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THE EFFECT OF ARMINGTON STRUCTURE ON WELFARE EVALUATIONS IN GLOBAL CGE-MODELS

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Abstract

In this paper, the welfare results in trade liberalisation scenarios in global CGE models (like GTAP) are analysed. The default modeling strategy in trade is the Armington assumption with bilateral trade flows in industries. The negative terms of trade effects that often dominate the negative welfare outcome in simulation experiments are decomposed to imports and exports price effects. The numerical examples show that even in unilateral liberalisation with decreasing import tariffs, the welfare effects are dominated by domestic price level changes that also drive the exports prices. The numerical examples are built around simple GTAP tariff cut experiments with 3x3 country and commodity aggregation. The inherent feature in this type of models is that they support arguments for unilateral market access, like preferences, at the expense of multilateral trade liberalisation.

Key words: CGE Modeling, trade liberalisation, terms of trade

1. Introduction

In assessing the world market impacts of multilateral trade reforms, nearly all the global general equilibrium models today draw on the global production, use, and trade database collected and maintained by Global Trade Analysis Project (GTAP) (Hertel and Ivanic (2006).

One essential feature of the database that also guides the modelling solutions, are the bilateral trade flows by industries. This means that both imports and exports in each industry are tracked by source or destination. In trade statistics each industry is composed of several distinct products making this two-way trade possible. According to Francois and Reinert (1997), applied trade policy analysis prefers model structures utilising accurate and current data at the expense of more consistent theoretical frameworks, whenever that trade data is available.

The modelling solutions based on Armington structure have their impact on the effects of welfare impacts from trade liberalisation. In this study those effects and arguments used in explaining the results are discussed. Especially, the negative welfare effects for many developing countries in the trade liberalisation have raised this interest.

The negative welfare effects in trade liberalisation are shown to be due to the cross-substitution of domestic and imported commodities. The decreasing price of imported commodities reduce the price of domestic commodity. If this commodity is further exported, its decreasing price causes a decrease in the price of exportables, terms of trade and welfare, respectively.

The paper is structured as follows. First, the welfare changes from trade liberalisation are analysed starting from the general approach in the form of expenditure function and decomposing the effect of tariff changes. After that, we introduce the Armington structure and how it has been applied in modelling trade in GTAP model. Next we take a numerical example of GTAP simulations to describe the decomposed effect of trade liberalisation. Finally, we discuss the implications that this modelling approach has in the arena of trade liberalisation discussion.

2. **Approximating welfare changes arising from a change in trade policy**

Assume there are N goods, each good is produced domestically and also imported. Part of the production is exported. World prices are denoted by vector $p_w = (p_{w1},\ldots p_{wN})$, and the vectors of domestic and imported prices as $p_d = (p_{d1}, \ldots, p_{dN})$ and $p_m = (p_{m1},\ldots, p_{mN})$, respectively.
Assume also that the behaviour of economies with existing distortions can be presented by maximised value functions where the following identity between expenditures and incomes holds:

(1.1) $S(p_d,p_m,p_w,u_0) \equiv G(p_d) + \sum(p_{mi}-p_{wi})m_i$

S are the expenditures with a given utility including the imported commodities as well. The income consists of production $(G(p_d))$, given by the economy's revenue or GDP function (part of which is exported with domestic price p_d) and the tariff revenue where $\tau = p_{mi}-p_{wi}$ is the tariff rate and m_i is imports.

Money metric welfare change, called equivalent variation, measures the expenditures in the new situation after a policy implementation compared to the original expenditures and is defined as

(1.2.) $EV = S(p_d,p_m,p_w,u_1) - S(p_d,p_m,p_w,u_0)$
A local approximation of the welfare change can be derived by assuming the expenditures in the new situation to equal with income [1]

(1.3.) $EV = (G(p_d) + \sum(p_{mi}-p_{wi})m_i) - S(p_d,p_m,p_w,u_0) = 0$

Holding utility constant ($du_0 = 0$), the equation can be totally differentiated

