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TOOLS FOR EXANTE TRADE IMPACT ANALYSIS

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Abstract

Trade reform is complex to analyze, as it combines a variety of economic mechanisms at the same time: macro-economic effects, sectoral effects, in the short and long run. Besides, the impact of the reform depends crucially on the initial situation: tax levels, distortions between sectors of activity, trade, production and consumption patterns. In such a real world, theory cannot suffice to identify optimal policies; in depth empirical analysis based on a consistent and detailed picture of the concerned economies is essential.

The objective of this technical document is to provide a review of the various tools used to ex-ante assessment of trade policies with a focus on three major categories: gravity models, partial equilibrium models and computable general equilibrium models.

Introduction

The purpose of this manual is to provide a written material to support member states technical capacities to understand and uses various modelling approaches on applied trade policy analysis. This technical document is prepared by the regional integration section (RIS) of the Economic Development and Integration Division (EDID) of the United Nations Economic and Social Commission for Western Asia (ESCWA) as a manual to assist interested readers on the tools used and being developed by UNESCWA for its activities on assessing potential trade agreements. This type of analysis is not intended to evaluate in force trade agreements but rather to provides insights on the potential implications of multiples scenarios of concluding new trade agreements that still being negotiated. A second technical paper will present the various tools used by RIS in assessing the effective implications of trade agreements. With these two technical documents, readers of ESCWA's publications on trade issues will be able to refine their knowledge on the used tools and their relevance for specific policy issue.

This document is composed by four chapters. In chapter 1 are provided the main modelling approaches used at the present time in applied trade policy analysis. This chapter one is quite long and can be viewed as the core element of this technical document. Three modelling tools are described and some of them are applied to simulate the impact of tariff policy scenarios. Chapter 2 is devoted to a presentation of CGE modelling as applied to the analysis of trade policy. In the course of explaining the functioning and price determination mechanisms of CGE models, we also provide an account of the various types of CGE models that used in trade policy analysis. In addition to distinguishing static and dynamic CGE models, we also classify CGE models according to their geographical scope. This means that we could define single country, regional and global CGE models. In Chapter 3 are developed two topics. The first one is to describe social accounting matrices which serve as a basis to implement a CGE model through a calibration process. The second topic of chapter 3 is to review the existing global trade databases that deal with trade patterns, trade policy instruments and other data information that are used in applied trade policy analysis. The last chapter of this manual focuses on two illustrative case studies in order to show how to interpret and discuss the simulation results generated by CGE models.

The review of the modelling approaches applied to trade policy analysis has been undertaken by consulting and referring to well established manuals or discussion written by well-known trade economists over the last twenty years. These manuals are as listed in the reference list[1].

[1] See in particular the following references: See in particular the following references: Bachetta et al. (2012), Gopinath et al (2014). Francois and Reinert (1997) and Piemartini and The (2005).

Chapter 1: Major quantitative approaches for trade policy analysis

In this chapter are reviewed the most important modeling approaches currently used to assess the economic and welfare impacts of trade policies. The first two approaches are based on a partial equilibrium framework within which commodity markets under study represented by partial trade equilibrium models allowing for the simultaneous determination of international equilibrium market prices and trade flows among commodities. These first two types of models are presented and explained assuming that they represent one international commodity market. The third modeling approach is based on a computable general equilibrium (CGE) framework which considers the economy as a whole, taking into account the various interlinkages among output and primary factor markets. This latter model is encompassing in the sense that it allows to assess the economy-wide impacts of any economic policies. The fourth modelling approach that is reviewed in this chapter is the gravity model which explains trade flows between two countries as a function of the country economic size and transportation costs represented by the distance between the two countries. This fourth modelling approach is econometric-based while the first three ones rest on calibration procedures aimed at representing commodity markets or the economy under study for a reference or base period (which is in most cases a given year)

To have an idea on how to assess the impact of trade policies, it is necessary in a first step to review the theoretical foundations behind such quantitative economic analyses. This attempt is part of the first section within which the price and volume impacts of tariffs are explained using a theoretical partial equilibrium approach. In this process, a graphical-oriented approach is not only adopted but also emphasis is put on showing the welfare impacts of imposing a trade policy instrument such as a tariff. Once the theoretical review of imposing a tariff is completed, we proceed in the following sections with the description and discussion of the four modeling approaches that are nowadays in use among trade analysts and economists. It is also worth pointing that tariff policy scenarios will be implemented and discussed using the partial equilibrium trade modeling approach developed further in this chapter. Concerning the CGE modelling approach, a brief overview is provided in this chapter while a detailed account on the structure and functioning of a CGE model is given in Chapter 2. The last section of this chapter is devoted to the gravity model.

1.1- Brief review on the economic and welfare impacts of a tariff policy

To protect a domestic industry, a country could have recourse to a tariff which raises the consumer price of the commodity. This in turn would benefit domestic producers who expand their production at the expense of imports which consumers must now buy at a price including the tariff. Facing higher prices, consumers reduced their purchases which are now supplied by a higher domestic supply. The imposition of a tariff generates revenues for the government, makes the producers better off relative to a situation free of a tariff, but of course affects the well-being of consumers who are facing a higher domestic price. What we just say could be represented by a two-panel diagram presented in Figure 1. In this context, assume the importing country is considered to be **small** in the sense that it has **no** influence whatsoever on the international price (also called world price designated by P_W). The left panel in Figure 1 represents the domestic market characterized an upward (downward) sloping supply (demand) curve. For a world price P_W (i.e. free trade situation) producers supply S_0^I, but consumers demand a higher quantity equal to D_0^I which is greater than the domestic supply (S_0^I). To fully satisfy the domestic demand, the country imports a quantity q_0 equal to the difference between domestic demand and supply. This imported quantity which is inversely related to the world price is represented by an excess or import demand curve (designated by *ED* in the right panel of Figure 1). Given a fixed world price P_W, the importing country face exporters who would supply the imported quantity q_0. This occurs in the right panel when the horizontal curve (representing P_W and designated by ES^2) intersects the import demand curve corresponding on the horizontal axis to a quantity q_0 which is equal to $D_0^I - S_0^I$. Let us assume now that the importing country is now imposing a specific tariff designated by *t*. An inspection of Figure 1 clearly shows that the imposition of this specific tariff truly plays its role of protecting the domestic market: The consumer price is now P_D which is equal to the world price including the specific tariff. This induces an increase in domestic supply to S_1^I while domestic demand shrinks to D_1^I; trade volume decreased by $q_0 - q_1$. Tariff revenues benefitting the Government (representing taxpayers) are equal to $q_1 \times t$ and corresponds to area *c* (*c´*) in the left (right) panel of Figure 1. Producer welfare is measured by the producer surplus[3]. With the imposition of a tariff, producer welfare, which is represented by a rise in the producer surplus corresponding to the area (*a*+*b*) in the left panel of Figure 1. By contrast with a lower domestic demand and a higher price, consumers experience a reduction in their welfare measured by a decrease in their consumer surplus[4] represented in Figure 1 by area (*a*+*b*+*c*+*d*). This reduction in consumer surplus benefits first the producers welfare (producer surplus) through a transfer equal to area *a* while area *c* corresponds to tariff revenues accruing to the government. Adding these transfers from consumers to producers and government results in the derivation of a residual term (area *b+d)* which represents the **deadweight losses** of imposing a specific tariff. This also corresponds to the loss in national welfare for the importing country. From the above and in the case of a small importing country, the full impact of the tariff is borne out by the consumers in the importing country.

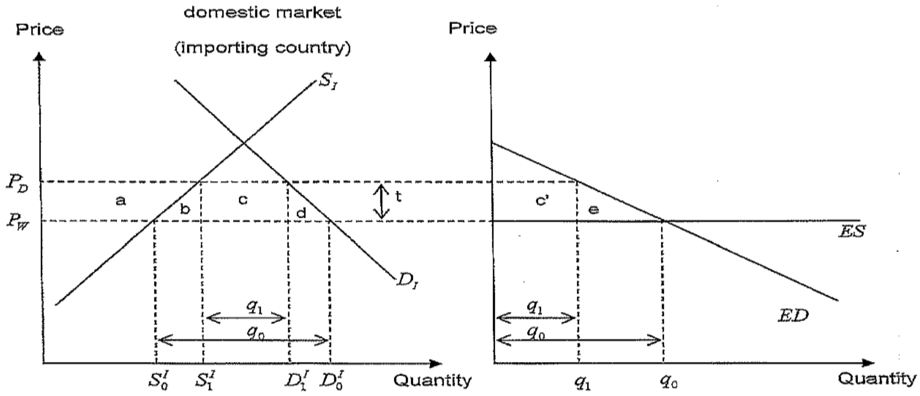
The impact of a tariff policy is somewhat more complex in the case whereby the importer exerts an influence on the determination of the world price. Although the fundamentals of the imposition of a tariff policy remain the same as in the previous case of a small country, the magnitude of the effects on domestic supply and demand of the importing country would

[2] The curve *ES* is called export supply. In the case of a small country as this curve coincides with the horizontal line representing the world price *PW*, we say the importing country is facing an infinitely elastic export supply curve.

[3] The producers' surplus is basically the net value obtained by owners of productive assets fixed in the sector to be analyzed (Houck, 1986). It is the gross return to those assets after the fully variable costs are accounted for. As the supply curve reflects the marginal cost of any additional output, the producer surplus is measured by the area above the supply curve but below the output price.

[4] Developed by the Cambridge economist Marshall in the early part of 20th century, the consumers' surplus measured in monetary units is equal to the "difference between the amount of money that a consumer actually pays to buy a certain quantity of a given commodity, and the amount he would be willing to pay for this quantity rather to do without it" (Koutsoyannis, 1978, p. 32). In the context of the partial equilibrium model, the consumer's surplus is the area below the demand curve and above the prevailing market price.

Figure 1

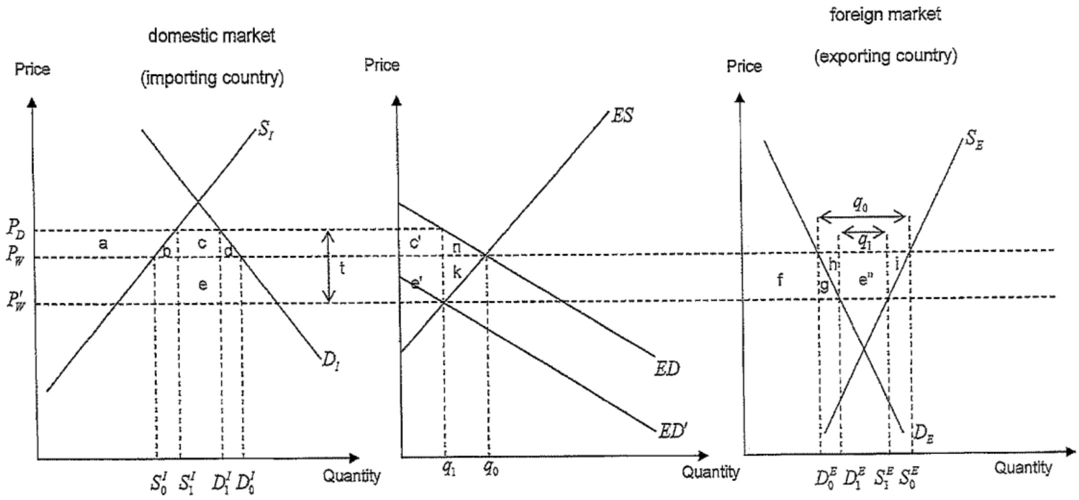


c = c'

b + d = e

Welfare effects	
	Importing country
Consumer surplus	- (a + b + c + d)
Producer surplus	+ a
Tariff revenue	+ c
National welfare	− (b + d)

Figure 2



c = c'

e = e' =e''

b + d = n

h + i = k

Terms of Trade effects = e = e' = e''

Welfare effects		
	Exporting country	Importing country
Consumer surplus	+ f + g	- (a + b + c + d)
Producer surplus	- (f + g + h + e'' + i)	+ a
Tariff revenue		c + e
National welfare	- (h + e'' + i)	e − (b + d)
World welfare	- (b + d + h + i)	

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depend upon the reduction in the world price which in turn would affect the domestic prices in the importing and exporting countries. As a result the burden of the tariff will be shared by the importer and exporter. This finding is dealt with in the following paragraphs which assumes that the importing country which influences the world price is viewed as a **large** country. This latter situation is depicted by Figure 2 in the case of a two-country commodity market. The left (right) panel in Figure 2 represents the domestic market of the importing (exporting) country. The middle panel represents the international market characterized by an upward (downward) sloping export supply (import demand) curve. In this two-country market the world price is the price prevailing in the exporting country. Under a scenario of free trade, the confrontation of export supply and import demand results in an equilibrium world price equal to P_W.and a trade volume equal to q_0. Assume now that a specific tariff (*t*) is imposed by the importer. A wedge between the world price and the domestic price in the importing country now appears. Facing a higher domestic price, consumers in the importing country would reduce their demand while domestic firms increase the volume of output produced. This induces a reduction in the imports. Because of its influence on the world price, the importer is willing to purchase the reduced volume of imports at a lower price, which leads the exporter to offer a traded quantity at this latter price level. This pattern observed for the decline of world price and of the traded quantity can be visualized using the three panels of Figure 2. The imposition of the specific tariff *t* by the importer induces a response of the import demand (curve *ED*) to the domestic price P_D which is equal to the world price including the tariff *t* (i.e. $P_W + t$). It is also possible to derive the response of *ED* to the world price P_W or the price of the exporting country. To do so, we have to deduct the tariff *t from the import domestic price to determine the export (world) price,* which results in a downward shift[5] of the import demand curve from *ED* to *ED´*. At the intersection of the *ED'* and export supply (*ES*) curves, the new lower equilibrium price (P_W') is derived along with the new quantity traded which is equal to q_1. Domestic supply (demand) in the importing country increases (declines) while in the exporting country, the lower world price benefit consumers but reduces the welfare of producers.

The total tariff revenue benefiting the importing country is *area* (*c*+*e*). Looking at left panel of Figure 2, we observe that the total tariff revenue consists of two parts: one is paid by consumers in the importing country (*area c*) and the other is paid by producers in the exporting country (area *e*). Area *c* corresponds to an income transfer from consumers to the government of the importing country while area *e*[6] represents the portion of the importer's tariff revenue paid by producers in the exporting country which is also viewed as a terms of trade effect enjoying the importing country at the expense of the exporter. Hence, we can conclude that the burden of the tariff is borne out by producers in the exporting country and consumers in the importing country, their respective shares depending directly upon the price responses (elasticities) of the export supply and import demand curves[7]. At the bottom of Figure 2 are

[5] It is also possible to express the impact of the specific tariff in terms of a shift in the export supply curve. In this case, the curve *ES* will be expressed in terms of the domestic import price ($P_D = P_W + t$), thus making the exports more expensive. As a result, the export supply curve will shift upwards to the left to meet the import demand curve *ED* at the equilibrium price P_D. Then deducting the tariff from P_D determines the world equilibrium price P_W.

