The Armington-Heckscher-Ohlin model

- an intuitive exposition

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Abstract

Global models of world trade are often used as input into assessing the possible effects of liberalising trade. As simplifications of the economic processes – and the counterfactuals that they are designed to explain – they include many assumptions on which their results depend.

Some of the crucial assumptions in global models of world trade include how – and which – gains from trade are captured. One of the main features of global models is the Armington assumption which differentiates products according to their geographic origin and gives rise to certain types of gains from trade. Although some trade is differentiated, trade in homogenous products exists and is responsible for other types of gains from trade.

The purpose of this paper is to provide an intuitive explanation for a modification of the standard Armington specification of trade models, to represent gains from trade in differentiated and homogenous products.

A toy model illustrates that in an A-H-O model:

- terms of trade effects from trade liberalisation are smaller than in a standard Armington model, and

- an A-H-O database combined with standard GTAP code is a good approximation for full-blown A-H-O model.

Illustrative experiments with a 25-country GTAP aggregation indicate that the A-H-O specification can quadruple the estimated effects of reducing tariffs globally in manufacturing.

Introduction

Different models capture different aspects of trade

Economists recognise several possible sources of gains from trade. As a result, when they want to estimate the gains from trade, they have built different models emphasising different aspects of possible gains:

1. Neo-classical theory emphasises gains from comparative advantage in which production is allocated across the world according to each country's cost structure, as conditioned by access to resources and technologies. These gains are emphasised in Ricardian and Hecksher-Ohlin models of trade.

2. Some authors, such as Krugman (1979), have emphasised other possible gains, such as access to increased varieties (in intermediate goods for producers, and in final goods for consumers). For example, models of monopolistic competition capture these kinds of gains. Some of these models are referred to as Love of Variety (LoV) models.

3. Gains from trade might also arise from productivity improvements that are induced by competition from foreign firms. This is sometimes referred to as a type of dynamic gains and is incorporated in models of firm heterogeneity of the type devised by Melitz (2003).

By capturing different aspects of trade, each model has the potential to produce different results when used to evaluate a change in trade policy such as unilateral or global liberalisation. The assumptions underlying these models are often included in global models of world trade called computable general equilibrium, or CGE, models. Ideally, all sources of gains from trade should be accounted for in any model, however this is subject to the costs of incorporating the many possible mechanisms in terms of data and computational resources.

The popular specification: the Armington model

The most popular specification used in applied global models of trade uses the Armington assumption, according to which products are differentiated by country of origin. In applied models of world trade, the Armington specification has been privileged because it provided a tractable solution to several modelling problems. In addition, it requires little information to implement – though it must be recognised that model results are sensitive to the Armington elasticity of substitution.

This type of model (referred to hereafter as the Armington model) was introduced for several reasons (Whalley 1985):

- It is consistent with 'cross-hauling', that is, the appearance in trade statistics that a country imports and exports the same goods. Since trade statistics consist of aggregations of detailed product flows, a country appears to be importing and exporting the same aggregate products. However, these are not actually the same and to model this imperfect substitution, between product aggregates in a model, the Armington substitution elasticity was introduced.

- It avoids the over-specialisation that occurs in neo-classical models. In neo-classical models with perfectly substitutable products trading partners tend to specialise in the production of very few products, a result which was difficult to reconcile with evidence.

- It is consistent with trade in geographically differentiated products, such as some agricultural products – think of French Brie and Champagne or Australian superfine merino wool, and many manufactured products. Typically in CGE models, the Armington assumption of product differentiation is applied to all products and services, which negates the possibility of trade in homogenous products. Francois and Shiells (1994) suggest that the Armington specification can approximate LoV models.[2]

Second thoughts

However, Lloyd and Zhang (2006) and Zhang (2006) also show that the Armington model is likely to underestimate the potential benefits from comparative advantage. The 'Armington problem' is well known and was identified for example by de Melo and Robinson (1989, p 49) who noted that the Armington assumption can 'help the specialisation problem, [but] lead[s] to unrealistically strong terms of trade effects that will dominate the welfare results of policy changes.'

Firm heterogeneity

Fan (2007) takes another approach and illustrates the potential for the Melitz model of firm heterogeneity to account for trade gains and how this model might be introduced in a CGE model. In the model of firm heterogeneity, gains from trade occur when low productivity firms are eliminated by foreign competition. This idea is particularly appealing and is very accessible to policy-makers. Illustrative simulations show that accounting for the extensive margin of trade in this manner doubles the gains modelled from a global cut in manufacturing tariffs (Fan 2007). The author also shows that results are subject to assumptions about firms' relative performances – a piece of information which is difficult to obtain.

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2 The Armington model requires fewer parameters. This makes it a more parsimonious model, which is easier to build, calibrate and interpret.

Another take on sources of gains from trade

Last but not least, Martin and Ng (2004, cited in the World Bank's 2005 *Global Economic Perspectives*) have argued that tariff reductions can have different sources and condition the type of liberalisation undertaken:

- *Unilateral* liberalisation (accounting for 65 per cent of the reduction in average tariffs among developing countries over 20 years) was typically part of a unilateral program of reform designed to increase the productivity of the domestic economy.

- Improved market access motivated commitments to *multilateral* liberalisation for reformed economies (25 per cent of the reduction in average tariffs).

- *Regional trade agreements* included tariff reduction as part of a broad range of measure to reduce impediments to trade, including often post-border harmonisation of policies (10 per cent of the reduction in average tariffs).

The Armington specification does not capture well the rationale for the dominant unilateral liberalisation, because in this specification, producers do not compete strictly in the same markets and therefore their productivity is not strictly comparable.

