 2005), where the 2001 tariff data originating from the Market Access Maps (MacMap) database has been used with some verification and minor modifications. The main
unskilled labour market closure of the model has been changed so that the supply of unskilled labour is endogenously determined by the labour supply elasticity. We believe this is more relevant to a labour-surplus economy like that of South Africa.

Like any applied economic model, this model is, of course, based on assumptions, both in terms of theoretical structure as well as the specific parameters and data used. Regional production is generated by a constant return to scale technology in a perfectly competitive environment, and the private demand system is represented by a non-homothetic demand system (a Constant Difference Elasticity function)\(^8\). The foreign trade structure is characterised by the Armington assumption implying imperfect substitutability between domestic and foreign goods.

The macroeconomic closure is a neoclassical closure where investments are endogenous and adjust to accommodate any changes in savings. This approach is adopted at the global level, and investments are then allocated across regions to equalise the marginal rate of return in all regions. Although global investments and savings must be equal, this does not apply at the regional level, where the trade balance is endogenously determined as the difference between regional savings and regional investments. This is valid as the regional savings enter the regional utility function. The quantity of endowments (land, skilled labour and natural resources) in each region is fixed exogenously within the model, although, as discussed, alternative unskilled labour market assumptions are investigated. The capital closure adopted in the model is based on the theory where changes in investment levels in each country/region become on-line instantly, updating the capital stocks endogenously in the model simulation\(^9\). Finally, the numeraire used in the model is a price index of the global primary factor index.

The global database combines detailed bilateral trade, transport and protection data characterising economic linkages among regions, together with individual country input-output databases which account for intersectoral linkages within regions. The database contains 96 regions and 57 sectors, and we have aggregated these to 12 regions and 41 sectors in order to keep the model within computational limits and focus on the individual member countries/regions of the FTA. These 12 regions are (a) the main FTA parties of South Africa (ZAF), Botswana (BWA) and Rest of SACU (shortened to XSC in the model,\(^8\) Hence the present analysis abstracts from features such as imperfect competition and increasing return to scale, which may be important in certain sectors. We are therefore using what can be thought of as a base GTAP structure.\(^9\) This capital closure adopted in the model is the so-called Baldwin closure as documented in GTAP technical paper no. 7.
with Lesotho, Namibia and Swaziland combined as they are in the GTAP database) and the EU27, and (b) another eight-country/region grouping of the US, Japan, China, India, Brazil, Nigeria, Rest of Africa and the Rest of the World.

The applied ad valorem equivalents (AVEs) tariff data found in the standard GTAP Version 6 databases originate from the Market Access Maps (MacMap) database, which is compiled from UNCTAD TRAINS data, country notifications to the WTO, AMAD, and from national customs information. The MacMap database contains bound, Most Favoured Nation (MFN) and bilateral applied tariff rates (both specific and ad valorem) at the 6-digit Harmonised Systems (HS6) level. These are then aggregated to GTAP concordance using trade weights compiled from the COMTRADE database.

**Baseline projection 2001 – 2015**

A meaningful evaluation of an anticipated policy change can be obtained by comparing the liberalisation scenario with a non-liberalisation (business as usual) base scenario. This base must contain projections of the macroeconomy and incorporate the effects of important policy changes other than specific policy changes to be analysed. Our business-as-usual baseline features a number of important policy initiatives by the EU and others that must be set in place first. These are (as shown in Box 1):

- a stylised implementation of the Agenda 2000 and the Mid-Term Review Reform of the CAP;
- the abolition of export quotas on textiles and apparel shipped to the EU and the US;
- the accession of China to the WTO;
- the final implementation of the UR commitments for developing countries;
- the enlargement of the EU with 12 new member countries;
- the implementation (and continuation) of the AGOA on textiles and wearing apparel;
- an update of India's applied MFN tariff rates to 2005, the latest year available; and
- the Everything But Arms (EBA) Agreement between LDCs and the EU.
Box 1. Assumptions shaping the baseline 2001–2015