[6] This area which is also equal to *area e'* in the middle panel of Figure 2 and *area e"* in the right panel are also viewed as a result of terms of trade effects.

[7] The fraction (*s*) of the tariff borne out by the consumers of the importing country is given by the following expression (Koo and Kennedy, 2005):

$$s = \frac{1}{\left| e_m / e_x \right| + 1}$$

where e_m and e_x are respectively the price elasticities of import demand and export supply. If e_x tends to $+\infty$ (case of an infinitely elastic export supply curve), *s* tends to one and the consumers of the importing country will pay shown the calculations to derive the welfare effects of a tariff in the case of a large country. We note that these calculations become more complex, especially in the case of the importer whereby the national welfare is divided in two parts: one negative component equal to area -*(b+d)* which corresponds to the deadweight losses identified previously in the small country case (see Figure 1) and a positive one corresponding to the terms of trade effects (area *e*). Hence, the overall welfare of the importing country could be positive[8].

This (brief) overview of the impact of a tariff sets the pace showing how a quantitative assessment of a trade policy can be conducted with a partial equilibrium model framework. The analysis of other trade policies including quantitative restrictions and policy regulations implemented by exporting countries can be undertaken in the same fashion as it has been done for a tariff policy. The following elements are to be remembered following the incidence of a specific tariff:

i) Any impact of a trade policy differs whether the country imposing a trade policy is considered as **small** or **large**. In the former case, the world price is exogenous and there is no need to consider the Rest of the World (i.e. the international market) in the analysis. In the latter case, the world price is "endogenous" and influenced by the trade policy imposed by the large country;

and

ii) When analyzing the impacts of any trade policy, it is important **not** to lose sight that there are gainers and losers. This aspect is an important part of analyzing the incidence of a trade policy and it can be accounted for by using the various concepts of producer and consumer surpluses but also the deadweight (efficiency) losses associated with the implementation of any trade policies.

1.2 - Partial equilibrium trade model: the homogenous product model[9]

The homogenous-product, partial-equilibrium trade model that is now presented can be viewed as a formalization and extension to two or more countries of the graphical analysis of the impact of a specific tariff represented by Figure 2. Thus, our intention is to present in this Section a more general homogenous-product model which is then used for policy scenario simulations based on the implementation of different sets of tariffs imposed by the importing countries. To make things simple, we develop a three-country commodity model made up of two importers (Countries *A* and *C*) and one exporter (Country *B*). Table 1 presents this three-country model which consists of the following elements: i) a set of linear domestic supply and demand equations[10] specified for each of the three countries *A*, *B* and *C*; ii) a net trade identity defined for each country obtained by taking the difference between domestic supply (QS_i) and domestic demand (QD_i). This latter variable is negative for importing countries and positive for the exporting country; iii) a price transmission equation linking the world (*PW*) and domestic ($PINT_i$) prices[11]; and iv) an overall the market equilibrium identity confronting all countries'

the full cost of the import tariff. This is not surprising and it corresponds to the case of the small country developed earlier in this section (see also Figure 1).

[8] In the trade policy literature, as the importing country could influence the world price, it could lead could lead to a situation whereby the importer would exert some market power aimed at determining the optimal tariff which maximizes the national welfare represented by area *e-(b+d)*. In such a case the world price would decline even more and the net welfare of the exporter would even be worse. This situation of optimal tariff, if implemented, would lead to some responses of the exporters who could retaliate by initiating some trade policies aimed at counteracting the existence of this optimal tariff. For more details on the analysis of an optimal tariff policy and its adverse consequences, see Houck (1986), and Koo and Kennedy (2005).

[9] As we shall see further, the homogenous-product model is also called the perfect-substitute model.

[10] *These supply and demand equations are also called "behavioral relationships because they are supposed to represent the respective response of firms and consumers to prices in a given county.*

[11] We assume that there are no transportation costs and no exchange rate.

net trade determining the world equilibrium price which in turn leads to derive each country's domestic price and hence domestic supply and demand.

The three-country model presented in Table 1 assumes a free trade environment. This implies that there is a perfect transmission between the world and each respective domestic prices. To analyze the impacts of various policy instruments such as tariffs or export subsidies or export taxes, the relevant price transmission equations are appropriately modified to take into consideration the trade policy instrument that is being assessed. See expressions (6a), (6b) and (6c) in Table 1 for examples of price transmission equations including such trade policy instruments. Other types of trade policy instruments including import and export quotas and/or domestic policies such as domestic subsidies can be analyzed and simulated with this three-country partial equilibrium trade model. This, however, requires further appropriate modifications in several behavioral relationships and price transmission equations of this three-country model, depending upon the policy scenario under study.

The homogenous-product, partial-equilibrium trade model has two basic characteristics which are worth mentioning. First there is only and only one world market price which determines any other "local" market prices, the differences between these two prices being represented by transportation costs. This important characteristic reflects the fact that the law of one price (LOP) is fulfilled by this type of partial equilibrium trade model. The world price in such model is preferably selected so that it reflects the comparative advantage of the lowest cost producer (exporter). Taking the example of wheat, a representative world price could be the export price free on board (FOB) New Orleans, thus reflecting the fact that the United States is a low cost producer of wheat. The second feature pertaining to this model stems from the fact that the commodity trade flow each country is net trade without any possible distinction between imports and exports. This is could be a problem when a large country or region is simultaneously importing and exporting the same commodity. A good example of such situation is prevailing in the European Union (EU) which is a significant exporter and importer of wheat. In addition, this latter characteristic could have some important implications when a country (for instance the EU) could use simultaneously trade policy instruments affecting at the same time import and exports. Despite this limitation, this latter problem should not be considered as a hurdle to apply this homogenous product model to analyze the impact of trade policies.

Table 1: The three-country partial equilibrium model

Model equations

Supply equation

$$QS_i = \alpha_i^S + \beta_i^S \times PINT_i \quad (1)$$

Demand equation

$$QD_i = \alpha_i^D + \beta_i^D \times PINT_i \quad (2)$$

Net trade

$$NT_i = QS_i - QD_i \quad (3)$$

Price transmission

$$PINT_i = PW \quad (4)$$

Net Trade equilibrium

$$\sum_i NT_i = 0 \quad \text{for } i = A, B \text{ and } C \quad (5)$$

Price transmission equations

Ad-valorem tariff: $PINT_{A,C} = PW \times (1 + TAR_{A,C})$ (6a)

Ad-valorem export subsidy : $PINT_B = PW \times (1 + SUBEXP_B)$ (6b)

Ad-valorem export tax: $PINT_B = PW \times (1 - TAXEXP_B)$ (6c)

Variables and parameters

Endogenous variables

QS_i: Domestic supply in country *i*

QD_i: Domestic demand in country *i*

NT_i: Net trade in country *i*

$PINT_i$: domestic price in country *i*

PW : World price

Policy variables

$TAR_{A,C}$: ad-valorem tariff implemented by Countries *A* and *C*

$SUBEXP_B$: Ad-valorem export subsidy implemented by Country *B*

$TAXEXP_B$: Ad-valorem export tax implemented by Country *B*

Parameters

α_i^S, α_i^D, β_i^S and β_i^D are parameters.

Source: adapted from Oskam and Meester (2006)

The three-country partial equilibrium model is implemented with the EXCEL[12]spreadsheet. The EXCEL layout of the model is presented in Appendix 1. The model is calibrated assuming a hypothetical situation that Country *B* is a net exporter shipping the commodity to the two importing countries *A* and *C*. The parameters α_i^S, α_i^D, β_i^S and β_i^D of the model are calibrated using base period data on domestic supply and demand, and prior values of own price elasticities of domestic supply and demand in each country. Note also that the summation of the net trade figures of the three countries is equal to zero. This latter condition is necessary to

[12] The EXCEL version of this three-country model is available upon request form the author.

ensure that a world equilibrium price will be determined. A closer look at the EXCEL program reveals that the model includes thirteen relationships determining an equal number of endogenous variables including (domestic and world) prices, domestic supply and demand and net trade flows for each country. Simulation solutions are generated with the SOLVER program of EXCEL. In addition, the model generates welfare indicators measuring the changes in consumer and producer surpluses, and tax revenues (costs) for the government, which in turn allow determining the national welfare of each country and hence the world welfare at large in terms of efficiency losses. To show how trade policies can be assessed with such a model, the following scenarios based on the imposition of a different *ad-valorem* tariffs by the two importers are implemented:

i) ***Scenario I***: Imposition of a 20% *ad-valorem* tariff by Country *A*
ii) ***Scenario II***: Imposition of a 50% *ad-valorem* tariff by Country *C*
iii) ***Scenario III***: Imposition of a 20% and 50% *ad-valorem* tariffs by Countries *A* and *C*
iv) ***Scenario IV***: Imposition of a common 20% tariff by Countries *A* and *C*

The results of these four scenarios are presented in Table 2. An inspection of the scenario results which consist of comparing the results of the each tariff policy scenario to the free trade situation confirms the theoretical and graphical developments of the previous section: The imposition of tariff(s) by the two importing countries results in a reduction of world prices and total net exports; in the countries imposing a tariff, domestic prices increase resulting in a decline in the domestic demand and an increase in domestic supply. However these overall results must be nuanced in the sense that the price and volume effects vary in magnitude, depending on which tariff policy scenario is implemented.
In Scenarios I and II characterized by only one country imposing a tariff, we observe that the world price decreases further the higher the tariff (In Scenarios I and II, PW is reduced by 3.9% and 16.7%, respectively). Furthermore, in these two scenarios, the importing country not imposing a tariff would face domestic prices which are equal to the world prices[13]. As a result, domestic supply would decrease and domestic demand would rise. When both countries impose a tariff simultaneously as in Scenario III, it is not surprising to find that the world price experiences a much larger decline (-19.4%) than in the Scenarios I and II. What is important to observe is the transmission effect of the lower world price to the domestic prices of the two importing countries *A* and *C*. In the latter case, the domestic price increases by 21%, which is much lower than the *ad-valorem* tariff of 50% imposed by Country *C*. By contrast, in country

[13] To illustrate this point, let us take the case of Scenario II whereby Country *C* imposes a tariff of 50%. In that case, Country *A*'s domestic price is the same as the world price which declines by 16.7%. Domestic supply in Country *A* is reduced by 11.5% from 6.4 to 5.67 and domestic demand is now equal to 8.17. Hence net imports would increase under such scenario from 1.40 to 2.50 (+78.5.%).

Table 2 : Tariff policy scenario simulations using the three-country partial equilibrium trade model

	Free trade	Scenario I		Scenario II		Scenario III		Scenario IV	
		Simulated values	Change (%)	Simulated values	Change (%)	Simulated values	Change (%)	Simulated values	Change (%)
World price (PW)	22.00	21.15	-3.85%	18.33	-16.67%	17.74	-19.35%	19.64	-10.71%
Country A									
Domestic price ($PINT_A$)	22.00	25.38	15.38%	18.33	-16.67%	21.29	-3.23%	23.57	7.14%
Domestic Supply (QS_A)	6.40	7.08	10.58%	5.67	-11.46%	6.26	-2.22%	6.71	4.91%
Domestic demand (QD_A)	7.80	7.46	-4.34%	8.17	4.70%	7.87	0.91%	7.64	-2.01%
Net trade (NT_A)	-1.40	-0.38	-72.53%	-2.50	78.57%	-1.61	15.21%	-0.93	-33.67%
Country B									
Domestic price ($PINT_B$)	22.00	21.15	-3.85%	18.33	-16.67%	17.74	-19.35%	19.64	-10.71%
Domestic Supply (QS_B)	10.80	10.46	-3.13%	9.33	-13.58%	9.10	-15.77%	9.86	-8.73%
Domestic demand (QD_B)	5.60	5.77	3.02%	6.33	13.10%	6.45	15.21%	6.07	8.42%
Net trade (NT_B)	5.20	4.69	-9.76%	3.00	-42.31%	2.65	-49.13%	3.79	-27.20%
Country C									
Domestic price ($PINT_C$)	22.00	21.15	-3.85%	27.50	25.00%	26.61	20.97%	23.57	7.14%
Domestic Supply (QS_C)	9.60	9.35	-2.64%	11.25	17.19%	10.98	14.42%	10.07	4.91%
Domestic demand (QD_C)	13.40	13.65	1.89%	11.75	-12.31%	12.02	-10.33%	12.93	-3.52%
Net trade (NT_C)	-3.80	-4.31	13.36%	-0.50	-86.84%	-1.03	-72.84%	-2.86	-24.81%
Welfare effects									
Producer surplus (Country A)	92.40	115.21	24.68%	70.28	-23.94%	87.91	-4.86%	102.70	11.15%
Consumer surplus (Country A)	304.20	278.37	-8.49%	333.47	9.62%	309.76	1.83%	292.07	-3.99%
Producer surplus (Country B)	140.80	131.80	-6.39%	103.89	-26.22%	98.44	-30.09%	116.45	-17.29%
Consumer surplus (Country B)	78.40	83.21	6.14%	100.28	27.91%	104.06	32.73%	92.16	17.55%
Producer surplus (Country C)	138.60	130.58	-5.78%	195.94	41.37%	186.08	34.25%	154.06	11.15%
Consumer surplus (Country C)	299.27	310.71	3.82%	230.10	-23.11%	240.65	-19.59%	278.58	-6.91%

Notes: The four scenarios are defined as follows: ***Scenario I***: Imposition of a 20% tariff by importing Country *A*; ***Scenario II:*** Imposition of a 50% tariff by importing Country *C*. ***Scenario III***: Imposition of a 20% tariff by importing Country *A* and 50% by Country *C*; ***Scenario IV***: Imposition of a 20% tariff by importing Countries *A* and *C*.

A, the domestic price declines from 22.00 under a free trade scenario to 21.29 in Scenario III (-3.2%). How to explain such counter-intuitive impact is the result of the huge decline in world prices which more than offsets the imposition of the 20% ad-valorem tariff. Note that the ad-valorem 20% tariff is equal to the difference between the domestic and world price which is equal to 3.55[14]. Domestic supply in Country *A* decreases by 2.2% from 6.4 to 6.26, and domestic demand slightly increases by 0.9% to 7.87. It results in an increase in net imports from 1.4 to 1.61 (+.15.2%). In country *C* which imposes the highest tariff (50%), the impacts price and volume impacts are as expected: the 21% increase in domestic price induce a higher domestic supply (+14.4%) and a lower domestic demand (-10.3 %). Hence, Country *C*'s net imports are significantly reduced by 2.77 (-72.8%).