The Armington-Heckscher-Ohlin (AHO) specification

In an attempt to capture gains from trade additional to those from LoV models, Zhang (2008) proposed recently an 'Armington-Heckscher-Ohlin (A-H-O) model' in which homogeneous and differentiated products are both identified, and which is designed to capture gains from liberalising trade in both types of goods.

The main challenge in producing an A-H-O model is to identify homogeneous products. These homogenous products are likely to:

- not be exported by all countries

- not be imported and exported by the same country

- compete with domestic production of homogenous and differentiated products.

Zhang (2008) also indicated that combining an A-H-O database with a standard Armington model structure is likely to capture a large proportion of the effects that a full-blown A-H-O model would produce.

The purpose of this paper is to provide some of the intuition behind the A-H-O model, based on a 'toy model' and on an early version of a full-blown A-H-O application.

- The toy model approach is often used to explain the intuition behind larger models, which are designed for policy advice. The toy model is based on a teaching version of the GTAP framework and database (Hertel 1997).

- The full-blown A-H-O application is built from the latest GTAP 7 database (Narayanan and Walmsley 2008). It is compared with the original GTAP model to evaluate the effect on model results of incorporating homogenous goods in the standard GTAP model.

The remainder of this paper is organised as follows. In the following section., certain aspects of the basic Armington model and of the A-H-O extension are exposed. Results from the toy model implementation are discussed in section 3. Results for a full-blown application with a large A-H-O database and standard GTAP code are analysed in section 4. Concluding remarks are found in section 5.

Main features of an Armington model

The Armington specification only deals with the demand side; the supply side can have a specification similar to that of an H-O model. A popular specification assumes that firms in each industry use primary factors and intermediate inputs to produce outputs under constant returns to scale and perfect competition. In equilibrium, there are no pure profits, and goods and factor markets clear.

Goods produced and exported by the same industry in different countries are considered to be imperfect substitutes by consumers in importing countries. Given prices and incomes, consumers choose a bundle of goods and services to maximise their utility.[3] This bundle typically includes differentiated products from all sources, including those produced domestically.

Some of the consequences of incorporating the Armington assumption in a trade model

Trade models incorporating the Armington assumption have larger terms-of-trade effects and smaller resource allocation effects than standard neoclassical models.[4] Zhang (2008) has shown that the terms of trade effects are the primary effect of policy change in an Armington model, whereas resource reallocation is only secondary. Thus, Armington models tend to underestimate the benefits of both unilateral and multilateral liberalisation. This shortcoming is often overlooked when interpreting the results of Armington models.

Market power and terms of trade effects

Because products are differentiated by their country of origin, every country has some market power in all the products that it exports. In particular, small countries have strong market power because their small resource base limits their capacity to expand production in response to an increase in demand for the goods they produce. As a result, for a similar reduction in tariffs, the relative price of exports to imports can decrease more in small countries than in larger countries, resulting in a large deterioration in terms of trade.

When tariffs are removed, the domestic prices of imports decline and consumers substitute imports for domestically produced goods. Whether this increases welfare depends on how income changes in response to the tariff reduction. In an Armington model, the prices of domestically produced goods tend to fall and world prices of imports

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3 Although this discussion is couched in terms of consumer theory, it applies to firms' derived demands for inputs.

4 See Lloyd and Zhang (2006) where the consequences of incorporating the Armington assumption in trade models are explored in depth.

tend to rise. This is because the supplies of differentiated goods are constrained by each country's resources. As the prices of domestically-produced (and export) goods fall, the terms of trade deteriorate and income declines.

Unilateral trade liberalisation might not benefit the liberalising country if it induces a sufficiently large terms-of-trade deterioration. In Armington models, because the terms-of-trade effects tend to be large, unilateral liberalisation typically does not benefit the liberalising country. In addition, because of the strong adverse terms-of-trade effects in an Armington model, multilateral trade liberalisation need not benefit all countries.

This contrasts with the common perception that freeing trade benefits all countries. This perception is based on gains from exploiting comparative advantage and the more efficient reallocation of production across the world and of resources within the economies, that underlie the benefits from reducing tariffs in the H-O model.

What happens when Armington elasticities are increased?

One response of modellers to the large terms-of-trade effects has been to increase the value of substitution elasticities. A typical Armington model assumes a two-stage substitution between domestically produced and imported goods. Expenditure on each good is first allocated between domestic and imported varieties and then expenditure on imports is allocated among competing national suppliers. Hence, there are two sets of Armington elasticities.

Changing the value of an Armington elasticity will affect changes in relative prices and therefore terms of trade effects. However, the effects of Armington elasticities in the two stages of substitution on the terms of trade are opposite to each other. If all elasticities are increased, the effects on the terms of trade offset each other. As a result, at high values of Armington elasticities, the terms of trade effect of a given policy change may remain constant as Armington values are increased. In addition, high Armington elasticities imply a high level of substitutability between goods – this is not consistent with the two-way trade patterns displayed by trade data.

Therefore, the large terms of trade effects in Armington models are not reliant on the choice of parameter values. They represent a more fundamental, structural characteristic, which is embodied in the model structure: increasing elasticity values does not reduce terms of trade effects appreciably.