<table>
<thead>
<tr>
<th>Projections</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shocks to GDP, factor endowments and population</td>
</tr>
<tr>
<td>Total factor productivity endogenously determined</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Trade Policy changes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abolishment of export quotas on textiles and apparel shipped to the EU and the US</td>
</tr>
<tr>
<td>Final implementation of the UR commitments for developing countries</td>
</tr>
<tr>
<td>Accession of China to the WTO</td>
</tr>
<tr>
<td>Enlargement of the EU customs union and the extension of the EFTA to include the new member countries</td>
</tr>
<tr>
<td>EBA agreement between LDCs and the EU</td>
</tr>
<tr>
<td>AGOA on textiles and apparel</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>EU Agenda 2000 and Mid-Term Review (MTR) Reform</th>
</tr>
</thead>
<tbody>
<tr>
<td>All direct payments deflated by two percent per year (maximum budgetary outlays fixed in nominal terms)</td>
</tr>
<tr>
<td>Adjusted hectare and livestock premiums (direct payments)</td>
</tr>
<tr>
<td>Decoupling of direct payments to a single farm payment</td>
</tr>
<tr>
<td>Sugar and milk quotas unchanged</td>
</tr>
<tr>
<td>Reductions in intervention prices modelled by reducing export subsidy rates and in the case of sugar the reduction of import tariffs</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>US agricultural subsidies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agricultural expenditure fixed in nominal terms at its 2001 level</td>
</tr>
</tbody>
</table>

As always, we apply shocks to GDP, population, labour force, and capital to project the world economy to the baseline year of 2015 – a year when the market access reforms are assumed to be completed. The projection of the world economy uses the exogenous assumptions listed in Table 1, and is important in shaping the baseline scenario. The general sources for these assumptions in Table 1 are given as a footnote to the table, and they represent the best estimates of the possible future path of the data. The GTAP model then determines changes in output through both an expansionary and a substitution effect in each country/region of the model. This expansionary effect represents the effects of growth in domestic and foreign demand shaped by income and population growth and the assumed income elasticities, while the substitution effect reflects the changes in competitiveness in each country/region shaped by changes in relative total factor productivity, cost of
production, as well as any policy changes. Thus, the GTAP model uses this set of macroeconomic projections to generate the ‘best estimate’ of the global production and trade data as it will be in 2015. Therefore, the relative growth rates between each country/region for GDP, population, labour, capital and total factor productivity play an import role in determining the relative growth in output of the commodities when projecting the world economy from 2001 to 2015, and we can now take the resulting data set from this baseline simulation as the new base for our FTA scenario. A simulation scenario measures the difference between our baseline model’s output at 2015 in the absence of the selected FTA against what it would be with the FTA introduced. Therefore, the model results shown in this paper present the isolated effect of the FTA outcome.

The baseline scenario, as mentioned above, builds the updated data base (2015) from which we evaluate the FTA. Changing the assumptions used to model/build the updated database (2015) would of course produce a different initial database from which we evaluate our simulated scenarios and would slightly influence/change the results of the FTA.

### Table 1: Macroeconomic projections, annual growth rates, 2001 – 2015

<table>
<thead>
<tr>
<th></th>
<th>Real GDP</th>
<th>Labour Force</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Pop.</td>
<td>Total</td>
<td>Unskilled</td>
<td>Skilled</td>
<td>Capital</td>
<td>TFP*</td>
</tr>
<tr>
<td>South Africa</td>
<td>3.2</td>
<td>0.4</td>
<td>1.3</td>
<td>1.2</td>
<td>1.9</td>
<td>3.2</td>
<td>0.5</td>
</tr>
<tr>
<td>Botswana</td>
<td>4.7</td>
<td>0.5</td>
<td>1.4</td>
<td>1.2</td>
<td>7.0</td>
<td>4.7</td>
<td>0.5</td>
</tr>
<tr>
<td>Rest of SACU</td>
<td>3.8</td>
<td>1.1</td>
<td>1.9</td>
<td>1.8</td>
<td>3.0</td>
<td>3.8</td>
<td>0.5</td>
</tr>
<tr>
<td>India</td>
<td>5.8</td>
<td>1.3</td>
<td>1.8</td>
<td>1.6</td>
<td>4.7</td>
<td>5.8</td>
<td>1.2</td>
</tr>
<tr>
<td>Brazil</td>
<td>3.3</td>
<td>1.1</td>
<td>0.9</td>
<td>0.6</td>
<td>3.5</td>
<td>3.3</td>
<td>0.5</td>
</tr>
<tr>
<td>Nigeria</td>
<td>3.1</td>
<td>1.9</td>
<td>2.9</td>
<td>2.8</td>
<td>3.5</td>
<td>3.1</td>
<td>0.4</td>
</tr>
<tr>
<td>Rest of Africa</td>
<td>4.0</td>
<td>2.0</td>
<td>2.6</td>
<td>2.5</td>
<td>3.6</td>
<td>4.0</td>
<td>0.4</td>
</tr>
<tr>
<td>China</td>
<td>7.2</td>
<td>0.6</td>
<td>0.9</td>
<td>0.8</td>
<td>3.9</td>
<td>7.2</td>
<td>1.3</td>
</tr>
<tr>
<td>Japan</td>
<td>1.8</td>
<td>-0.1</td>
<td>-0.2</td>
<td>0.2</td>
<td>-0.7</td>
<td>1.8</td>
<td>0.6</td>
</tr>
<tr>
<td>EU</td>
<td>2.2</td>
<td>0.0</td>
<td>0.2</td>
<td>0.2</td>
<td>0.2</td>
<td>2.2</td>
<td>0.5</td>
</tr>
<tr>
<td>US</td>
<td>3.2</td>
<td>0.8</td>
<td>1.2</td>
<td>1.4</td>
<td>1.0</td>
<td>3.2</td>
<td>0.7</td>
</tr>
<tr>
<td>Rest of World</td>
<td>3.7</td>
<td>1.2</td>
<td>1.8</td>
<td>1.6</td>
<td>3.7</td>
<td>3.7</td>
<td>0.4</td>
</tr>
</tbody>
</table>