(1.4) $$dEV = \sum_{i=1}^{N}\Big[\frac{\partial G}{\partial p_{di}} dp_{di} + (dp_{mi}-dp_{wi})m_i + (p_{mi}-p_{wi})dm_i - \Big(\frac{\partial S}{\partial p_{di}} dp_{di} + \frac{\partial S}{\partial p_{mi}} dp_{mi}\Big)\Big]$$

By the properties of the revenue and expenditure functions we have $\partial G/\partial p_{di} = q_i$, the supply of the commodity i, $\partial S/\partial p_{di} = d_i$, the demand for domestic commodity i and $\partial S/\partial p_{mi} = m_i$ is the demand for imports. Including these to the previous equation we get

(1.5.) $$dEV = \sum_{i=1}^{N} [(q_i-d_i)dp_{di}-m_i dp_{wi})+(p_{mi}-p_{wi})dm_i)]$$

where q_i-d_i measures exports, domestic production minus consumption and the dp_{di} is the change in the price of the domestic commodity. The first term in brackets measures the sum in terms of trade change when both exports and imports are taken into account. The last effect is the trade volume effect which

[1] Adapted from Bowen et al. (1998), p. 197.

measures the change in tariff revenue when volume of imports changes. The last term can be thought to describe the general deadweight loss due tariffs.[2]
To make the case even more comparable with GTAP results, the equation can be divided by d τ and recognise the substitutability of domestic commodity with imported one $\partial p_{di}/\partial p_{mi}<0$.

$$(1.6)\ dEV/d\tau = \sum_{i=1}^{N} [(q_i-d_i)dp_{di}/dp_{mi}(dp_{mi}/d\tau) - m_i dp_{wi}/d\tau + (p_{mi}-p_{wi})dm_i/d\tau]$$

The effect of tariff changes to welfare can be decomposed to exports market effect, the effect of the tariff to world market prices and the allocative effect through increased imports (in tariff decreasing case). The last effect is usually positive as increased, cheaper imports improves efficiency when replacing the domestic production with distortions.

2. Modelling bilateral trade with nested CES-functions

The default modelling strategy for bilateral trade flows in competitive trade models is to assume an Armington type import demand, where domestically produced and imported commodities are imperfect substitutes with each other sourced by their origin (Armington 1969) The common assumption also treats imported varieties as substitutes with each other. Import demand is a two-stage nested CES-function. The widespread use of CES-functions in this type of analysis is partly due to their limited need of information on elasticities. The aggregation of industries is also possible with a CES-function.

GTAP modelling of trade.

Differences in modelling Armington type trade can be characterised whether the Armington aggregation is specific to each agent within a region or instead is simply performed at the border. (Hertel et al. 1997). In GTAP Model the composite imports is tracked for every agent (producers, consumers, government).

The producer behaviour is a two-nested CES-function where the upper-level part of the function combines primary inputs with intermediate inputs with fixed coefficients. The value added nest itself is a CES-function with same elasticities among all factors of production. The intermediate inputs are formed of domestic products and imported composite and imported composite is further a composite of products imported from different simulations. The base data defines the original shares that in simulations adjust to new prices finding the magnitude of changes from the parameters.

[2] Graphical exposition in a one commodity case, see Bowen et al, figure 5.3.