Figure 1 uses an example of the GTAP model to illustrate that a proportionate increase in all Armington elasticities from their default values is unable to reduce significantly the terms-of-trade effects of a tariff. This is because there are opposite effects on a country's terms-of-trade, from (1) increasing the elasticity of substitution between domestically produced goods and import composites; and (2) increasing the elasticity between different import sources. In this example, US tariffs are increased by 10 per cent, creating a terms of trade gain of 4 per cent. When both sets of elasticities increase by the same proportion,

their effects on the terms of trade are offset, and the increase in terms of trade is reduced from 4 to 3.6 per cent as elasticity values are quadrupled.

Toy model implementation

Three model and database combinations are used in this section. They are based on the 3-sector (food, manufactures and services), 3-factor (land, labor and capital), 3-region (US, EU and ROW) simplified GTAP model shown in Hertel (1997).

- The 'Armington model' (**Model 1**) is the standard model in Hertel (1997). All goods are differentiated. Armington elasticities are the same across all countries (2.4, 2.8 and 1.9 for food, manuf and serv, respectively; double for the elasticity between imports from different sources)

- The 'A-H-O model' (**Model 2**) consists of 4 sectors and equations that are consistent with trade in homogenous goods. The homogenous good is produced in all countries, but exported only by the ROW. This is the only 'one-way trade' good; all others are traded both ways on all routes. The homogenous good accounts for half of ROW production and half of ROW exports of manufacturing, and 10 per cent of manufacturing production in the US and EU.

- The 'Split manufacturing and high elasticity model' (**Model 3**) combines:

  - the 4-sector database with the homogenous good

  - the equations for the pure 'Armington model' and

  - Armington elasticity values twenty times larger than in the Armington model for the homogenous manufactures.

As in Hertel 1997, the experiment consists of a 10 per cent reduction in the tariffs applied to US agricultural exports to the EU. The tariff in this database is 37 percent.

Results

The results are assessed in terms of effects on 'equivalent variation' (EV),[5] and on terms of trade (ToT), see figure 2.

In terms of welfare (EV), the most striking results include that:

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5 The equivalent variation (EV) evaluates a change in welfare as the change in real income induced by the policy change evaluated at 'pre-policy change' prices. Practically, in GTAP, it is defined as changes in real private and public consumption plus savings.

1. the Armington model allocates the largest benefit from reducing a tariff to the exporter (the US), not the importer – a typical mercantilist result.

2. by contrast, the A-H-O model allocates the largest benefits from reducing its tariff to the importer (the EU) – consistent with ideas about comparative advantage and improved allocative efficiency when eliminating a distortion.

3. in the A-H-O model, no country loses from the tariff reduction and the world as a whole experiences a larger net gain than in the Armington model; since both importer (EU) and exporter (US) incomes increase, both increase their imports from the ROW.

4. results for Model 2 and Model 3 are very similar – introducing homogenous goods into the database along with differentiated goods is a reasonable alternative to building a full-blown A-H-O set of equations for the homogenous products.

Results for the terms of trade reinforce the ideas above and provide an insight into the source of differences: the market power inherent in the Armington model, in which all products are differentiated by region, produces a large reduction in terms of trade when a country reduces its tariff. Since terms of trade effects must add to zero and EU terms of trade decrease, there is a compensating terms of trade gain in the US – the source of the US gains in EV. By contrast, the terms of trade effects in Models 2 and 3 are very muted.

The main conclusions from the toy model results include that: (i) the behaviour of the A-H-O model is consistent with the expectations in the previous discussion; (ii) combining an A-H-O database with a standard Armington code is a reasonable approximation of a full-blown A-H-O model; and (iii) this combination produces a reasonable approximation of stylised ideas about the different origins of gains from trade.

Application with a large A-H-O database

In this section, the standard GTAP code is used to run simulations with two databases — the original GTAP7 database and an A-H-O database derived from the GTAP database.

The A-H-O database

The A-H-O database contains 16 new homogeneous manufactured commodities;[6] as a result, the number of commodities or industries increases from 57 to 73. The new

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[6] In this paper, only manufactured goods have been separated into homogeneous and differentiated commodities. This is because manufacturing sectors use only mobile factors of production and are more likely to exploit any comparative advantage that they have in response to price changes. Although agriculture and mining could also be split, this paper has focused on manufacturing to illustrate most clearly the effects of introducing homogeneous goods into an Armington database. Determining the gains from liberalising agriculture in countries that specialise in producing homogeneous agricultural commodities would, however, be a valuable addition to the current debate over agriculture protection policies and provides an opportunity for further research.

commodities were split from the original database by assuming that homogenous goods within a GTAP category were characterised by lower prices (unit values) than the corresponding differentiated products. Where the price rules did not produce one-way trade flows for the homogenous good aggregates, commodities were reallocated to the differentiated group in order to ensure one-way flows for the homogenous goods.[7]

Basic characteristics of the database are found in tables 4.1 and 4.2:

- 14 per cent of the world's manufactured output is identified as homogeneous

- homogeneous output accounts for less than 10 per cent of total output in each region and just 4 per cent globally

- all other traded goods (primary and food processing), account for 10 per cent of world output.

Experiments

The A-H-O database is combined with the standard GTAP code. In addition, the Armington substitution elasticities (ESUBD and ESUBM) for the homogenous, one-way trade goods are set at 20 times the original values that are applied to the original corresponding commodity aggregates.

In the following, the GTAP equations with the modified elasticities when run with the A-H-O database will be referred to as the **A-H-O model**. The GTAP equations run with the original GTAP7 database will be referred to as the **GTAP model**.

The following scenarios are used:

- three *unilateral* trade liberalisation scenarios: a 10 per cent reduction in tariffs on imports of manufactured goods into the US, Australia and China

- a *multilateral* 10 per cent reduction in the tariffs on manufactured imports.