Sources: World Bank forecasts, Walmsley (2006) and own assumptions
Note: *The annual growth rate in Total Factor Productivity is determined by the exogenous variables (GDP, unskilled, skilled labour force, capital), the model and the associated database.
As outlined above and shown in Box 1, we have modelled the full implementation of the TDCA agreement between South Africa (SACU)\(^{10}\) and the EU as an essential part of generating the new baseline for subsequent analysis. This was done as the TDCA is a ‘known’ policy change in the same way as the other components in Box 1 are, but it was done in such a way as to enable us to examine the implications of the TDCA as a simulation in its own right from a similar (but not identical - the TDCA itself changes the South African economy) basis. Before the simulation the tariff rates from MacMaps between the TDCA partners of South Africa and the EU were slightly modified to give a better fit to the initial pre-TDCA rates and the so-called end period preferences, an elastic time around 2010 to 2012 when all preferences are fully implemented. Earlier tralac analysis shows that the 2006 SACU tariff schedule is around a half-way point between the initial and end period rates.

The limitations of and the assumptions used in the GTAP as used

Firstly note that we are not modelling reductions in either services or any non-tariff barriers, and this will make a difference to the overall results. Secondly, it is always possible to do an almost endless number of ‘what if’ scenarios. We have limited our analysis to the primary FTA outcome where all tariffs between the partners are reduced as per the agreement, although at times we have modelled (a) the overall FTA results following our Doha outcome and (b) alternative labour market closures to assess the options of different labour market policies in South Africa.

In addition, there are some extra assumptions and general limitations that need to be recorded.

- In the Doha simulations we have not addressed the issue of reducing the US domestic support or included measures of equivalent export subsidy values of export credits and State Trading Enterprises and food aid.
- For the India, Brazil and South Africa (IBSA) FTA we have not disaggregated/split gold out of the GTAP non-ferrous metals (NFM) sector in the database (this ‘golden story’ was shown to be the major feature of the IBSA FTA). By not doing so we are affecting other industries which are using NFM as inputs in South Africa - especially the motor

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\(^{10}\) We note that while the TDCA is technically an agreement between South Africa and the EU, for all practical purposes it is between the EU and SACU for imports into SACU but does not cover the BLNS exports into the EU.
vehicle sector\textsuperscript{11}. They are, of course, not using gold but some other mineral which is aggregated together with gold in NFM.

- In the Japan FTA we are not capturing the full potential of expanded agricultural export from South Africa to Japan. This is because of the Tariff Rate Quotas (TRQ) regimes in Japan where we have chosen to use in-quota tariff rates on import from all regions with zero-quota rents.

- For US FTA, we see a large benefit to South Africa exports of textiles and wearing apparel. We have not reduced any of the HS6 digit numbers on these products to zero as a part of the AGOA during the base line period 2001 – 2015 as this is a complex operation given the nature of AGOA.

- As always, we use the so-called Armington assumption to differentiate trade between different suppliers of the goods. This also means that if there is no initial trade between the partners (perhaps because the tariffs are so high as to ‘kill’ or ‘chill’ the trade), there is no benefit from the FTA.

- As above, we have not included Non-Tariff Barriers (NTBs) and there are no trade facilitation issues modelled. There is also no liberalisation of services, and no increase in efficiency (TFP) due to scale economies.

- We have not modelled Tariff Rate Quotas.

- We have not modelled tariff revenue transfers between the SACU member countries, and this is an important feature of tariff-reducing policies in SACU.

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\textsuperscript{11} We have not modelled the tariff rebate policy that operates as a de facto subsidy to the South African motor vehicle sector.


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