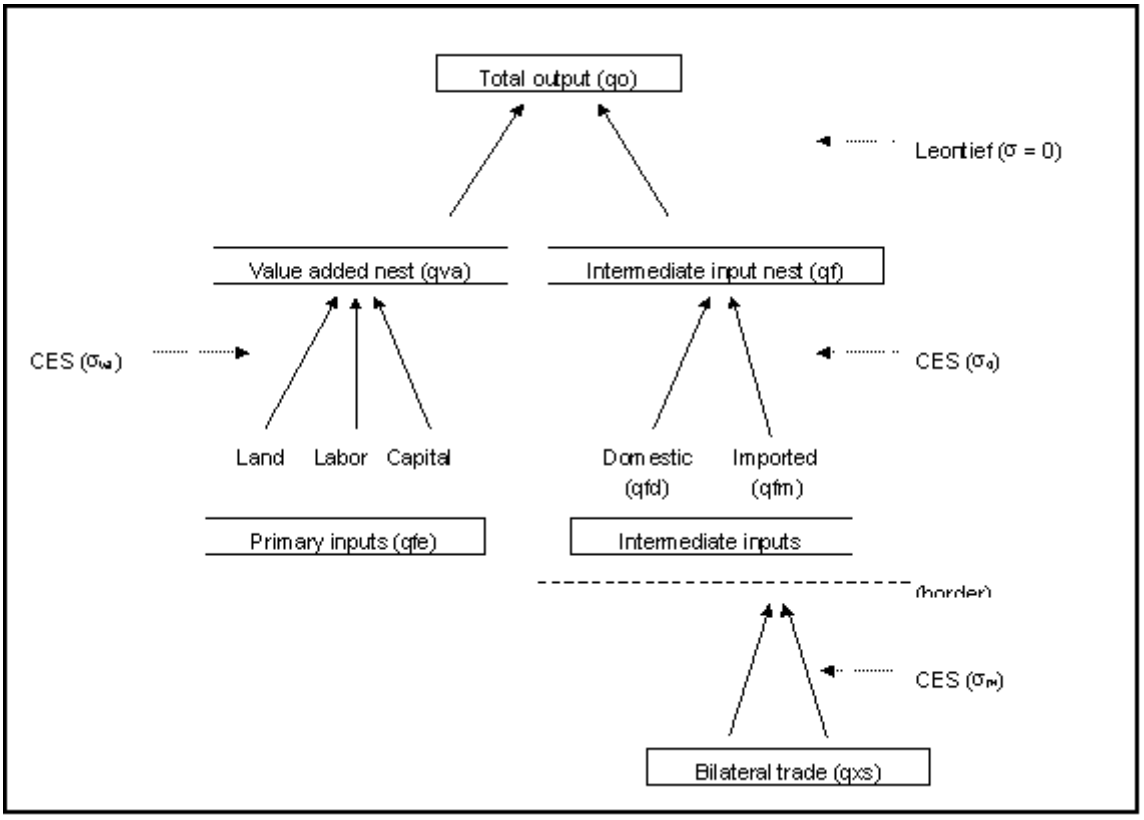

Figure 2.1: The production technology tree in the GTAP model
Source: Adapted from Hertel and Tsigas (1997, p.56).

3. Transmission of tariff cuts to terms of trade

The effect of tariffs on world market prices (middle effect in 1.6) measures how much of the tariff changes passes through to world market prices. In homogenous goods models, the small country takes world market prices as given, but the large country can pass some of the tariff increase to decreasing world market price, implying positive optimal tariffs for a large country. As has been noted by Gros (1987), Panagariya (2000) and is well known, the Armington type of models imply positive market power for all exporters. Increasing exports through tariff cuts implies positive terms of trade gains even for small countries.

This argument is commonly used in explaining the negative negative welfare effects due to trade liberalisation and is stated for example in Hertel and Ivanic (2006) p. 59. It claims reason behind this outcome to be the relatively high optimal tariffs even for small economies. Reducing tariffs below their optimal levels would lead to negative welfare effects.

Armington structure and the form of composite imports, creates an import supply function which is flat instead of steep. An infinitely elastic import demand reflects a situation where tariff reductions do not pass through to international prices, implying the optimal tariff argument does not hold. The general approach namely thinks the properties of tariff to be optimal at the tariff setter's viewpoint.

Instead, the negative welfare effects in trade liberalisation are due to the cross-substitution of domestic and imported commodities. The decreasing price of imported commodities reduce the price of

domestic commodity. If this commodity is further exported, its decreasing price causes a decrease in the price of exportables, terms of trade and welfare, respectively.

Armington structure implies export demand function for every trading country to be elastic. The import supply curve that responds to changes in tariffs is still flat, for each of the country. This note has been raised explicitly at least in Horridge and Zhai (2005). This explains why the imports prices do not respond to the tariff cuts when exports prices in exporting countries simultaneously do.

4. Numerical example

To show these effects with a numerical example we use a 3x3 aggregation with three countries (EU,Mozambique,Row) and three commodities (Food,Manufactures,Services) and analyse a case of 10 percent tariff cut in the power of tariff for food exported from EU to Mozambique. As such, it is a unilateral trade liberalisation by Mozambique.