Scenario IV is interesting on its own because it corresponds to the creation of a customs union between countries *A* and *C* which now forms only one common region with a common tariff. To make this trade agreement attractive, the common and lower tariff of 20% is implemented. The simulation results pertaining to this scenario illustrate very well the graphical analysis developed with Figure 2 in the case of a large region made up of Countries *A* and *C*. As expected, the world price declines from 22 to 19.64 (-10.7%) while the domestic price in both importing countries increases by 7.1% to a level of 23.57. As expected, domestic demand in the customs union declines by 3.5% in Country *C* and by 2% in Country *A* while domestic firms being more protected increase the volume of domestic supply by 4.9% in both importing countries. Net exports under Scenario IV decrease from 5.20 to 3.79 (-27.2%).

The welfare impacts of these four tariff policy scenarios are presented in Table 3. As stated earlier, there will be gainers and losers when these tariff policies are implemented. The notes at the bottom of Table 3 show how the national and world welfare indicators are linked to each other. They also indicate that the world welfare is also the summation of all country's deadweight losses[15]. Finally, note also the terms of trade effects cancel each other. Looking at the first two scenarios I and II where only one importing country is imposing a tariff. In the importing country implementing the tariff, producers experience a higher welfare as shown by the increase in their surpluses. On the other hand, facing a higher domestic price combined with a lower domestic demand, consumers end up having a lower surplus and hence a reduction in their welfare[16]. Government revenues would increase and the total national welfare of the importing country imposing the tariff would depend upon the size deadweight losses relative to the terms of trade effects. For the other importing country not imposing a tariff, the national welfare is positive, resulting from favorable terms of trade more than offsetting the deadweight losses[17].

The welfare analysis of the tariff policy in Scenarios III and IV is interesting to examine more closely due to some more complicated induced effects which occur when several countries impose simultaneously tariffs. A first observation to make is that the world welfare is negative in both scenarios[18]. The exporting country (Country B), while facing a lower world price experiences an overall negative welfare which is the result of deteriorating terms of trade which

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[14] $PINT_A - PW = 21.29 - 17.74 = 3.55$.

[15] Note also that also these calculations are consistent with the graphical welfare analysis conducted in the previous section and presented in Figure 2.

[16] Taking the case of Scenario I, the producer surplus in Country A (which imposes a tariff of 20%) increases by 22.81 while the consumer surplus decreases by 25.83.

[17] For instance in Scenario II, Country A is not imposing any tariff and its total welfare is positive. This stems from the fact that the increase in the consumer surplus resulting from a much lower world price (-16.7%) offsets the loss in producer surplus which declines by 22.12.

[18] It is respectively equal to -11.90 and -2.78 in Scenarios III and IV,

Table 3: Welfare effects of various tariff policy scenarios

	Scenario I	Scenario II	Scenario III	Scenario IV
Change in world prices (%)	-3.85%	-16.67%	-19.35%	-10.71%
Change in total net trade(%)	-9.76%	-42.31%	-49.13%h	-33.67%
Country A				
A.1-Change in PS	22.81	-22.12	-4.49	10.30
A.2- Change in CS	-25.83	29.27	5.56	-12.13
A.3-Government revenues	1.63		5.72	3.65
A.3.1-Portion paid by consumers	1.30		-1.14	1.46
A.3.2-Portion paid by exporters	0.33		6.87	2.19
A.4- National welfare	***-1.39***	***7.15***	***6.79***	***1.82***
A.5.1-Deadweight losses (Supply)	-1.15	-1.34	-0.05	-0.25
A.5.2 -Deadweight losses (Demand)	-.0.57	-0.67	-0.03	-0.12
A.6 - Terms of trade	0.33	9.17	6.87	2.19
Country B				
B.1-Change in PS	-9.00	-36.91	-42.36	-24.35
B.2- Change in CS	4.81	21.88	25.66	13.76
B.3-Government revenues				
B.3.1-Portion paid by consumers				
B.3.2-Portion paid by exporters				
B.4- National welfare	***-4.19***	***-15.03***	***-16.70***	***-10.59***
B.5.1-Deadweight losses (Supply)	-0.14	-2.69	-3.63	-1.11
B.5.2 -Deadweight losses (Demand)	-0.07	-1.34	-1.81	-0.56
B.6 - Terms of trade	-3.97	-11.00	-11.26	-8.92
Country C				
C.1-Change in PS	-8.02	57.34	47.48	15.46
C.2- Change in CS	11.45	-69.16	-58.62	-20.69
C.3-Government revenues		4.58	9.16	11.22
C.3.1-Portion paid by consumers		2.75	4.76	4.49
C.3.2-Portion paid by exporters		1.83	4.40	6.73
C.4- National welfare	***3.43***	***-7.24***	***-1.99***	***5.99***
C.5.1-Deadweight losses (Supply)	-0.11	-4.54	-3.19	-0.37
C.5.2 -Deadweight losses (Demand)	-0.11	-4.54	-3.19	-0.37
C.6 - Terms of trade	3.64	1.83	4.40	6.73
W.1- World welfare	***-2.15***	***-15.12***	***-11.90***	***-2.78***

Notes: PS =Producer surplus, CS= Consumer surplus.
Scenario I: Imposition of a 20% *ad-valorem* tariff by Country *A;*
Scenario II: Imposition of a 50% *ad-valorem* tariff by Country *C;*
Scenario III: Imposition of a 20% and 50% *ad-valorem* tariffs by Countries *A* and *C;*
Scenario IV: Imposition of a common 20% tariff by Countries *A* and *C*
National welfare: Country A, A.4=A.1+A.2+A.3; Country B, B.4=B.1+B.2+B.3; Country C, C.4=C.1+C.2+C.3.
World Welfare: W.1=A.4+B.4+C.4 or W.1=A.5.1+A.5.2+B.5.1+B.5.2+C.5.1+C.5.2
Terms of trade: A.6+B.6+C.6= 0

in turn benefits the two importers[19]. Looking more closely at the information presented in Table 3, the importing country A under Scenario III ends up with an overall welfare which is positive. As explained earlier, this result is not surprising, reflecting the fact that a much lower world price (see Table 2) "overcrowds" the impact of the tariff (in this case 20%), thus inducing a lower domestic price and then an increase in domestic demand decline. No wonder then that the consumer surplus (CS) in Country A rises by 5.52 while firms in this country experience a reduction in their producer surplus (PS) by 4.49. Then combining the increase in government revenues with the positive change in CS offsets the negative variation in PS and thus induces an overall increase in the national welfare of Country A (+6.79). Note also in Country A the positive terms of trade effect benefitting this country will entirely "pay" the government revenues but also provides a "rebate" to the consumers through a lower domestic price[20]. In Scenario IV, it is worth mentioning that the national welfare is positive for both importing countries. Although the changes in surpluses obtained in these two countries are as expected (i.e positive for consumers and negative for producers), the revenues obtained from the proceeds of the tariffs combined with the increase in welfare of consumers are enough to offset the negative welfare effects faced by the producers in Countries *A* and *C*. On the other hand, the exporting country *B* is characterized by an overall national welfare which is negative and equal to -10.59. This result is the direct outcome of the lower world price resulting for the formation of the customs union by the two importing countries *A* and *C*.

The detailed analysis of the impact of tariff policies conducted with the above three-country model could serve as a basis to interpret simulation results generated by more realistic partial equilibrium trade models that are in use to assess the impact of domestic and trade policies. In this process, it is always important to undertake the interpretation and discussion of the simulation results in a piecemeal fashion. In a first step, it is advised to analyze and discuss the impacts on world prices and net trade. Then, through the linked price transmission equations, we could check the induced effects of these trade policies on domestic prices. Having now a certain idea and/or picture on the price effects of these trade policies, it is possible to analyze the changes in domestic supply, demand and net trade in each country covered by these models. Finally, we could then proceed with the welfare analysis using the CS and PS indicators and deduct the deadweight losses.

Over the last thirty years but also in response to the need to provide quantitative assessment of agricultural policy reform or agricultural trade liberalization, global models representing agricultural commodities worldwide and based on the homogenous-product partial equilibrium trade framework were developed and are still in use[21]. In addition, these global models could also serve other purposes such as providing regular medium term market outlook and long term projections of world agriculture. In Box 1 are given three examples of such global models which have been or still in use by international organizations. The first cited model – ATPSM – was an important quantitative modeling tool to assess the impact of the agricultural trade liberalization scenarios following the Uruguay Round but also to

[19] In the case of scenario III, Country B's national welfare is equal to -16.70, two-thirds of which is represented by a negative term of trade effect (-11.26). This latter figure is then broken down between the two importing countries as follows: Country A: 6.87 and Country B: 4.40.

[20] To get a full understanding of this result, let us remember that under scenario III, the world price is reduced by 19.4% from 22 to 17.74 while the domestic price in Country A ($PINT_A$) declines from 22 to 21.29 (-3.2%). This induces an increase in the domestic demand in this importing country and hence an increase in the consume surplus by 5.56. The positive terms of trade effect which is equal to 6.87 is a transfer from the exporting country B. This latter figure is enough to pay for the government tariff revenues which are equal to 5.72. The remaining difference is then attributed to consumers which face a lower domestic price.

[21] For an overview of some of these global partial equilibrium trade models used in the nineties and early 2000s, see van Tongeren et al. (2001).

Box 1: Examples of (partial equilibrium) world agricultural commodity models

Model ATPSM: The Agricultural Trade Policy Simulation Model (ATPSM) was developed by UNCTAD and FAO in the late nineties to simulate trade policies, especially in the context of the Uruguay Round (UR) Agreement on Agriculture. ATPSM is a comparative-static, multi-commodity, multi-region, partial equilibrium for agricultural products (Peters and Vanzetti, 2004). Conceived to as a quantitative tool to assist trade negotiators, policy makers and economists interested in the assessment of various negotiating proposals and the UR agreement, ATPSM is a comparative-static, multi-commodity, multi-region, partial equilibrium for agricultural products. It covers 160 individual countries and the European Union as a region. The model is quite comprehensive in terms of commodity coverage (36 commodities). It also includes a wide range of trade policy instruments, including not only tariffs but also tariff-rate quotas, domestic and export subsidies. All these policy instruments are all measured in tariff-equivalents. The model determines for each commodity a unique world price obtained by confronting and equating to zero the sum of all net trade flows. An interesting aspect of the ATPSM model is an option to proceed with commodity and country aggregation before the simulation of a policy scenario. Several applications of the model ATPSM including a simulation of the Doha Round are available on UNCTAD's website.

Model IMPACT: To implement and assess long term scenarios for world agriculture, the International Food Policy Research Institute (IFPRI) developed at the beginning of the nineties the International Model for Policy Analysis of Agricultural Commodities and Trade (IMPACT). Basically, IMPACT. It is a multi-commodity, partial equilibrium market model of global production, trade, demand and prices for agricultural commodities. Since its creation, IMPACT has undergone several refinements and improvements. The present Version 3 of IMPACT has moved towards an integrated modelling system that links information from climate models, crop simulation models and water models linked to the core global, partial equilibrium, multi-commodity model specified within IMPACT for World Agriculture. (Robinson et al., 2015) A the present time, IMPACT 3 covers 159 countries, 154 water basins and 320 food production units with a commodity coverage consisting of 39 crops, 6 livestock and 17 processed commodities. In addition, the core part of the IMPACT (i.e. the multi-commodity, partial market equilibrium model) is presently linked to five modules/models including water, crop, food security, value chains and land use modules. By its scope and coverage, the present version of IMPACT can be considered as an exhaustive bio-economic model able to provide ex-ante assessment of the future long-term evolution of Word Agriculture stretching up 2050. For further information on IMPACT, see Robinson et al. (2015) and the following website: https://www.ifpri.org/program/impact-model.

Model Aglink –Cosimo: is a recursive-dynamic, multi-commodity partial equilibrium model aimed at assessing developments of annual market balances and prices of the main agricultural commodities produced, consumed and traded worldwide (OECD, 2015a). Its main function is to serve as the quantitative tool behind the OECD-FAO Agricultural Outlook, the objective of which is to establishing medium term projections of the major agricultural commodities worldwide. The model encompasses two sub-modules, Aglink and Cosimo, each of which is maintained by the OECD Secretariat and FAO, respectively. Aglink-Cosimo covers 93 commodities on the supply side, 40 market clearing prices and market balances in each region it covers (OECD, 2015, p. 5). Aglink-Cosimo is made up of a series of modules which interact to each other. Fourteen regions (ten OECD countries consisting of Australia, Canada, the EU, Switzerland, Norway, Japan, Kporea, Mexico, New Zealand, and the USA and four non-OECD countries including Argentina, Brazil, The People's Republic of China and Russia) are explicitly represented in Aglink by specific modules representing each country's agricultural sector. The Cosimo component of the model is made up of 42 endogenous modules[22] including three OECD members (Chile, Israel and Turkey), a further 27 single countries and 12 regional aggregates.

the next Doha Round. This model is not available anymore because it is not maintained by the Trade Division of UNCTAD. The two other global models – Aglink-Cosimo and IMPACT – are still in use to undertake medium term and long term projection scenarios of the world agricultural markets. As hinted in Box 1, these two global models serve different purposes. On one hand, Aglink-Cosimo look at the medium term outlook of World agriculture and publish on a regular basis what is projected in world agriculture over the next five to ten years[23]. On the other hand, The IMPACT model is more oriented for long term projections (up to 2050) of world agriculture, As a result, it is not surprising to see that the agricultural commodity market module of IMPACT is linked to other simulation models analyzing the global evolution of the natural resources such a water and land use.

[22] These 42 endogenous modules in Cosimo are distinct from those appearing in Aglink.

[23] For a recent global medium outlook of agricultural commodity markets, see OECD (2015b).

1.3 – Partial equilibrium trade model: The national product differentiation or Armington model

Acknowledging that a product could possess different characteristics, trade economists developed a model framework which assumes that products can be differentiated by their source of origin. This idea was initially proposed by Armington (1969b) in analyzing the import patterns of several developed economies. To explain country's imports, he made the following two assumptions (Armington, 1969a): Traded goods are **not** homogeneous and differentiated according to their **geographical** origin. The notion of imperfect substitution between imported and domestically produced goods is adopted in this model. This imperfect substitution is measured be a constant elasticity of substitution denoted by σ .