The tariffs reductions are applied to both homogeneous and differentiated manufactured products. The same policy shocks are imposed on the GTAP database and the A-H-O database.

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7 To avoid detracting from the discussion about model properties and results, the reader is referred to Zhang and Osborne (forthcoming) for details about database production. The remainder of the paper provides some of the characteristics of the A-H-O database used.

Results

The results of the experiments outlined above are assessed according to their effects on real equivalent variation (EV) – the measure of welfare, real GDP – the measure of economic activity, and the terms of trade.

Equivalent Variation

The welfare effects of the four liberalisation experiments are assessed in terms of the effects on EV (figure 3).

Global results

The A-H-O database generates higher welfare gains from trade liberalisation for the world as a whole in all scenarios (table 3). In particular, the increase in global EV from the US tariff cut is more than four times larger with the A-H-O model than with the GTAP model. In the multilateral trade liberalisation case, the global gains are more than two and a half times larger with the A-H-O model than with the GTAP model. These gains are due mainly to reallocating activity among the homogeneous goods industries across the world, an effect which is absent from the standard GTAP model.

Unilateral tariff reductions

In unilateral liberalisation experiments with the GTAP model, the USA and Australia, which have relatively low import tariffs, tend to experience welfare losses from reducing tariffs on manufactured imports. With the A-H-O model, the welfare losses for these two countries are projected to be much smaller. This is particularly the case for the Australian tariff cut: when other countries take advantage of Australia's tariff cuts by increasing their exports of manufactured goods to Australia, their demand for Australia's exports of industrial raw materials increases. This feedback effect is much stronger with homogeneous exports as captured in an A-H-O model than in a conventional Armington model. This effect helps reduce the substantial welfare losses, which the GTAP model projects for an Australian tariff cut.

For China, the situation is different. In the database, which is calibrated for 2004, China still has relatively high tariffs on manufacturing imports. According to the GTAP model, reducing China's tariffs on manufactured imports leads to substantial losses in its welfare. However, China is a major exporter of many manufactured goods in the world, many of which are homogeneous in nature. A reduction in import costs could make Chinese exports more competitive and enable Chinese exporters to expand further in the world market. When these effects are taken into account in the A-H-O model, the net effect of the tariff cut becomes positive: China is projected to gain from its own trade liberalisation, consistent with traditional trade theory.

Real GDP

Real GDP is an indication of changes in economic activity. The differences between the two models can be seen clearly in the changes in real GDP, because the A-H-O model accounts for reallocation gains, which result in increased world production, whereas gains in the GTAP model are distributional.

The results show that trade liberalisation tends to generate larger output expansions with the A-H-O model than with the GTAP model (figure 4). This effect is especially evident in the results for the countries that initiate the trade liberalisation. This occurs because the A-H-O model captures the more active resource reallocation triggered by each country's own tariff cuts. These efficiency gains increase welfare gains (in the case of China) and reduce welfare losses (in the cases of the USA and Australia) in trade liberalisation experiments.

The output gains from the multilateral trade liberalisation simulation are larger in the A-H-O model results than in the GTAP model results. This indicates that when homogeneous goods are explicitly accounted for, trade liberalisation leads to a strong expansion of world output. As the world's resources are fixed, these gains are allocative efficiency gains.

Terms of trade effects

When Armington elasticities are low, large price changes are required to accommodate small changes in quantities. In the GTAP model, this leads to large terms of trade losses that exert a strong negative influence on welfare gains. This means that trade liberalisation often leads to net welfare losses for the liberalising country.

In an A-H-O model, on the other hand, homogeneous commodities are traded according to the 'law of one price'. The large Armington elasticities associated with homogeneous goods allow for large quantity changes without requiring large changes in prices. This reduces the terms of trade losses projected with the GTAP model.

When considering the results for the terms of trade effects from the A-H-O model, two factors should be kept in mind:

1. the terms of trade effects are a combination of the small price changes for the homogeneous goods and large price changes for the differentiated goods and they depend on the magnitude of the policy change,

2. the welfare effects of trade liberalisation are a combination of quantity changes (real GDP expansion) and price effects (terms of trade).

The results for terms of trade changes from the four tariff simulations are compared in figure 5.

Unilateral tariff reductions

For the USA and Australia, the database tariff rates are already very low. A 10 per cent tariff cut alters relative prices only modestly for these countries. The relatively small price changes generate only small output reactions and resource reallocations in the GTAP model. In the A-H-O model, however, small shocks to prices can trigger large resource reallocation and output changes. To restore equilibrium, all prices have to change which results in slightly larger terms of trade effects, but these effects are outweighed by strong output expansion effects and result in the smaller welfare losses mentioned earlier.

The terms of trade effects in the A-H-O model for China are much smaller and are also smaller for many of its trading partner countries and regions. This result can be explained by China's high initial tariff rate and the type of goods it exports. A 10 per cent cut in Chinese tariffs causes a relatively large increase in the domestic demand for imports. China therefore exports more to balance its trade. Due to the 'law of one price', when China increases its exports, the world prices of these exports do not decrease to the same extent as in the GTAP model. This explains why, in the A-H-O model, China does not suffer from heavy terms of trade losses, and also why other countries do not gain as much in their terms of trade. These smaller terms of trade losses combined with the large output expansion captured in the A-H-O model lead to the welfare gains for China predicted as a result of China's trade liberalisation.

Multilateral tariff reduction

In the multilateral trade liberalisation, terms of trade losses are generally smaller with the A-H-O model. For example, Australia experiences a terms of trade loss with the GTAP model but a gain with the A-H-O model. China experiences large increases in its terms of trade gains with the A-H-O model and Bangladesh and India experience much smaller terms of trade losses.