The example here resembles a lot the GTAP book's first example (Hertel 1997), where EU unilaterally reduces the tariffs for imports by 10 %. In that example countries are aggregated to EU, USA and ROW. Commodity aggregation is the same as here. All the results are analogous and about the same magnitude. The only difference and the mutual gains in the book example come from the positive allocation effects. The terms of trade effects are of same magnitude. For comparison, we also report the results for GTAP book example. In the base data the size of this bilateral tariff for imports of food from EU to Mozambique is 30 %. In the latter case, the tariff for imports from USA to EU is 36.9 %.

Table 4.1. Decomposed Welfare and terms of trade effects from unilateral trade liberalisation

Aggregation with EU Moz and ROW

Welfare, in MIO USD, 10 cut in Moz tariff of food from EU	Allocative effect	Terms of trade	Investment Effect	Total
1 EU	-0,48	1,03	0	0,55
2 Mozambique	0,41	**-0,52**	-0,03	-0,14
3 ROW	0,01	-0,51	0,04	-0,46
Total	-0,05	0	0	-0,05

Terms of trade Moz	1 pworld	2 pexport	3 pimport	Total
1 Food	0	-0,18	0	-0,18
2 Mnfcs	0	-0,14	0	-0,14
3 Svces	0	-0,19	0	-0,19
Total	0	-0,52	0	**-0,52**

3x3 Book example

Welfare, in MIO USD, 10 cut in EU tariff of food from USA	Allocative effect	Terms of trade	Investment Effect	Total
1 USA	-7,21	659,43	34,98	687,2
2 EU	881,23	**-406,76**	-21,23	453,2
3 ROW	-102,66	-252,67	-13,75	-369,1
Total	771,4	0	0	771,4

Terms of trade EU	1 pworld	2 pexport	3 pimport	Total
1 food	0,86	-49,44	-6,32	-54,91
2 mnfcs	-0,14	-185,41	-41,04	-226,6
3 svces	0,78	-100,02	-26,01	-125,26
Total	1,5	-334,88	-73,38	**-406,76**

The tables on the left report the welfare results (EV measured in Millions of USD) decomposed to allocative effect, terms of trade effect and investment effect. The last effect is borne from the behaviour of global savings closure and we ignore it here. The positive allocative effects are borne from increasing imports that replaces domestic production and are positive for liberalising countries in both cases. The terms of trade effects are also negative in both cases. The further decomposition of the terms of trade effects to world market prices (pworld), export prices (pexport) and imports prices (pimport) reveals that in both cases, the negative effects are bourne on exports effects (Terms of trade –decomposition developed by Robert McDougall, see the Model code of GTAP). Mozambique is so small country that its imports has no effect on export price of EU, neither on world market prices.

Instead EU, is so big player, that it's unilateral liberalisation has power on both imports prices as well as world market prices (Price changes are reported as changes in Millions of USD in values, for comparison). Still, in both cases the cross-substitution effect on imports prices to export prices dominates the effects.

5. Discussion

The changes in terms of trade for a liberalising country through its exports prices, not imports prices, raises a question of the role of the aggregation played here. The aggregation has an impact to the substitution structure within one economy. Let us think of a EU is importing oranges and exporting wheat. If it decreases the tariff for wheat, how does this affect on the price of wheat. If goods are disaggregated, the effect comes through demand. But if they are aggregated, the effect comes apart from demand but also from the production and the import composites of different actors. Increasing demand decreases the price of domestic composite and exports, thus the price of wheat.

The real effect on outcome on trade liberalisation is due to determination of factor prices and how they are determined. In Davis (1996), the factor prices depend only on exports prices, not on the prices of importables. These effects drive the welfare effects of trade liberalisation.

The more clear conclusion of the Armington structure raises from the policy implications it entails. Unilateral market access is the most beneficial policy to any country in the model. Vice versa, increasing imports is always harmful in the terms of trade sense. Imports is beneficial only in cases where it replaces production with large distortions, like in the EU. In the appendix the exact formulation of the import demand function in GTAP is presented as an example.

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