The theoretical foundations underlying the Armington model are presented in Appendix 2 for the case of two composite goods that can be supplied by two sources of supplies, one that is imported and one of domestic origin. Assuming a representative consumer characterized by a two-stage level preference structure, it can be shown that the demand for domestically produced and imports for a given good are first determined as a function the relative prices of the two supply sources. Then, once the different demands of different supply sources have been determined, the aggregate demand for the good of interest is then obtained as a function of the aggregate price of the good which in turn is linked through appropriate price linkage equations to the prices of imported and domestically produced products. In this process, due to the adoption of a linearly homogenous utility function, the (optimal) aggregate demand for the good is consistent with the purchased quantities of imported and domestically produced products.

Relative to the homogenous-product model, the Armington model framework allows explaining the different sources of supplies that can be purchased by the representative consumer depending on relative prices. As a result, there is not a single market for the good under study but a large number of sub-markets differentiated by the geographical sources of origin and characterized by different prices. This feature of the Armington model must be emphasized because there is not **one** common reference price guiding international trade for the product under study. To provide a better understanding of the differences between the Armington and homogenous product model, we present in Table 4 the two models in the case of one good and two countries called ″Country *A*″ and ″Country *B*″. To facilitate the comparison between the two models, we also assume that: i) there are no barriers to trade (tariff for instance), ii) there are no transport costs, and iii) there is only one common currency in the two countries.

If we look first at the homogeneous product model (Model 1), the assumption of the perfect substitutability among products (infinite elasticity of substitution) does not allow distinguishing imports and exports. Hence, this model explains **net trade flows**. Another outcome of the homogeneous product assumption adopted in model *A* is as follows. The market equilibrium price obtained by confronting (equating) excess demand and supply of the two countries (identity 7) is unique. Indeed, we have one unique ″world equilibrium price″ that is then transmitted to the domestic markets of countries *A* and *B*. As a result, the homogeneous product model satisfies the **Law of one price** (*LOP*). This law states that in a given market, there is only **one** reference price. All other prices that are observed in this market are linked to this former reference price through a marketing margin that is equal to the transport cost of carrying one

Table 4 - Comparing homogenous-product and Armington models

Model 1: Homogenous product model	**Model 2**: National product differentiation model
Country A	**Country A**

(1)	***Domestic supply*** $S_A = f_A(P_A)$ where $\frac{\partial f_A}{\partial PA} > 0$	(1)	***Domestic supply*** $S_A = f_A(P_A)$ where $\frac{\partial f_A}{\partial PA} > 0$
(2)	***Domestic Demand*** $D_A = g_A(P)$ where here $\frac{\partial g_A}{\partial P} < 0$	(2)	***Total Domestic demand*** $D_A = g_A(PA)$ where here $\frac{\partial g_A}{\partial PA} < 0$
		(3)	***Demand for domestically produced product*** $D_{AD} = h_{AD}(P_A, P_B)$ where $\frac{\partial h_{AD}}{\partial P_A} < 0$ and $\frac{\partial h_{AD}}{\partial P_B} > 0$
		(4)	***Demand for imports*** $I_{AF} = h_{AF}(P_A, P_B)$ where $\frac{\partial h_{AF}}{\partial P_A} > 0$ and $\frac{\partial h_{AF}}{\partial P_B} < 0$
		(5)	***Aggregate price of the product*** $PA = k_A(P_A, P_B)$
(3)	***Net trade*** $NT_A = S_A - D_A$	((6)	***Exports*** $E_A = S_A - D_{AD}$
Country B		**Country B**	
(4)	***Domestic supply*** $S_B = f_B(P_B)$ where $\frac{\partial f_B}{\partial P_B} > 0$	(7)	***Domestic supply*** $S_B = f_B(P_B)$ where $\frac{\partial f_B}{\partial P_B} > 0$
(5)	***Domestic demand*** $D_B = g_B(P)$ where here $\frac{\partial g_B}{\partial P} < 0$	(8)	***Total Domestic demand*** $D_B = g_B(PB)$ where here $\frac{\partial g_B}{\partial PB} < 0$
		(9)	***Demand for domestically produced product*** $D_{BD} = h_{BD}(P_A, P_B)$ where $\frac{\partial h_{BD}}{\partial P_A} > 0$ and $\frac{\partial h_{BD}}{\partial P_B} < 0$
		(10)	***Demand for imports*** $I_{BF} = h_{BF}(P_A, P_B)$ where $\frac{\partial h_{BF}}{\partial P_A} < 0$ and $\frac{\partial h_{BF}}{\partial P_B} > 0$
		(11)	***Aggregate price of the product*** $PB = k_B(P_A, P_B)$
(6)	***Net trade*** $NT_B = S_B - D_B$	(12)	***Exports*** $E_B = S_B - D_{BD}$
Supply-demand market equilibrium identity		**Supply-demand market equilibrium identities**	
(7)	$NT_A = NT_B$	(13)	$I_{AF} = E_B$
		(14)	$I_{BF} = E_A$

Notes: Seven endogenous variables including S_A, D_A, NT_A, S_B, D_B, NT_B and P are simultaneously determined in Model 1. In Model 2, 14 endogenous variables are simultaneously determined. This includes S_A, D_A, D_{AD}, I_{AF}, E_A, S_B, D_B, D_{BD}, I_{BF}, E_B, P_A, PA, P_B and PB.

unit of the product between the reference point and all other points in the markets where prices are observed. LOP can be formally represented by one of the two relationships:

Additive model

$$p_j = T_{ij} + p_i \quad (1)$$

or

Multiplicative model

$$p_j = (1+T_{ij})p_i \quad (2)$$

where p_i and p_j are the prices of the product in countries (regions, etc.) *i* and *j*., respectively; and T_{ij} represents the transport cost between countries *i* and *j*.

In the homogeneous product model we must define a reference country within which the world price is determined. Generally speaking, the selection of the reference country is the one that has the highest competitive edge, which means the one with the lowest production costs.

The Armington model (Model 2) that is characterized by an imperfect substitution of supplies of domestic and imported origin allows explaining exports and imports simultaneously. This latter characteristic is the major strength of the Armington model because it allows taking into account an observed phenomenon that has been growing over the years concerning trade flows. Indeed, for a same product, it has often been observed that a country tends to be characterized by the simultaneous existence of imports and exports. This phenomenon called ″intra-industry trade″ is mainly observed for industrial products or any products that have undergone an advanced stage of processing. A second characteristic of the Armington model is that it does not satisfy LOP. A simple inspection of the expressions defining this model in table 3 shows that there are as many equilibrium prices (and ″world prices″) as there are sources of supplies. Another aspect of the Armington model that should not be overlooked has to do with the existence of an aggregate demand for the food which also serves to determine the consumer surplus when trade policy scenarios are implemented.

The Armington model is also an ideal tool to assess the effects of trade policies such as tariffs, export subsidies, import quotas, etc… However, when we simulate the impacts of such policy instruments with such a model, we must be aware that we may get important price effects that are sometimes out of line, while at the same time the quantity impacts on the levels of supplies tend to be minimized (Brown, 1987 and Zhang, 2006). On the other hand, the homogeneous products model induces effects that are more magnified on the quantity side so that it could ultimately predict a full specialization of countries towards the production of goods for which they have the most pronounced comparative advantage. All these statements tend to reveal that any simulation results of the impact of trade policies using an Armington-like model are directly linked to the values adopted for the underlying elasticities of substitution. Thus, it is the reason why it is strongly advised to undertake sensitivity analysis when undertaking trade policy scenarios with such models. This sensitivity analysis is done by changing the values of the elasticities of substitution.

Francois and Hall (1997 and 2001) developed on EXCEL an Armington-like model called *GSSIM* and specified along the same lines as Model 2 in Table 3. Two versions of *GSSIM* exist. The first version is made up of four countries while the second could accommodate up to 24 countries. All the expressions (behavioral equations and identities) of *GSSIM* are expressed in first-order log-differences and then all the policy scenarios are implemented with the SOLVER program of EXCEL: In terms of output results, *GSSIM* provides the following quantitative information: i) equilibrium prices, ii) relative changes in demand, supply and trade flows, simulated levels trade flows between countries and market (export) prices and domestic prices of imports and welfare indicators in the form of changes in consumer and producer surplus and the cost or revenues generated by the implementation of any economic policy,

Appendix 3 presents the various layouts of the *GSSIM* model in the case of four countries, including the base period data (initial tariffs and trade flows in Table A3.1), the calibrated values of the parameters of the behavioral equations (Table A3.2) and the presentation of the model solutions (Table A3.3). An hypothetical case is made, consisting of four regions (the United States (USA), the European Union (EU), Japan and the Rest of World (ROW) with high tariffs (Table 5). The EXCEL sheet presenting these various layouts also include not only the expressions to calibrate the model to the base period data, but also the behavioral equations and identities expressed in log-differences. The SOLVER of EXCEL provides the model solutions. The trade policy scenario that is implemented herein is different from the one developed with the homogenous product model within which various increases in tariffs were simulated. Now, we decided to only implement a customs union scenario between USA and the EU with *GSSIM* (Table 5). The tariffs between USA and EU which were initially equal to 32% and 41% are eliminated while a common tariff equal to 25% is imposed on imports from other regions (Japan and Rest of World). The new set of final tariffs appear in the low part of Table 5.
What should be expected *a priori* from this scenario? A strengthening of intra-trade between EU and USA resulting from lower price imports will likely occur. On the other hand, it is expected higher (market) export prices of EU- and US-produced products. Due to a lower common tariff (25%), USA and EU also have an incentive to import more from the other countries/regions. However this pattern may depend upon the relative prices of various imported products entering the USA and EU which substitute to each other. Finally, the lower prices of imports would offset the market prices of US and EU-made products, resulting first in a higher demand for the aggregate commodity in the US and EU and second in an improved consumer welfare in the two regions. On the other hand and contrary to the tariff-reduction results of the homogenous-product model which suggest a decline in domestic supply, the increased EU and US exports combined with higher market (export) prices obtained by the Armington model lead to higher supply combined with an increased producer surplus in the customs union.

Table 5: Tariff policy scenario - Establishing a customs union EU-USA

initial import tariffs

	Destination			
	USA	JAPAN	EU	ROW
USA	1	1.21	1.41	1.22
JAPAN	1.37	1	1.31	1.23
EU	1.32	1.36	1	1.18
ROW	1.57	1.41	1.25	1.15

final import tariffs

	Destination			
	USA	JAPAN	EU	ROW
USA	1	1.21	1	1.22
JAPAN	1.25	1	1.25	1.23
EU	1	1.36	1	1.18
ROW	1.25	1.41	1.25	1.15

Table 6: Implementation of the Customs Union EU-USA: Model solutions

MARKET CLEARING CONDITIONS
Relative price changes

		benchmark prices	new prices	change in supply	change in demand	Excess Demand
Origin	USA	0.0000	0.0818	0.1227	0.1227	0.0000
	JAPAN	0.0000	-0.0015	-0.0023	-0.0023	0.0000
	EU	0.0000	0.0389	0.0583	0.0583	0.0000
	ROW	0.0000	0.0061	0.0091	0.0091	0.0000

trade values and quantities
trade quantities: percent change

		Destination			
		USA	JAPAN	EU	ROW
origin	USA	0.0	-28.6	77.1	-24.2
	JAPAN	-6.3	0.0	-3.7	17.5
	EU	50.9	-7.1	-46.8	-2.7
	ROW	48.0	9.3	-30.4	13.7

Trade at world prices: new values

		Destination			
		USA	JAPAN	EU	ROW
Origin	USA	0.0	38.6	383.2	246.1
	JAPAN	467.9	0.0	144.2	234.6
	EU	470.4	96.5	110.5	202.2
	ROW	74.5	109.9	77.0	22.9

Trade at world prices: change in values

		Destination			
		USA	JAPAN	EU	ROW
origin=sum=	USA	0.0	-11.4	183.2	-53.9
	JAPAN	-32.1	0.0	-5.8	34.6
	EU	170.4	-3.5	-89.5	2.2
	ROW	24.5	9.9	-33.0	2.9

Proportional change in internal prices

		Destination			
		USA	JAPAN	EU	ROW
Origin	USA	0.0818	0.0818	-0.2328	0.0818
	JAPAN	-0.0890	-0.0015	-0.0473	-0.0015
	EU	-0.2130	0.0389	0.0389	0.0389
	ROW	-0.1990	0.0061	0.0061	0.0061
	Composite price	-0.1388	0.0329	-0.0813	0.0446

Tariff revenue and consumer surplus

		destination			
		USA	JAPAN	EU	ROW
	Tariff revenue	-173.9	0.4	-100.7	-3.1
	Consumer surplus	174.9	-11.3	69.7	-39.9

Total welfare effects

		A	B	C	D=A+B+C
		Producer surplus	Consumer surplus	Tariff revenue	Net welfare effect
Country	USA	47.7	174.9	-173.9	48.7
	JAPAN	-1.3	-11.3	0.4	-12.2
	EU	32.0	69.7	-100.7	1.0
	ROW	1.7	-39.9	-3.1	-41.3

Examining the model solutions provided by *GSSIM* (Table 6) indeed confirms most of our expectations. Market prices of US- and EU-produced products decrease by 8.2% and 3.9%, respectively. Intra-trade flows between US and EU also increased significantly: the volume of US exports to the EU rise by 77% while the EU shipments to the USA increased by 51% in volume terms. On the other hand EU and US exports to Japan and the Rest of the World are reduced significantly in volume and value terms. Internal prices of US-imported products decrease by more than 8% while in the EU a similar pattern occurs for the internal prices of Japanese (-4.7%) and US (-23.3%) imports. On the other hand the internal price of EU-produced products which is the market or export price increases by 3.9% while the remaining internal price of the EU imports from ROW increased marginally by 0.6%. In the US, as a result of these significant decline in the internal prices of imports, it is not surprising to observe a 13.9% decrease in the composite price of the aggregated goods. This in turn yields a higher demand for the composite goods resulting in a positive variation by 174.9 of the US consumer surplus. A similar pattern occurs, but to a lesser extent in the EU, where the change in consumer surplus rose by 69.7.

As indicated earlier, higher market (export) prices of the domestically produced products in the customs union combined with increasing domestic supply led to higher producer surpluses which increase by 47.7 in the US and 32.0 in the EU. With lower tariffs, government revenues in the EU and USA decrease and offset the positive variation in the producer and consumer surpluses. The end result is a net welfare effect of 48.7 in the US and 1.0 in the EU. In the other two regions – Japan and ROW- the impact of the customs union leads to negative net welfare effects which are equal to -12.2 and -41.3, respectively.