Conclusion

Gains from trade liberalisation have different sources. Different model specifications incorporate assumptions, which can account for these different sources. The most common specification of large trade models incorporates the Armington assumption of product differentiation, which accounts for one of the sources of gains from trade.

This paper starts from the assumption that trade in homogeneous goods exists in practice and that trade models that are based on aggregate data and do not account for this type of trade would benefit from being able to take it into account. This does not mean that all

possible gains from trade are accounted for. In particular, given adequate data, accounting for gains from firm heterogeneity seems to be a promising avenue for improving global trade modelling.

The inclusion of homogeneous goods can significantly increase the gains from trade liberalisation that are projected by the GTAP model. In the example shown, welfare gains from trade measured in terms of EV projected with the standard GTAP model were doubled (in the multilateral liberalisation simulation) or quadrupled (in a unilateral simulation). The mechanisms by which these gains come about — increased output expansion and smaller terms of trade effects — are effects that are not captured in Armington models. The A-H-O model allows these effects to be accounted for, when appropriate.

The paper has also shown that combining an A-H-O database with the standard set of GTAP equations is a viable alternative to developing separate equations for homogenous goods.

Zhang (2008) identified that the main challenge in accounting for homogenous goods trade is to identify them in a global database. As a result, in the A-H-O database developed in this paper, homogenous goods were identified only among manufacturing products. Expanding this to certain primary products could result in further increases in gains from trade liberalisation.
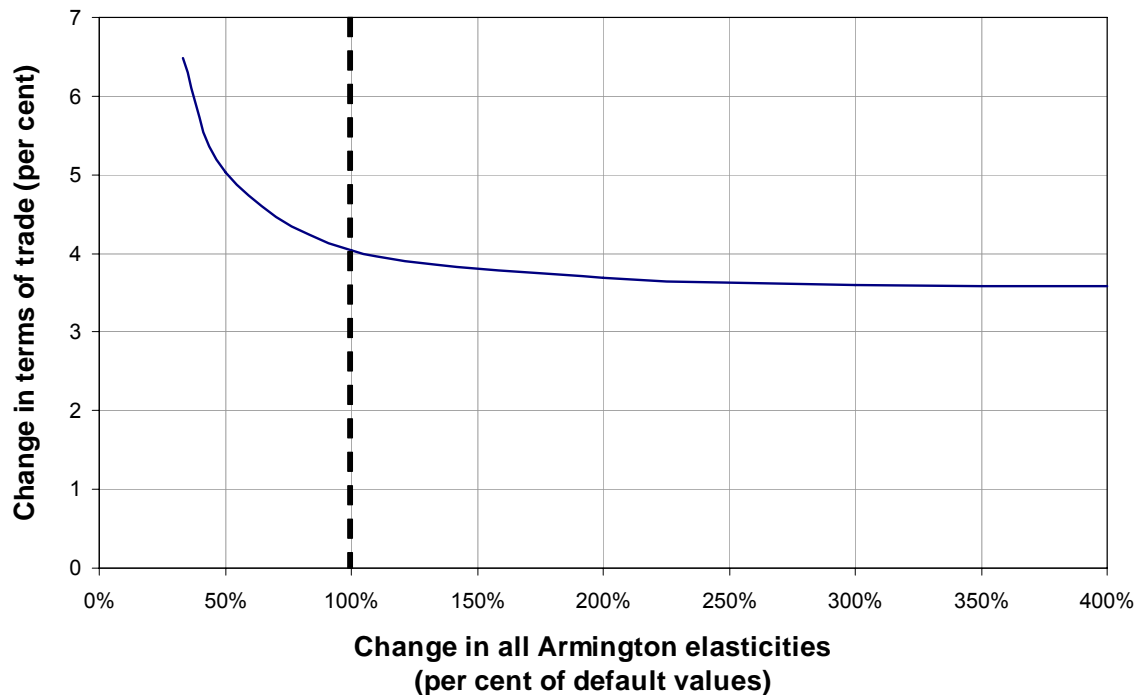
Tables

Figures

References

Figure 1 **Increasing all Armington elasticities proportionately does not force change in the terms-of-trade toward zero[a]**

Improvement in US terms of trade due to a 10 per cent increase in US tariff

[a] Simplified 3 commodity, by 3 industry, by 3 region GTAP-based model. Regions are US, EU and Rest of the World. All Armington elasticities are raised by the same proportion. Default values of the elasticities (100 per cent in the diagram) between imports and domestic are set at: 2.4 for food, 2.6 for manufactures and 1.9 for services; import-import elasticities are 4.6, 6.1 and 3.9, respectively. Few models contain values that are smaller than these values.

Source: Zhang 2006, Figure 6.2.

Figure 2 **Percentage changes in equivalent variation and in terms of trade in 3 different models**[a]

10 per cent reduction in tariff on food exported from US to EU
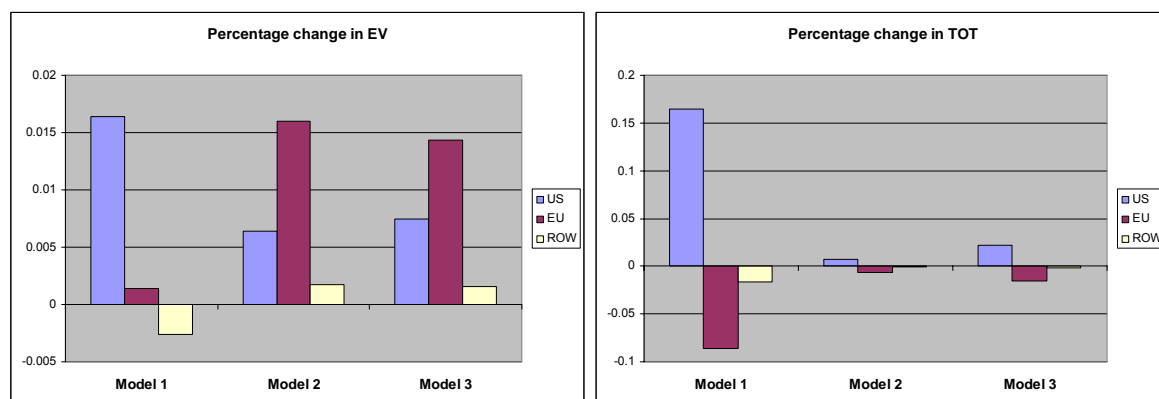
[a]**Model 1**: Armington model; **Model 2**: A-H-O model; **Model 3**: Split manufacturing and high elasticity model.

Table 1 **World output of homogeneous and other products in manufacturing industries**

Based on GTAP 7 database, includes intermediate inputs, base year 2004

GTAP sectors	Homogeneous goods (US$ million)	Others goods (US$ million)	Proportion of homogeneous in total output
Textiles	175,830	697,852	0.20
Wearing apparel	175,517	472,303	0.27
Leather products	73,314	169,319	0.30
Wood products	141,302	568,621	0.20
Paper products, publishing	196,733	1334,828	0.13
Petroleum, coal products	343,370	1091,594	0.24
Chemical, rubber, plastic products	331,748	3370,713	0.09
Mineral products nec	92,782	714,417	0.11
Ferrous metals	198,555	918,177	0.18
Metals nec	139,160	506,217	0.22
Metal products	168,424	1107,089	0.13
Motor vehicles and parts	276,126	2099,540	0.12
Transport equipment nec	49,423	612,559	0.07
Electronic equipment	309,550	2029,251	0.13
Machinery and equipment nec	316,634	3220,104	0.09
Manufactures nec	116,273	678,576	0.15
Total	*3,104,741*	*19,591,160*	*0.14*

Source: A-H-O database; see Zhang and Osborne 2009

Table 2   Proportions of industries in total output, by country

Based on GTAP 7 database, includes intermediate inputs, base year 2004

Region	Homog. Manufac.	Differentiat. Manufac.	Total Manufac.	All other traded goods[a]	All non-traded goods[b]	Total
AUS	0.02	0.16	0.18	0.12	0.70	1.00
NZL	0.03	0.16	0.19	0.16	0.64	1.00
CHN	0.11	0.36	0.47	0.15	0.38	1.00
HKG	0.00	0.12	0.12	0.06	0.82	1.00
JPN	0.04	0.25	0.29	0.05	0.66	1.00
KOR	0.09	0.37	0.45	0.05	0.49	1.00
TWN	0.10	0.38	0.48	0.05	0.46	1.00
IDN	0.07	0.25	0.31	0.25	0.44	1.00
MYS	0.11	0.48	0.58	0.15	0.27	1.00
PHL	0.04	0.36	0.40	0.18	0.41	1.00
SGP	0.07	0.38	0.45	0.02	0.53	1.00
THA	0.13	0.34	0.47	0.15	0.38	1.00
BGD	0.08	0.15	0.23	0.29	0.48	1.00
IND	0.05	0.26	0.31	0.24	0.45	1.00
ROA	0.04	0.19	0.23	0.29	0.48	1.00
CAN	0.06	0.20	0.26	0.11	0.63	1.00
USA	0.02	0.20	0.22	0.05	0.72	1.00
MEX	0.07	0.39	0.46	0.18	0.36	1.00
BRA	0.05	0.24	0.30	0.17	0.53	1.00
ROM	0.04	0.22	0.26	0.22	0.52	1.00
EUN	0.03	0.28	0.31	0.08	0.61	1.00
RUS	0.07	0.17	0.24	0.23	0.53	1.00
ROE	0.05	0.22	0.27	0.16	0.57	1.00
ZAF	0.06	0.26	0.32	0.12	0.56	1.00
ROF	0.02	0.17	0.19	0.35	0.46	1.00
World	0.04	0.25	0.29	0.10	0.61	1.00

**a** Primary and food processing. **b** Services

Source: A-H-O database; see Zhang and Osborne 2009

Table 3   Global EV gains from four trade liberalisation scenarios

| Country/region liberalising	GTAP database (US$ million)	A-H-O database (US$ million)	A-H-O / GTAP
USA	399	1,766	4.43
Australia	94	156	1.66
China	670	1,387	1.98
Multilateral	4,557	12,026	2.64