An important element not to lose sight in the context of a customs union is the possibility to compute the trade creation and diversion effects generated by this trade policy. Looking at the figures reporting the changes in trade values in Table 6 (middle of the table), it can be seem that the total value of US and EU exports increase by 117.9[24] and 79.6[25], respectively. In the case of the US, this result stems from the significant rise in the value of bilateral trade between the USA and the EU (+183.2) which offsets the diverted exports of the USA to Japan (-11.4) and the ROW (-53.9). Looking at the trade diversion effects experienced by the EU mainly concerns the negative variation of the value in intra-EU trade which decreases by 89.5. However, the increase in the value of EU exports to the US (+ 170.4) more than offsets the former trade effect. Japan is experiencing a slight decline in the total value of its exports (-3.3). This figure is the result of a reduction of Japanese shipments to EU and US which are compensated by an increase of its exports to the ROW. With the establishment of the customs union between the US and EU, the ROW is now facing a lower tariff of 25% for its exports to the US while it was initially equal to 57%. This significant reduction in tariff induces a sharp reduction (-19.9%) in the domestic price of ROW imports in the US. As a result, ROW exports to the US increase in volume and value terms. ROW exports to Japan also increase (+9.9) but are offset by a reduction in the value of exports to the EU (-33.). In the end the ROW is experiencing an overall trade creation effect equal to 4.3[26]. When all the relevant figures are collected, we conclude that the creation of the EU-US customs union generated an overall trade creation effect equal to 198.5[27], which represents an increase by 8% in the total value of world exports following the implementation of this customs union between the USA and the EU.

The Armington model is at the moment the main model specification used by economists to explain trade flows in computable general equilibrium (CGE) models. Although its description was developed in the context of imports of consumer goods, it is possible to use the Armington model in other situations and make it more realistic by introducing changes in its mathematical formalization. It is the reason why adaptations or refinements of the Armington have taken place over the years:

[24] This figure corresponds to the US row total sum of -11.4+183.32-53.9=117.9.

[25] In a similar fashion, the total trade creation effect for the EU is the EU row total equal to 170.4-3.5-89.5+2.2=79.6

[26] This figure is obtained as follows: 4.3=24.5+9.9-33+2.9.

[27] This overall figure could also have been obtained by recording all the trade creation and diversion effects of imports.

1) If we have explained the Armington model in the context of imports assuming consumer goods, it is also possible to explain its structure in the context of imports of intermediate goods. In such a case, the underlying theoretical framework is not anymore the micro-economic consumer theory, but the neo-classical theory of the firm whereby firms minimize their costs of supplies subject to a technology constraint represented by a constant returns to scale CES production function whose arguments are the different sources of supplies. This alternative form of the Armington model is appropriate in CGE models to represent imports and domestic supplies of intermediate goods.

2) It is possible to use the Armington model to explain exports of a given sector. To do so, we assume that firms in this sector are able to segment their sale outlets by distinguishing domestic and international (export) markets. The theoretical framework behind this alternative form of the Armington model rests on the adoption of a multiproduct technology represented by a constant elasticity of transformation (CET) function. Then, firms maximize their revenues subject to a given amount of aggregate resources and to a CET technology.

3) The third refinement of the Armington model is to generalize it to more than two sources of supplies. Hence, if we adopt a EU perspective, we could assume that there are three sources of supplies including domestically produced supplies for one EU member country, supplies from the rest of the EU and those originating outside the EU (Rest of the World). In such a configuration, we would have to use a CES utility function with three arguments that of course would correspond to the three sources of supplies. However, such a model specification is not unique and we could easily assume alternative structures based on different separability assumptions between the three sources of supplies.

4) Many empirical studies have shown that more general model specifications which did not impose *a priori* a constant elasticity of substitution between supply sources and a linearly homogeneous utility function[28] were accepted, while the Armington model was rejected.

5) Finally, we should point out that since the mid-eighties economists developing and specifying CGE models have refined the notion of product differentiation by assuming that the former notion was taking place, not only at the geographical level but also at the firm level. In short, we assume that goods produced by different firms in a given sector can be distinguished according to their own varieties (that are specific to each firm). Such a model specification is not only relevant to explain foreign trade but also when we want to study economic sectors characterized by imperfect market structures such as monopolistic competition. In such a case; the number of firms becomes endogenous at the same time as quantities produced and prices.

1.4 -Computable general equilibrium model

In this section are presented the main features of a computable general equilibrium (CGE) model. A more detailed description of CGE modeling is provided in Chapter 2.

1.4.1 -Scope of a CGE model

CGE modeling is by nature based on an *ex-ante* approach, which implies quantifying the future impacts of a given new policy. CGE models are computer simulation models that use data to explore the economic impact of changes in policy, technology and other factors. They show how different sectors inside one economy are linked and how several economies are connected to each other, and how resources such as labor, capital and natural resources are best allocated across all economic activities. One of the main motivations underlying their use is to

[28] For an extension and generalization of the Armington model, see the empirical work of Surry et al. (2002) on processed food products.

be able to consider large scale policy changes using the present economic situation as a benchmark. In other terms, CGE models are generally preferred to partial equilibrium models when the scope of the economic policy experiment is large and when inter-market linkages, budget constraints and real exchange rate effects are expected to be particularly important. Trade policy generally presents the latter characteristics, especially when it comes to examining the effects of trade liberalization, regional integration or the implementation of a customs union. Even a scale change in a single industry has the potential to cause drastic and unexpected consequences given backward and forward linkages within the economy. These interdependencies between industries need to be considered in order to analyze the full impact of (trade) policy changes.

The main advantage of using a CGE model lies in the possibility of combining detailed and consistent databases with a theoretically sound framework, able to capture feedback effects and market interdependencies that may either mute or accentuate first-order effects. The equilibrium is general in the sense that it concerns all the markets simultaneously. The main benefit of CGE models is that they offer a rigorous and theoretically consistent framework for analyzing trade policy questions

CGE models have been used for several purposes and became the "toolkit" available for the economists to analyze various scenarios of economic instruments. One popular field of research has been to quantify the macro, employment, allocation and welfare effects of changes in terms of foreign trade and changes in taxation policy. The environmental effects of energy production, effects of regional policy changes and regional effects of large infrastructure investments have also been studied by using CGE model simulations. Most developed countries now have at least a national CGE model.

1.4.2- Elements and implementation of a CGE model

Building a CGE model can be decomposed into three main steps that bring together three different skills of the modeler. The first step of model specification is mainly a theoretical work based on economic theory. The second step of model calibration consists of collecting and harmonizing the data, most often in the form of a social accounting matrix (SAM), and assigning values to the behavioral parameters. The last step deals with the resolution of the model, which means the mathematical transcription of the theoretical model in a programming language and the implementation of the scenarios are essentially of a computer nature. Naturally, it is necessary to define very precisely the objectives of the research at the beginning.

- ***The specification step*** can itself be decomposed into several other steps. The choice of geographic coverage of the agents taken into account and the specification of their behavior, the rules that ensure the equilibrium of the different markets and macroeconomic closures. To accomplish this step, one needs to understand truly the structure of the economy by addressing five main aspects:

- How do goods and factors flow through the economy?
- In each sector, how does production take place?
- In each industry, how does the market structure look like?
- At the consumer level, how does consumption take place?
- Finally, who owns which factors of production and firms?

In its mathematical form, the CGE model is a system of simultaneous, non-linear equations. The model is square – that is, the number of equations is equal to the number of variables. The equations define the behavior of the different actors. In part, this behavior follows simple rules captured by fixed coefficients (for example, *ad valorem* tax and subsidy rates). For production and consumption decisions, behavior is captured by non-linear, first-order optimality conditions – that is, production and consumption decisions are driven by the maximization of profits and utility, respectively. The equations also include a set of constraints that have to be satisfied by the system as a whole but which are not necessarily considered by any individual actor. These constraints cover markets (for factors and commodities) and macroeconomic aggregates (balances for savings-investment, the government, and the current account of the rest of the world).

The major constraint in applied models is that the chosen functional forms to represent producer's and consumer's behaviors have to be consistent with the economic theory (well behaved). This explains why in CGE models, the most used forms are Cobb-Douglas, constant elasticity of substitution (CES), constant elasticity of transformation (CET) or Linear Expenditure System (LES).

Regarding international trade, almost all CGE models assume that the foreign and domestic products are not perfect substitutes so that products are differentiated by their country of origin (the Armington assumption).

- ***Calibration step:*** in this step, the modeler has to gather data on the endogenous and exogenous variables of the model in the form of a SAM for a particular geographical entity and year. The building process of the SAM is not an easy task particularly because the modeler has to harmonize heterogeneous data coming from different available sources. The second phase consists in calibrating the behavior parameters of the model, for example, the Allen partial elasticities of substitution at the level of production technology. In practice, this phase is like solving the model upside down so as to retain values of unknown behavioral parameters that allow the reproduction of the initial equilibrium of the economy represented by the SAM. In the calibration process, the modeler has to reduce the space of unknown parameters by exogenously specifying elasticity values, which are usually based on previous literature estimates because the benchmark data only give price and quantity observations associated with a single equilibrium.
- ***The resolution of the model***: This step consists in solving the model as a system of nonlinear equations using a computer software such as GAMS (General Algebraic Modeling System).

1.4.3 How to simulate the impact of trade policy instrument with a CGE model

Once the CGE model has been specified and calibrated, a fully specified numerical model specification will be available and can now be used for studying the impacts of different policy changes. Therefore, one can start doing counterfactual experiments. This is basically asking the question what would happen to the equilibrium following a policy change. In this context, a counterfactual equilibrium is computed for the new policy regime, and policy appraisal can be made by comparing the counterfactual to the benchmark equilibrium. In the case of trade effects, one could ask the questions what would happen if the country at hand changes its trade policy. For example, what would happen if the country engages in unilateral trade liberalization, enters a new customs union, or reduces tariffs under a multilateral tariff reduction scheme.

A good CGE analysis includes sensitivity tests using different values for the elasticities. It is quite probable that the results of the simulations are sensitive with respect to the elasticity values. It is, however, a usual outcome that the sign of a result does not change. Sensitivity tests should also be done with respect to the size of the shock.

The last phase in the CGE analysis is to give economic policy recommendations. Through model simulations the researcher can provide the decision makers with solid calculations and recommendations that will improve their ability to make better decisions.

1-5 - The Gravity model

Now considered as the workhorse in applied trade analysis, the gravity model states that trade flows between two countries is a function of their respective country size represented by their gross aggregate income or gross domestic product (GDP) but is also inversely related to distance which plays the role of a proxy for transportation costs. This implies that larger countries would have an incentive to trade more with each other while the more distant two countries are the less occurring trade is. Put into a model form, the gravity framework is written as follows:

$$X_{ij} = G\frac{Y_i^{b_1} Y_j^{b_2}}{d_{ij}^{b_3}} \qquad (1)$$

where X_{ij} designates the trade flows of country i originating in the exporting country j, Y_i and Y_j designate gross aggregate income or gross domestic product (GNP) of each respective country; d_{ij} is the distance between countries i and j; and b_1, b_2 and b_3 are parameters. G is a constant which can be interpreted as summarizing the effects of all other factors, other than distance and size, that influence the volume of amount of trade flows between the two countries. It is expected that b_1, b_2 and b_3 are all positive. Furthermore, if $b_1 = b_2 = 1$, it implies that the trade flow X_{ij} is proportional the economic masses (GDP) of both importer i and exporter j for a given distance. On the other hand assuming GDPs of both countries i and j fixed and $b_3 = 1$, then a 1% increase in distance results in an equal variation in the opposite direction of bilateral trade flow.

Using the logarithmic transformation, the gravity model is linearized and then becomes a regression equation that can be estimated by ordinary least squares (OLS).

$$\mathrm{Log}(X_{ij}) = \mathrm{Log}(G) + b_1\mathrm{Log}(Y_i) + b_2\mathrm{Log}(Y_2) - b_3\mathrm{Log}(d_{ij}) + \varepsilon_{ij} \qquad (2)$$

where ε_{ij} is a random error term accounting for omitted variables.

For empirical purposes, expression (2) will be appended with other explanatory variables that are supposed to capture a set of factors influencing trade costs. In addition, policy variables could be included. All these additional variables in most cases are dummies and include the following ones: common language, colonial links, contiguity, monetary and trade agreements. Since its first econometric application to trade by Tinbergen (1962) in the early sixties, the gravity model was not used extensively by trade economists. This state of affairs lasted until the early 2000s and can be explained on the grounds that its theoretical foundations were not firm enough and well established. Indeed, it is possible to argue that the gravity model could be explained by several alternative trade theories (Feenstra et al., 2001).

Anderson and van Wincoop (2003) were able to improve the theoretical specification of gravity model by incorporating multilateral resistance terms. In so doing they developed a structural gravity model specification with better grounded theoretical foundations which is defined by the following relationship:

$$X_{ij} = \frac{Y_i Y_j}{Y_w} \times \left(\frac{T_{ij}}{P_i P_j}\right)^{1-\sigma} \qquad (3)$$

where Y_i and Y_j have the same definition as in expression (2), Y denotes the world income; T_{ij} accounts for transport cost and other trade barriers; P_i and P_j are multilateral resistance terms and σ is a constant elasticity of substitution. This alternative specification of the gravity model, albeit attractive from a theoretical standpoint is difficult to implement empirically because it is almost impossible to find good proxies for the multilateral resistance terms. One way to overcome this latter problem has been to estimate the gravity model using panel data with country fixed (importer and exporter) effects that are supposed to capture the existences of these multilateral resistance terms in the gravity equation.

Improvements in the specification of the gravity model took place recently theoretically and econometrically[29]. First, micro-foundations were brought up to justify the theoretical underpinnings of the gravity model. Second a general equilibrium interpretation was given to given model (Larch and Yotov, 2018). This is quite interesting as the gravity model could become a substitute to CGE models used for trade policy analysis. Third, a major effort has been made on the econometric front by capturing the heterogeneity of trade data and the fact that trade flows include zero values. Finally the notions of extensive and intensive margins appearing recently in the trade literature has been successfully incorporated into empirical specifications of the gravity model applied to trade.

We close this section on the gravity model by discussing some econometric results pertaining to the determinants of the gravity model. Using a meta-analysis approach, Disdier and Head (2008) and Head and Mayer (2014) computed mean and median values of all gravity estimates in the trade literature. Their results, presented in Table 7, indicate that parameters associated to GDP (which are also elasticities) are close to one. Such finding is expected and conform with trade theory, but also with any graphical analysis which supports the existence of a linear

Table 7: Estimates of typical gravity variables

	All Gravity				Structural Gravity			
Estimates:	median	mean	s.d.	#	median	mean	s.d.	#
Origin GDP	.97	.98	.42	700	.86	.74	.45	31
Destination GDP	.85	.84	.28	671	.67	.58	.41	29
Distance	-.89	-.93	.40	1835	-1.14	-1.1	.41	328
Contiguity	.49	.53	.57	1066	.52	.66	.65	266
Common language	.49	.54	.44	680	.33	.39	.29	205
Colonial link	.91	.92	.61	147	.84	.75	.49	60
RTA/FTA	.47	.59	.50	257	.28	.36	.42	108
EU	.23	.14	.56	329	.19	.16	.50	26
CUSA/NAFTA	.39	.43	.67	94	.53	.76	.64	17
Common currency	.87	.79	.48	104	.98	.86	.39	37
Home (border)	1.93	1.96	1.28	279	1.55	1.9	1.68	71

Source: Head and Meyer (2014)
Notes: The number of estimates is 2508, obtained from 159 papers. Structural gravity refers here to some use of country fixed effects or ratio-type method.
#: Number of observations. s.d.: standard deviation.

relationship between exports and GDP. Distance parameter estimates have value gravitating around one, which again is expected. It is worth noting that trade agreements

[29] For an account of all these recent improvements in the theoretical and empirical specification of the gravity model, see Keith and Meyer (2014).

RTA/FTA, CUSA/FTA) have a positive effect as shown by the positive signs of their parameter estimate. This would also indicate that these trade agreements generate trade creation effects. Other results shown in Table 7 could be interpreted along the same lines as we did for distance, GDP and trade agreements.

1.6 – Summary and concluding remarks

Four modelling approaches applied to trade policy analysis have been explained and discussed in this chapter. Three of them are model-based while the fourth one is based on the use of econometric procedures. The first modeling approach which we call the homogenous product model approach is based on the partial equilibrium trade model. It is the easiest one to implement but it lacks the theoretical appeal that can be attributed to other modelling approaches. The Armington model is also a partial equilibrium trade model but has better theoretical foundations. However the Armington assumes imperfect substitution among commodities differentiated by geographical sources of origin. This latter feature could be a drawback for some commodities which tend to be more homogenous. This explains why the Armington model seems more appropriate for any products that are processed or semi-processed. The third modeling approach is based on a CGE framework. It has a lot of appeal because it is theoretically sound. However his application to trade policy analysis must be well justified because it requires an important investment and resources. The gravity model is now the one that seems to be preferred by trade analysts.

Of these four approaches, which ones are the most appropriate to conduct sound and relevant trade policy analysis? There are no definitive answer to this question. Each of these four approaches have advantages and weaknesses for which trade economists should be aware of. Applying any of these four approaches depends for a large part on the nature of the trade policy issue that must be assessed and analyzed but also on the time and resources at the disposal of the investigator.

Chapter 2: Introduction to CGE modeling

CGE models distinguish themselves by their theoretical frameworks and underlying assumptions. Differences across CGE models reflect differences in the theory behind the behavioral equations, the extent to which linkages within the economy are explained, and the data used to conduct the analysis. In the following sections, we present different types of CGE models used to tackle issues of trade policies.

2.1. Static versus dynamic CGE models

CGE models can be static or dynamic. In their static form, the impact of a policy reform such as a tariff reduction is assessed by comparing equilibrium properties before and after that reform. In other words, Static CGE models don't reveal the path of the economy from the benchmark equilibrium to the new equilibrium when a shock enters. In static models, time is implicitly introduced through changes in the closure, representing different adjustment time horizons. For example, a short-run simulation may treat capital as sector-specific, a medium-run simulation may allow capital to be mobile across sectors but available in a fixed total supply, and a long-run simulation may allow the capital stock to adjust to maintain steady-state real returns to capital. Also, in static CGE models saving-investment balance plays a minor role. Indeed, variations of the investment level subsequent to changes in savings have few consequences as they only affect the level of demand for investment goods.

The distinguishing feature of a dynamic CGE model, however, is that growth of output is possible and changes due to policy reforms can be tracked over a given period of time. Changes in economic indicators during the adjustment process can be retrieved. There are two types of dynamic CGE models: recursive and inter-temporal. Recursive dynamic CGE models consist of multiple static models linked to each other sequentially. The first model is solved for one period and then all variable values determined at the end of that period are used as initial values for the following one. Current economic conditions are dependent on past outcomes but are unaffected by forward-looking expectations and economic agents have myopic behavior imposed on them by the modeler. Some of the variables in the model may evolve exogenously following a pre-determined baseline scenario. Changes in variables, whether they are endogenously (capital) or exogenously determined (population), will be reflected in the growth path of the modeled economy along its adjustment path towards the new equilibrium. That is, the impact of the policy reform is to be anticipated with respect to the baseline scenario outcomes in each period.

Unlike sequential dynamic CGE, inter-temporal ones are based on optimal growth theory, where the behavior of economic agents is characterized by perfect foresight. In this type of dynamic CGE models, households choose a consumption plan (a sequence of consumption decisions) during the period under consideration that maximizes the discounted stream of their utilities. This means that in some periods households may consume more than they earn (dissave), while in other periods they may consume less than they earn (save). For their part, firms choose a production plan (a sequence of production decisions) that maximizes their discounted stream of profits. The availability of savings from households makes it possible for firms to turn these savings into new capital stock, thereby augmenting their productive capacity. Thus the growth rate in a dynamic CGE model is endogenously determined by the savings and investment behavior of households and firms.

The evolution of the economy would be driven by trade performance and its linkage to total factor productivity amongst other features considered by the modeler, the level of government investment on infrastructure and its assumed linkage to total factor productivity, as well as the investment in education through its impact on labor productivity. In the context of inter-temporal CGE models there is no need for an extensive baseline scenario. However, forward-looking behavior could complicate the computational exercise tremendously since some variables in the current period could be affected by variables in the future.

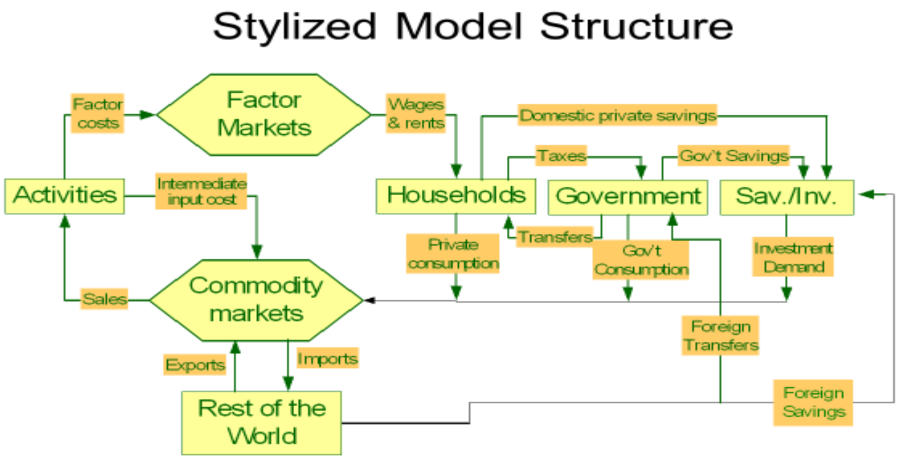
2.2. Single Country CGE model: Functioning and implementation

The single country CGE models are the most used CGE model type to tackle various issues of economic policies. This is because decision makers are generally interested on details and would like to have models as detailed as possible. In some other situations, the raised issue of policy analysis requires more details modeling of specific national economies which in turn can be fulfilled only by the use of single country CGE model. This kind of model has been used to analyze external sector issues as the impact of restrictions on foreign trade or the impact of changes in net foreign transfers or world prices on the equilibrium of the real exchange rate. The regional and multi-country CGE models are however typically concerned with resource allocation and the welfare implications of tariff reductions.

To provide a clear understanding on how a single country CGE model functions, let us refer to Figure 3. In this graphical presentation is shown a stylized structure of an economy within which commodity and factor markets interact to determine equilibrium prices. It can be seen that the market price mechanisms include direct and indirect channels which involved all economic stakeholders (firms, households, government) and the rest of world. Hence, commodity prices are derived by confronting the various final demands (private and government consumption, investment and exports) to supplies provided by industries (activities) and the rest of World (imports). A similar mechanism determine factor prices whereby the demand by industries (activities) meet and balance with the supplies of factors offered by households. The right part of Figure 3 shows two important aspects of a CGE model. First, it presents the way that the various sources of savings are used in the economy to finance investment. The second element has to do with an explicit representation of government budget which includes on the revenue side taxes and expenditures broken down between government consumption and savings. In this stylized model structure of a national economy, the foreign prices of imports and exports are assumed to be given.

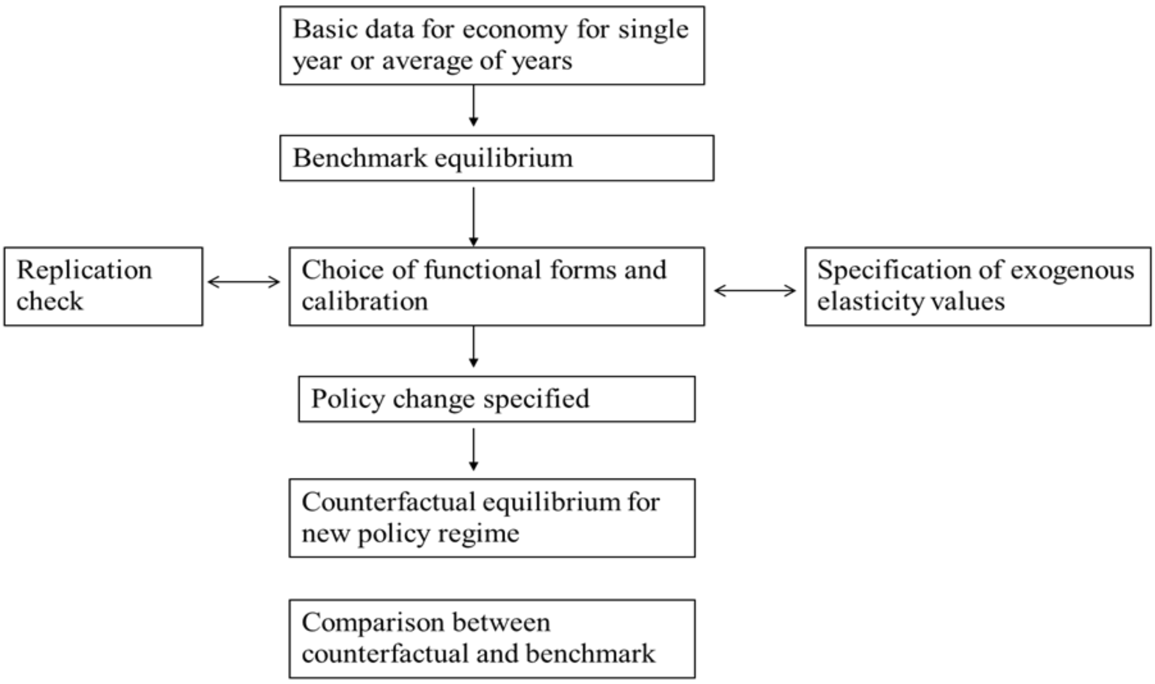
A single-country CGE model includes not only a set of behavioral relationships describing the behavior of economic agents but also various identities balancing not only supplies and demand in commodity and factor markets but also expenditures and revenues of households government and activities (industries). As economic agents are not subject to monetary illusion they respond to relative prices, which require to define a numeraire, As a result, it is important to realize that CGE models satisfy the Walras law. Finally, a CGE model is closed with several macro-closures. To implement a CGE model of any nature (whether single-country, regional of global) requires to implement a set of several steps that are shown in Figure 4.that encompass those defined in Section 1.4.

Figure 3: Stylized CGE model structure



Source: Lofgren et al.

Figure 4: Various steps in implementing a (single country) CGE model



Source: Lofgren et al.

2.3 - Implementation and simulation of a CGE model using GAMS software

To illustrate the implementation process of simulation models in GAMS, we use the model of Kuwait as an example on how to implement a CGE model using this software. In fact, as stated earlier once the structure of the model has been defined, the next step in running CGE models for policy analysis is to calibrate the model to reproduce the base year (static model) or a reference scenario (dynamic model). Once these two steps are implemented and checked, the model can be used for simulation purposes. To show this process, we use the model developed by Lofgren, Chemingui and Robinson (2004) for the Kuwait economy for fiscal policy analysis. The set of GAMS input files for the Kuwait standard CGE model includes two Kuwait data files (an aggregate and stylized database for 1992 and a more detailed database for 2001) that enable the user to define and carry out model simulations without any changes elsewhere in the model. More advanced user may also develop new databases and/or change the model structure. This section provides a brief guide to the GAMS files and suggestions for how to use this modeling system. The files themselves include additional explanatory comments.

Table 8 summarizes the contents of the different files and Figure 5 provides a schematic representation of the structure of the GAMS model and data files. The modelling system is segmented into two main GAMS files, *kuwmod.gms* and *kuwsim.gms*. This segmentation corresponds to the two main steps in a typical CGE modelling project. In the first main file, *kuwmod.gms*, the model is set up and calibrated to a Kuwait data set that is read in the form of an include file (*<name>.dat*). The Kuwaiti dataset illustrates how data sets should be defined. The SAM may be included directly in the *<name>.dat* file or be read into this file using a GAMS GDX file command. If the account imbalances in the SAM exceed a low cut-off point, a simple SAM balancing program is activated. The file *varinit.inc* is used to initialize all variables at base levels. In the optional file *varlow.inc*, lower limits close to zero are imposed for selected variables as this may improve solver performance.

Two models are defined inside *kuwmod.gms*, one for MCP (mixed-complementarity programming) and one for NLP (non-linear programming) solvers.[30] The MCP model is identical to the model presented above. The NLP model differs in that it also includes an objective function. The objective function is needed given that this is an optimization problem, but it has no influence on the solution since there is only one feasible solution that satisfies all constraints. After having solved the model for the base, the program calls up the file *repbase.inc*, which generates a report on the base solution.

In *kuwsim.gms*, which restarts from the save files of *kuwmod.gms*, simulations are defined and carried out.[31] A note at the beginning of the file specifies the steps required when additional simulations are introduced. For each simulation, the user can choose between alternative closures for macroeconomic constraints and factor markets (three alternatives for each factor and simulation). The user has the option of selecting the base levels of the model variables as the solver's starting point for selected simulations (by including the file *varinit.inc*); this may facilitate the solver's task of finding a solution relative to the default, according to which it uses the variable levels from the preceding model solution. Report parameters are declared in *kuwsim.gms* and defined in include files (*reploop.inc*, *repperc.inc*, and *repsum.inc*). The parameters are designed to contain most of the information that an analyst may be interested in. *Repsum.inc* may be used as a starting point for user-defined reports that highlight information of interest in a specific application. The modeling system which we presented can be used in a variety of ways. The first and most straightforward approach is to carry out simulations with an existing data set without making any changes in the modeling structure. Here the user is required only to define new simulations. The file *kuwsim.gms* includes a note that summarizes the core steps to take when carrying out additional simulations.