Source: A-H-O and GTAP model simulations

Figure 3   **Changes in EV from reducing tariffs[a]**
(US$ million)
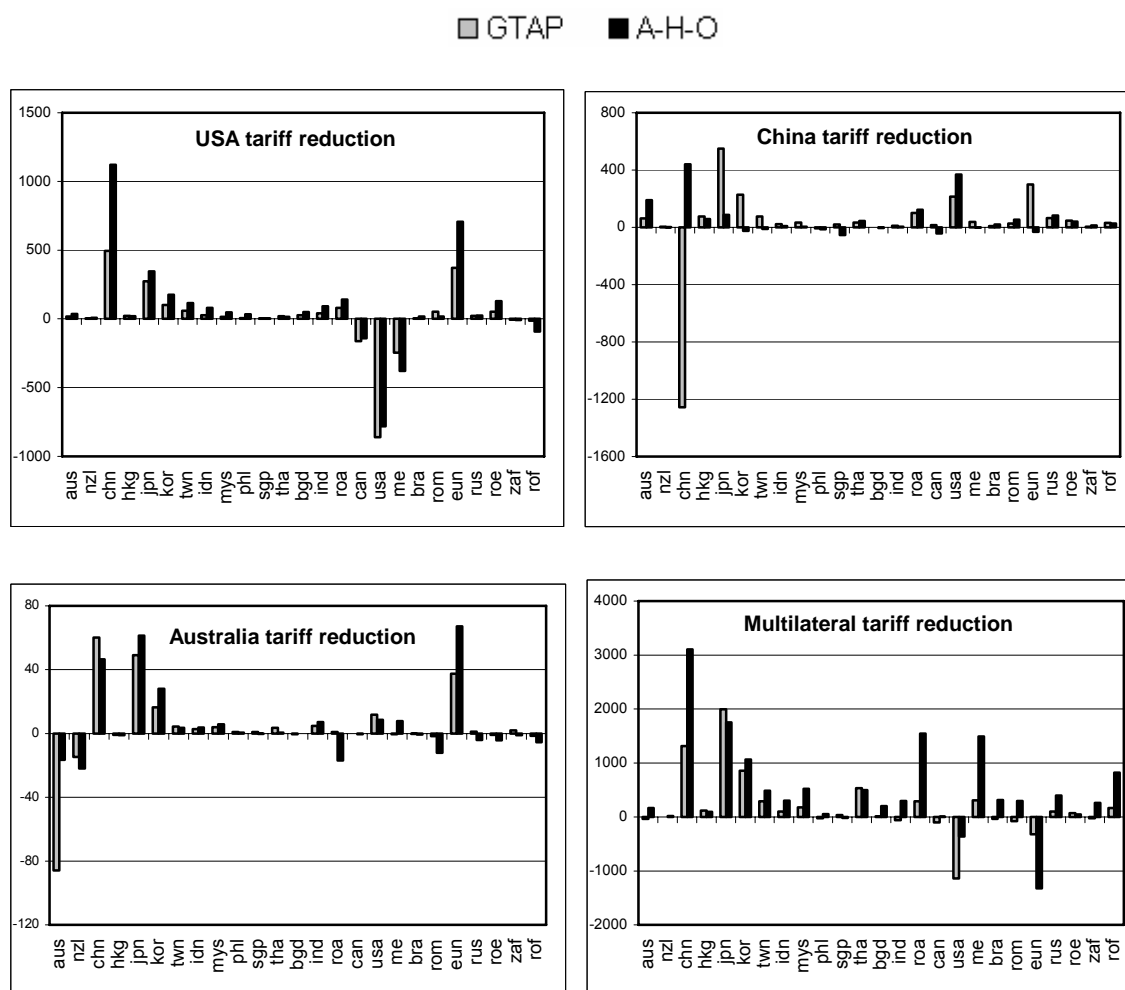
a Unilateral 10 per cent reductions in tariffs on manufacturing imports into the US, China and Australia and multilateral reduction.
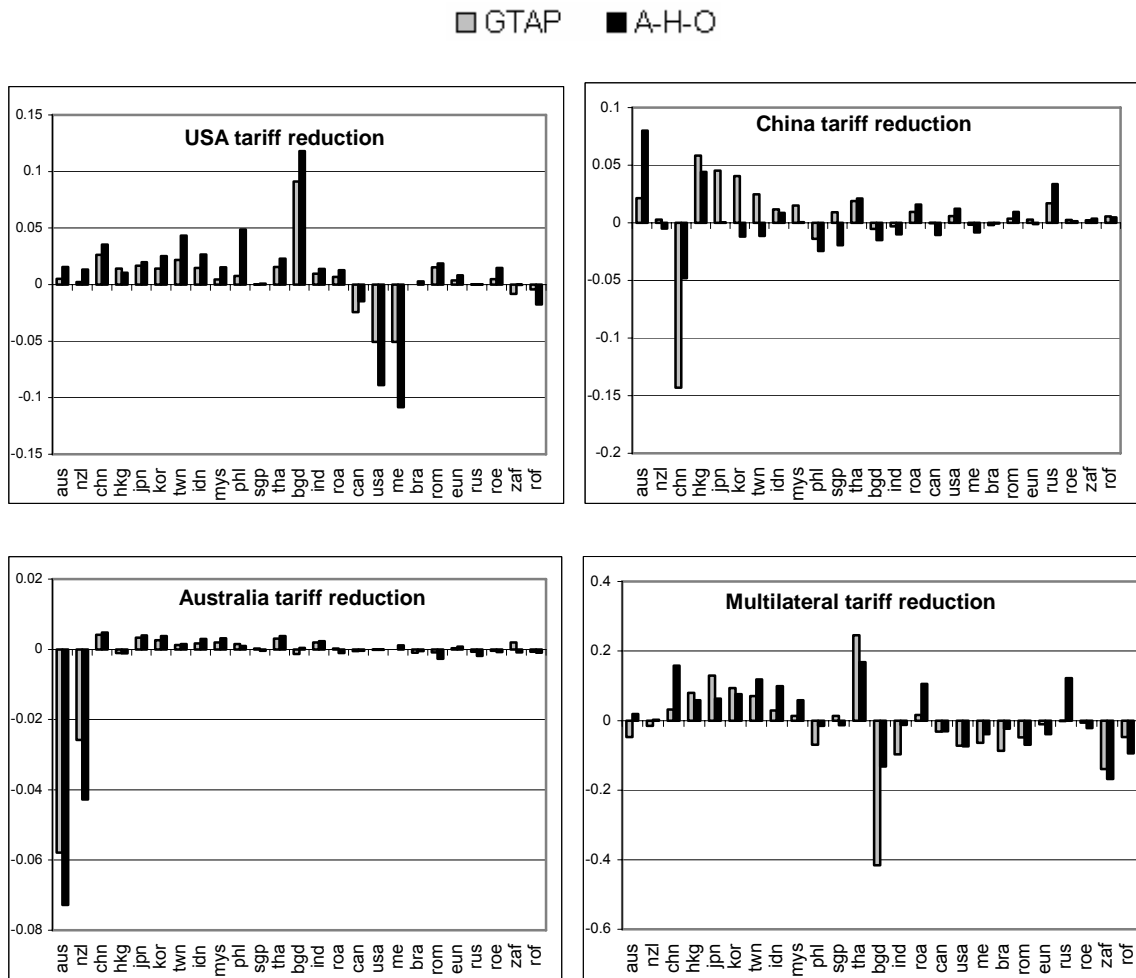
Source: A-H-O and GTAP model simulations