In a second approach, users may wish to take the additional step of applying the model to their own data set. If so, it is preferable to structure the data set in the same way as in the sample data files. The most critical additional step is to generate a properly formatted SAM. If

[30] For information on solvers, visit the web site of the GAMS Development Corporation (www.gams.com).
[31] For save and restart facilities in GAMS, see Brooke et al. (1998: 199).

an available SAM has a different format (e.g., exports from activity accounts instead of commodity accounts

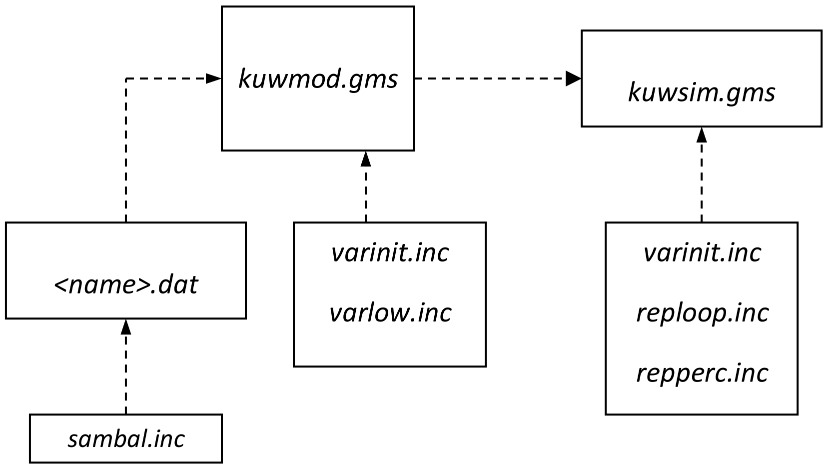
Table 8—File structure in GAMS Kuwait standard CGE modeling system

File name	Description
kuwmod.gms	All items (sets, parameters, variables) that appear in the model equations as well as the equations themselves and the CGE model are declared. Except for the sets, these items are also defined. The model is solved for the base.
<name>.dat	Include file for *kuwmod.gms* with a data set. The data consists of set elements (used to define model sets), a SAM, elasticities, selected physical factor quantities, commodity value shares for home consumption (if needed), and a parameter transforming SAM tax data.
sambal.inc	Include file for *<name>.dat*. A simple program that balances the SAM if its account imbalances exceed a cut-off point.
varinit.inc	Include file for *kuwmod.gms* (and, optionally, for *kuwsim.gms*). All model variables are initialized.
varlow.inc	Optional include file for *kuwmod.gms.* Imposes lower limits on selected model variables.
repbase.inc	Include file for *kuwmod.gms*. Using data from the base solution, defines an economic structure table, a GDP table, and a macro SAM.
kuwsim.gms	Restarted from *kuwmod.gms.* The file includes: (a) declarations and definitions of sets for simulations, experiment parameters, closures for macro system constraints, closures for factor markets, and sets for reports; (b) declarations of report parameters; (c) a loop over the set of current simulations that contains definitions of simulation-specific parameters and variables, a solve statement, and an include file defining report parameters; (d) additional processing of report parameters (in include files), checks for errors in report parameters, and a display of report parameters.
reploop.inc	Include file for *kuwsim.gms*. For each simulation, the file defines report parameters for (a) the levels of each model variable;* (b) the value of parameters that are subject to change in simulations; (c) the incomes and expenditures of each SAM account; (d) national accounts data; (e) macro and factor market closure; (f) consistency checks for data in (c) and (d).
repperc.inc	Include file for *kuwsim.gms*. For all relevant parameters under (a) through (d) in *reploop.inc*, computation of percentage change from base for non-base simulations.**
repsum.inc	Include file for *kuwsim.gms*. Summary results tables based on report parameters defined in *reploop.inc* and *repperc.inc.*

* These parameters have the same name as the corresponding variable with *X* added at the end.

** These parameters have the same name as the corresponding parameter in *reploop.inc* with *P* added at the end.
Source: Chemingui et al. (2003)

Figure 5: Structure of GAMS model and data files



or a different treatment of taxes), we strongly recommend that the user reformat the SAM (a task that can be done inside the GAMS include file). The alternative of adjusting the model code to a differently formatted SAM is likely to be more time-consuming and error-prone. Once the model properly calibrates to the new data set, the user can proceed with simulations.

The third approach is also the most involved. Here, in combination with the two approaches we just defined, more advanced users may wish to change the model, a step that involves changing the files *kuwmod.gms* and, quite likely, *<name>.dat*, as existing model elements (sets, parameters, variables, and equations) are modified or new ones are declared and defined. If the user is also applying the model to a new data set (as in the second approach above), it is probably easier to divide the process into two steps, first generating a data set to which the original model calibrates and second modifying the model. Changes in the model structure will also require the user to modify and/or add to the report system, for example, adding new parameters to account for new model variables and modifying the parameters that define the incomes and expenditures of SAM accounts.[32]

After having read this document, we recommend that users familiarize themselves with the contents of the different files. For users who limit themselves to the first approach, the most important task is to become familiar with the file *kuwsim.gms* and its include files. For users who also add their own database, as in the second approach described above, it is also crucial to be aware of the detailed structure of the standard SAM and how it may differ from the original format of any new SAM that the user wants to apply. A thorough study of the modeling system is required for users who, in addition, wish to modify the model, using it as a tool to develop further in different directions.

2.4. Regional CGE models

[32] The modeling system includes consistency checks on the report parameters which will generate error messages if, for example, the reports show imbalances between the income and spending of SAM accounts.

Regional trade CGE models add to the previous single country models the desire to examine the interactions or the impact on welfare between two or few number of countries or regions with the distinction of the Rest of the World as a big partner. In other words, the rest of the world is still considered as a big residual partner and world prices are set exogenously. However, import demand and export supply are endogenous. When the model is actually used, the within country and between country relationships are solved for simultaneously. The model database consists of SAMs for each country, including data on their trade flows. The development of a consistent multi-country data base is in itself not an easy task.

The literature covers several regional trade CGE models implemented to tackle various issues. For example, Elbehri and Hertel (2003) have conducted a study focused on Morocco, where the effects of a preferential, bilateral liberalization process with the EU are assessed, then compared with those from a multilateral liberalization scenario for this country. The model is a modified version of the GTAP static model, incorporating scale economies. Three regions are included: Morocco, EU, and a Rest of World aggregate. Constant returns to scale and perfect competition are assumed in the agriculture and service sectors, while manufacturing sectors are modeled with an oligopolistic structure. At the sector level, in this EU-Morocco Free Trade Agreement (FTA) scenario output is falling in most of manufacturing sectors because market share losses of Moroccan firms on their domestic market are not compensated by gains on export markets due to the real exchange rate depreciation which follows liberalization. Overall, in this scenario, projected efficiency gains from industry rationalization and resource reallocation are not enough to compensate the terms of trade losses incurred by the country in the process of unilateral tariff reduction with the EU

Ben Hammouda et al. (2007) estimate the impacts of the Tunisian, Moroccan and Egyptian bilateral agreements with the EU jointly in a regional CGE model using “MIRAGE” (see Bchir et al. (2002)). Their study focuses on the potential adverse effects of these agreements on the economies of south Mediterranean countries, and asks whether the inclusion of agricultural products to the integration process could help rebalance the outcomes.

Consistently with other studies, the Barcelona initiative process is found to have strong reallocation and de-industrialization effects on North-African economies, resulting in net negative welfare variation for these countries. The authors examine whether broadening the agreements’ coverage to include agriculture could mitigate the losses for North African economies. The answer is negative and none of the measures envisaged to reduce distortions in agriculture manages to yield positive welfare effects for North African economies.

2.5. Global CGE models

In the last two decades, the emergence of WTO has accentuated the need to assess the potential consequences of trade policies. The Uruguay round and Doha round negotiations are typical examples. Policy makers would like to know the likely effects of trade liberalization on income, production and other relevant macroeconomic variables. It could also be useful for them to know the distribution of these effects across countries or sectors to evaluate who are the winners and who are the losers. CGE models are an important tool for meeting this need because they allow a lot of trade information to be elaborated in a coherent economic structure.

Typically a global CGE links all countries through a set of import and export demand functions. The interaction between them determines a new equilibrium for prices and quantities of goods in the world. In this kind of CGE model, there are no exogenous commodities prices, since the model is global. Any price or quantity change in any country inside the model must generate changes in the overall world equilibrium, and a new equilibrium must be computed. In a single country model, however, a much different adjustment process takes place. Typically, a single country model takes as given the external prices of both its exports and imports assuming the small country assumption. This is a very important difference between the two kinds of models. In a global model, world prices are by definition endogenous as the most important actors are taken into account. A global approach has the unquestionable advantage of taking into account within the same theoretical structure the trade relationships of all countries or groups of countries in the world, such as the EU, the USA, China, India and Africa. Accordingly, it is very important to have a consistent economic global database that covers all parts of the world. The GTAP database[33] has been created to satisfy this need. Table 9 presents the main characteristics of three global CGE models that are presently used by economists. A brief description of these three global models follows.

The GTAP database is most commonly used with the GTAP model and the RUNGTAP program[34]. Alternatively, it is possible for users to extract country SAMs or I-O tables from the GTAP database for single country models. The most used large-scale global CGE trade models are GTAP and MIRAGE. The MIRAGE model has been constructed in order to assess the impact of globalization on the individual regions in the global economy. The model is a relatively standard neo-classical model of economic activities. It is based on the GTAP database. The model is designed for analyzing dynamic scenarios. The scenarios are solved as a sequence of static equilibrium, with the periods being linked by dynamic variables — population and labor growth, capital accumulation, and productivity. Policy scenarios are compared to a baseline, or business-as-usual, scenario[35]. As far as dimensions are concerned, there are three essential dimensions for the MIRAGE model, namely sectors, regions and time. Due to the existence of a flexible aggregation facility, the regional and sectoral definitions of the model are easy to modify.

However, in 2015, a new global CGE trade model has been built by OECD known as METRO (ModElling TRade at the OECD) which builds on the GLOBE model developed by McDonald, Thierfelder and Walmsley (2013). The METRO database currently covers 61 economies across 57 economic sectors. It is based on the GTAP database and allows users to analyze global value chains by drawing on the OECD-WTO Trade in Value Added database, providing a platform to more fully integrate structural policy issues in the analysis of trade policy. Using METRO, it is now possible to track trade flows by their use (intermediate, household, government and investment) in addition to the bilateral links between source and destination markets. This will greatly enhance the ability to model movements of goods and services, especially along global value chains.

[33] see next chapter for more details on this global database
[34] This program can be downloaded from the GTAP website.
[35] The complete and detailed technical specification of the MIRAGE model can be found in Bchir et al (2002)-

Table 9: Main characteristics of GTAP, MIRAGE and METRO CGE models

Characteristics of the CGE model	GTAP	MIRAGE	METRO
Nature	Static (latest version 9.0)	Sequential dynamic	Sequential dynamic
Number of countries	150	Easy aggregation and disaggregation	61
Number of sectors	57	Easy aggregation and disaggregation	57
Data base	(SAMs for the base years 2004, 2007 and 2011)	GTAP and *MacMaps* data bases	GTAP data base + TiVA data base
Focus	Wide array of applications on trade policies	Studying a large scope of trade agreements	Global Value chain Analysis
Advantage	All the countries are fully introduced in the model and no Residual “Rest of the World”	FDI are explicitly described, notion of vertical product differentiation with 2 quality ranges	Possibility to track trade flows by use (intermediate, household, government and investment)
Implementation	Based on GEMPACK	GAMS Software	GAMS Software

Global CGE models can be used to assess the impact of global free trade on the countries' welfare and the distribution of income across the regions. Further, the model may be extended It's also important to highlight that a combination of a single country CGE and a global one can be done when the raised issues necessitate it. The interest in this kind of application is growing in recent years, and encompasses a wide range of theoretical as well as practical questions. The linkage between the global and the single CGE models can be useful for example when the first determines the new world prices following a given shock which can be transmitted to the single country CGE and feed backs are also possible. In this regard, Horridge and Filho (2003) for instance provide hints and considerations on linking GTAP model to a single CGE model for Brazil.

2.7 Summary

The objectives of this chapter are three-fold. First, to give an overview of the different types of CGE models that are used to assess the economy-wide effects of CGE models. In so doing, we contrast static and dynamic CGE models and then single-country against global CGE models. The second aspect dealt with in this chapter was first to explain the functioning of a CGE model and second to describe the implementation and simulation of a single-country (Kuwait) CGE model using the GAMS software. Finaly three examples of global CGE models – GTAP, MIRAGE and METRO – are presented and compared.

Chapter 3: Social accounting matrices and data bases

As pointed in the previous chapter, the calibration of a CGE model requires that a social accounting matrix (SAM) of the economy under study is available. This is the reason why it is important that the notion and structure of a SAM must be developed. A second objective of this chapter is to provide an overview of relevant databases which economists can use to build a CGE model. To achieve these two objectives, this chapter is divided into three sections. In the first one is developed the concept and structure of a SAM. This is then followed by an hypothetical example which will help illustrate how the information provided by a SAM can be used to describe an economy. The third section is devoted to some important databases that are suited to trade (policy) analysis and CGE modeling

3.1 Social accounting matrix (SAM)

Initiated by Stone (1986) in the sixties and seventies, the social accounting matrix is an alternative tool to present and analyze national accounts of an economy, It is a double entry table providing all the transactions between economic agents occurring in a given period (mainly a year). It assumes that there is balance between revenues and expenses for each economic agent but also for the economy as a whole. A SAM is divided into several accounts which are gathered in a table recording column-wise the expenses and row-wise revenues (see Table 10).

i) Activity accounts (1): report all purchases of intermediate inputs and services made by sectors or activities. Column-wise, activity accounts include the purchase of intermediate commodities and value added consisting of payments to fixed factors (wages and capital rents) but also government tax (mainly value-added taxes) on activities. The column total of each activity account determine the total value of output which is then equal to the total row-wise activity receipts consisting of domestic sales, exports and export subsidies.

ii) Commodity accounts (2): provide in a way the usual supply-demand commodity balance. On the revenue side (row-wise), each commodity account reports the various uses of the commodity which represent receipts from sales to the various sectors in the form of intermediate products, but also sales to the final consumption of goods by households and government and investment goods in the capital account. Column wise, the commodity account includes the purchases of the various sources of supplies (purchases of domestically produced goods and purchases of imports), the various services from the trade sectors and all indirect taxes and tariffs imposed on imports.

iii) Factor accounts (3): report all the transactions pertaining to the payments and revenues of capital and labour. On the column side are included the following items: payments to households and firms (labour income and distributed profits), payments to government in the form of taxes (taxes on social security, taxes on profits) and factor payments to the Rest of the World which mainly consist of labor income to foreigners.

iv)Institution accounts (4): refer to all transactions made by households, firms and government. Households' incomes include the factor incomes reported in the previous accounts, various transfers coming from other households, firms, government and from abroad (for instance remittances). On the column side, the households account includes not only private consumption expenditures, but also all payments (transfers) made to other households, firms and to the Rest of the World, direct (income) taxes and a residual item corresponding to the savings made by households. It is important to stress household accounts can be broken down into several sub-accounts, depending on the level of the households' incomes[36]. Firms' revenues which consist of profits and transfers serve to pay taxes and transfers. The residual firms' expenditures represent savings which are transferred to the capital account. Row-wise, the government account reports all the various sources of tax revenues to which are added transfers from abroad. These government revenues are then redistributed to firms and households in the form of transfers but also serve to pay other items such as other (export) subsidies and public service expenditures provided by the (service) activities. After all government expenditures have been accounted for, the residual term corresponds to government savings. If they are negative, it means that the government is running a budget deficit.

v) Capital account: reports the various sources of domestic savings and net capital transfers from abroad necessary to finance net investment and change in stocks.

vi) Rest of world account: report not only international trade flows (exports and imports) of the economy but also financial transactions with the Rest of the World.