Figure 4   Changes in real GDP from reducing tariffs[a]
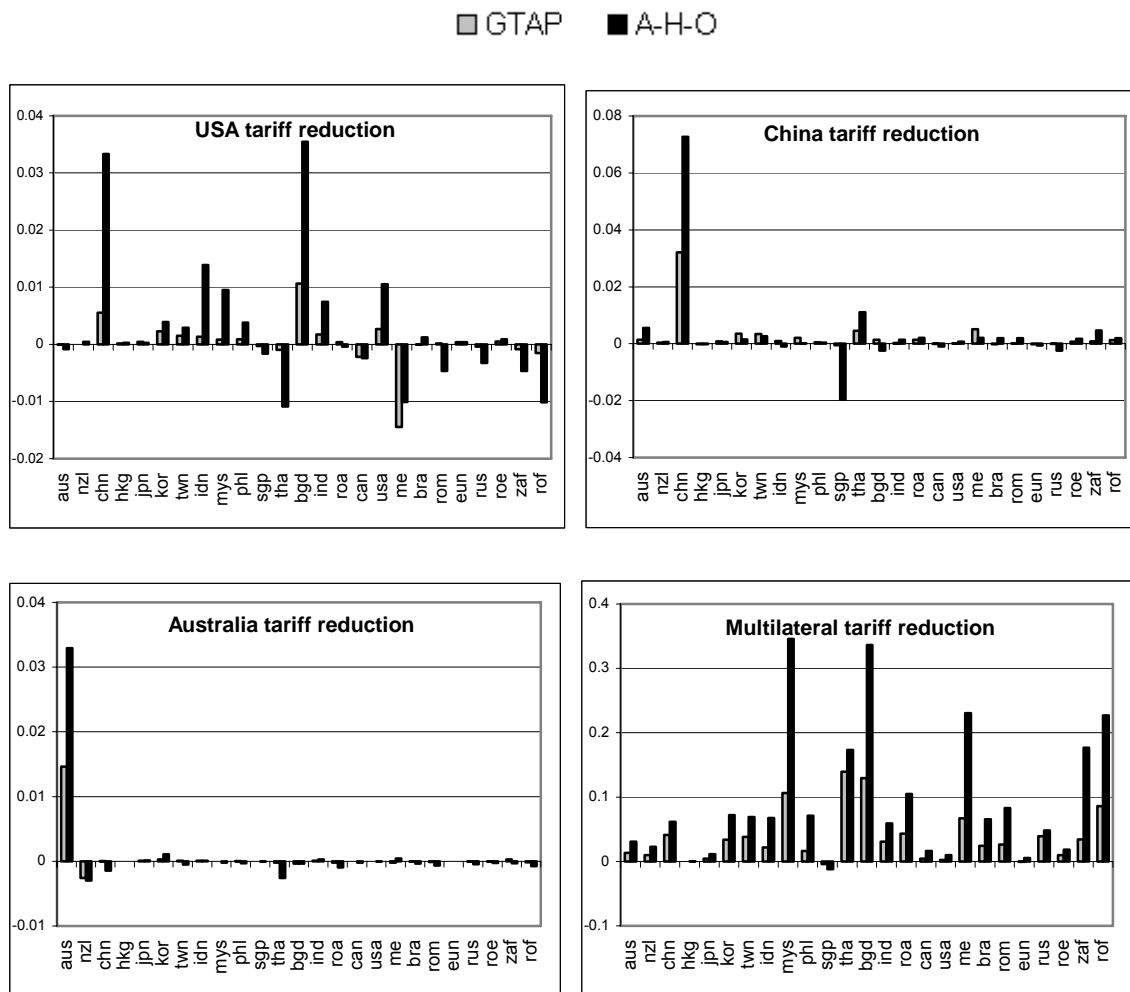
(percentage changes)

□ GTAP   ■ A-H-O

a Unilateral 10 per cent reductions in tariffs on manufacturing imports into the US, China and Australia and multilateral reduction.

Source: A-H-O and GTAP model simulations

Figure 5   **Changes in terms of trade from reducing tariffs[a]**
(percentage changes)

□ GTAP   ■ A-H-O

a Unilateral 10 per cent reductions in tariffs on manufacturing imports into the US, China and Australia and multilateral reduction.

Source: A-H-O and GTAP model simulations

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