There are different ways to present a SAM. Although the structure presented in Table 10 is the most commonly used among economists, it is possible to change the ordering of the accounts, which results in an alternative but equivalent form of constructing a SAM. It is also worth mentioning that the distinction between activity and commodity accounts is not clear-cut and sometimes these two categories of accounts can be merged into common activity accounts. An inspection of the SAM structure in Table 10 also reveals a SAM also encompasses inter-industry transactions which are the foundations of the input-output table. Another element that can be considered in developing a SSAM has to do with the fact that a distinction could also be made between imported and domestically-produced goods. This, when it occurred, would require to expand the SAM by creating additional commodity and activity accounts which would distinguish commodities according to their geographical sources of origin. In so doing, it would also be possible to report in the SAM import flows according their intermediate and

Although the notion of SAM is in a way easy to figure out, its implementation requires to use a huge amount of data information that is not often available and also not consistent among each other. This is the reason why a SAM must be adjusted at the outset to macroeconomic aggregates found in national accounts. To be able to fill factor and household accounts would require to use not only information obtained from input-output tables but also data generated by firms and households surveys conducted at the country level by census bureaus or national statistical offices. Concerning the rest of the word account, data on trade and financial flows with abroad could be obtained from customs and the central bank. The final stage in the construction of a SAM is to make sure that all accounts balance within and between each other. If inconsistencies or imbalances still prevail, it would be necessary to use matrix or table balancing procedures such RAS or entropy methods (Fofana et al., 2005).

[36] In the case of developing countries, a distinction is made between rural and urban household accounts.

Table 10 : Structure of a social accounting matrix

		EXPENDITURES: 1 Activities	2 Commodities	3 Factors		4 Institutions			5 Capital account	6 Rest of world	7 Total
				Labor	*Capital*	*Households*	*Firms*	*Government*			
INCOMES	1 Activities		Domestic sales					Export subsidies		Exports	Production
	2 Commodities	Intermediate demand				Household Consumption		Government consumption	Investment		Domestic demand
	3 Factors										
	Labor	Wages								Factor incomes from abroad	Gross national product at factor cost
	Capital	Rent									
	4 Institutions										
	Households			Labor income	Distributed Profits	Intrahousehold Transfers	Transfers	Transfers		Transfers from Abroad	Households income
	Firms				Nondistributed Profits	Transfers		Transfers			Firms income
	Government	Value-added taxes	Tariffs Indirect taxes	Taxes Social Sec.	Taxes on profits	Direct Taxes	Taxes				Government income
	5 Capital account					Household savings	Savings	Government savings		Capital transfers	Total savings
	6 Rest of World		Imports	Factor payments		Current transfers abroad					Imports
	7 Total	Production	Domestic supply	Factor outlays		Household expenditures	Firms expenditures	Government expenditures	Total investment	Foreign exchange earnings	

Source: Sadoulet and de Janvry (1995)

When a SAM is used in its own, it generates multipliers as in input-output analysis (Pyatt et al., 1989). In so doing, all transactions are determined by final demand which will be fixed by considering the investment, government and rest of world accounts as exogenous. In addition, it also assumes that prices are exogenous and fixed. To link a SAM to a CGE model, prices must be made endogenous. Then SAM transaction which are reported in monetary values could be expressed in volume terms as prices are observed. Combining this latter information with additional ones on elasticities, it is then possible to calibrate the behavioral parameters of the CGE model[37].

Implementing SAMs is now viewed as routine work by economists and modelers. Numerous articles and research reports have been published over the years and are now available: they do provide strategies and guidelines to follow to construct SAMs in the best conditions as possible. In this respect, it is worth mentioning all the work undertaken at the International Food Policy Research Institute (IFRPRI) in Washington which has developed over the least two decades expertise and modules to construct SAMs. IFPRI made publicly available on its website SAMs they have implemented for many developing countries.in Africa, Asia and Latin America.

3.2 An example of social accounting matrix

Table 11 presents a SAM describing an hypothetical economy consisting of three sectors (agriculture, food and others). Three categories of households – rural, poor urban and rich urban – are also considered. Looking at the structure of this SAM, it can be seen that exports are recorded in the commodity accounts. This implies that it is not possible to have independent domestic sales shown in the row activity accounts. What is shown as revenues of each activity account is the total values of each sector output.

Domestic production is best measured by value added which is computed as the sum of the payments to the factors of production and to the households and firms[38]. This shows that the agri-food sector combining agriculture and food represents 27% of domestic activities. The ratio of value added over total output is the highest for the agricultural sector with a figure of 58%. In the food sector, the ratio of value-added over total output is only 23 %. The economy is open to foreign trade, with exports and imports representing 21 % and 31 % of GDP. The structure of exports shows agriculture and food do only represents 11% of the total. This hypothetical economy seem to be quite urbanized in the sense that urban households represents 70% of total household incomes. The saving rate is equal to 18% for rural and rich urban households. On the other hand this figure falls to 8% for the poor urban households. As government savings are negative and equal to -2003. This is indicative of the fact that the government is running a budget deficit.

With this SAM example, it would be possible to build a small-country CGE model that can be easily implemented in EXCEL In this process, it could be assumed that market and factor prices could be normalized to unity. Then, if a Cobb-Douglas functional form is used to represent the

[37] This ultimate stage of CGE calibration depends upon the type of functional forms that adopted in the CGE model. If, for instance, a Cobb-Douglas form is used, there is no need to provide extra information on elasticities. The information contained in a SAM is sufficient to derive values for the Cobb-Douglas parameters as they are directly linked to budget or cost shares.

[38] The total sum of all factor payments across all activities determine the gross domestic product (GDP) of the economy which is equal in this example to 63799. This figure is valued at factor costs because it is not adjusted with subsidies and taxes. If these latter items were taken into consideration, we them determine a GDP and value added for each sector at market prices. In our example, the GDP at market prices is equal to 72532.

Table 11: Example of a SAM matrix

		ACTIVITIES			COMMODITIES			FACTORS		INSTITUTIONS					CAPITAL	REST OF WORLD	Total
		Agriculture	Food	Other	Agriculture	Food	Other	Labor	Capital	Firms	Rural Households	Urban Poor households	Urban Rich households	Government			
ACTIVITIES	Agriculture				21464											1912	23376
	Food					14801										1167	15968
	Other						95963									10103	106066
COMMODITIES	Agriculture	2365	5228	2655							4615	5152	1810		1738		23563
	Food	402	2480	3595							3141	4703	2369		186		16876
	Other	5897	4528	45728							6430	12809	8231	13589	16009		113221
FACTORS	Labour	8500	1592	24528													34620
	Capital	5134	2102	21923													29159
INSTITUTIONS	Firms								14733								14733
	Rural households							8549	5134	1734				330		2100	17847
	Urban poor households							19937		2552			129	371		1896	24885
	Urban rich households							6134	9292	1513				123		188	17250
	Government	1078	38	7637	191	89	1278			2358	357	249	1540				14815
CAPITAL										6005	3304	1972	3171	-2003		5484	17933
REST OF WORLD					1908	1986	15980			571				2405			22850
Total		23376	15968	106066	23563	16876	113221	34620	29159	14733	17847	24885	17250	14815	17933	22850	

household preferences, production technologies and trade patterns, it would be straightforward to calibrate this CGE model with all the data information reported in Table 11.

3.3 – Important and relevant databases.

3.3.1 GTAP database

Since the early nineties, Professor Tom Hertel from Purdue University took the initiative of developing and conceiving a model and data framework able to provide in consistent way a global database representing national economies that are interconnected through price and trade linkages. Such a global database then serves as a basis to calibrate and implement a global CGE model that can be used to assess agricultural policy reforms and agricultural trade liberalization scenarios in the context of the Uruguay Round of trade negotiations. More than a quarter of century later and during that period, GTAP has steadily growing so that it is now a global network of researchers who conduct quantitative analysis of international economic policy issues, especially trade policy. The latest version of the GTAP database, GTAP 9.0 is a large social account matrix (SAM). It contains complete bilateral trade information as well as transport and protection linkages among 170 countries or groups of countries and 57 sectors for the base years 2004, 2007 and 2011. Policy measures are widely covered and include domestic and trade policy instruments that measured in tariff-equivalents.

An important and useful feature of the GTAP database is the existence of a platform which allows to perform different treatments of the data. Hence it is possible through the program called GTAPagg or FLEXagg to aggregate GTAP data by sectors and countries to form bigger regions, In the same vein, SAMs and Input-output tables distinguishing the different uses of imports (i.e intermediate or final use) can be constructed using appropriate programs implemented in GAMS or EXCEL. This flexibility in the use of the GTAP database is very useful to develop global CGE models focusing on a smaller number of regions or sectors.

At the outset, the GTAP database was developed with a special focus on global agricultural trade issues. However over time, new global issues linked to energy, resources and the environment became of concern so that there was need to develop new and relevant satellite data that can be added to the GTAP data base. Thus, the GTAP website indicates that the following satellite data are now available the GTAP 9.0[39].

i) GDyn Data Base facilitates development of baseline projections consistent with the GTAP 9 Data Base and for direct use with the GDyn Model.

ii) GMig2 Data Base contains global bilateral migration and remittances data.

iii) GTAP-E Data Base provides carbon dioxide (CO_2) emissions data distinguished by fuel and by user for each of the 140 countries/regions.

iv) GTAP-Power Data Base is an electricity-detailed extension of the GTAP Data Base. The GTAP 'ely' sector is disaggregated into: transmission & distribution, nuclear, coal, gas (base and peak load), oil (base and peak load), hydroelectric (base and peak load), wind, solar, and other power technologies.

v) Land Use and Land Cover Data Base builds global land cover and land use databases for base years: 2004, 2007 and 2011. Unlike previous versions, the data is directly constructed from publicly available geospatial maps (circa 2000/01 at 5-minute grid resolution). These are then aggregated for each AEZ-region and updated to each base year using national level output price, land use and land cover information from FAOSTAT (2016).

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[39] https://www.gtap.agecon.purdue.edu/databases/Utilities/default.asp.

vi) GTAP Non-CO2 Emissions Data Base complements the GTAP-E Data Base and provides information on other greenhouse gas (GHG) emissions such as Methane (CH4), Nitrous Oxide (N2O), Fluorinated gas (FGAS).

More detailed and relevant information on the GTAP database is available on its website. To access the GTAP database and use it, it requires to register first and then pay a differential entry fee depending on several parameters such as the type of license, the country of residence and status (academic or not). It is important to be aware that a cycle of three to four years is needed to update the GTAP database. The latest version 9.0 provides data information for 2011. It is expected version 10 of the GTAP data base will be released soon and will provide data information for 2014.

3.3.2 - Trade and other integrated databases:

For ease of exposition, the other databases which we consider of interest for trade (policy) analysis and CGE modelling are described in this Section using texts gleaned on the various relevant websites promoting these databases. Below is given a description of these databases which we have selected.

UN COMTRADE:

This database is the United Nations International Trade Statistics database. It provides annual international trade statistics detailed by commodities/service categories and partner countries. The UN COMTRADE is the largest depository of international trade data. It contains more than 3 billion data records since 1962 and is available publicly on the internet. All commodity values are converted from national currency into US dollars. All traded quantities are converted in metric tons, Commodities are reported in the current harmonized system (HS) and can be obtained up to HS-6 digits. It is also possible to obtain trade data classified according to the SITC system

FAOSTAT database:

FAOSTAT provides free access to food and agriculture data over 245 countries and territories and FAO regional groupings from 1961 to the most recent years. Although FAO convers various facets of agriculture and food sectors in all countries, it also has a data component pertaining to international trade in crops and livestock products and live animals. Imports and exports are available on an annual basis in volume and value. An interesting feature of the FAOSTAT trade database is the availability of trade matrix containing bilateral flows. FAOSTAT database are publically available on the internet.

UNCTAD TRAINS

The UNCTAD trade analysis information System (TRAINS) is a comprehensive computerized information system at the HS-6 based tariff level (HS6-digit). The data base provides data on trade and trade measures pertaining to tariffs, para-tariffs, non-tariffs measures and imports by suppliers at the HS-6 digit level. These data are reported by 150 countries. Depending on the country, the data are available from 1968 onward.

WTO statistics

The World Trade Organization develops and maintains databases on trade flows, trade in services, tariffs, non-tariff measures (NTM) and trade in value added. Concerning merchandise trade, WTO provides annual data on imports and exports of goods aggregated or individually by product and/or country. Quantitative information on trade in services are made available by the WTO Secretariat. This includes trade-policy information, data on trade and services by sector and supplier, and other information in services trade. The WTO website offers sophisticated options on tariff, tariff-quotas, imports and countries commitments on agricultural subsidies. The information supplied by WTO on NTMs is quite comprehensive, including members' notifications on NTM's, as well as information on ´specific trade concerns raised by members at WTO committee meetings. Finally, in the area of trade in value chains, the WTO website aims to support the exchange of projects, experiences and and practical approaches in measuring and analyzing trade in value chains and global value chains, All the quantitative information (databases, statistics) provided by the WTO is publically available on the internet through its website.

WITS: (World Bank) Integrated data solution:

This integrated database includes several facets that are quite instrumental in doing trade (policy) analysis. It includes a software that provides access to data on international merchandise trade, tariff and non-tariff measures. In browsing the Country profile, it is possible to country trade (imports and exports), tariff statistics along with relevant development data. It is also interesting to note that WITS also has some tools that can be used to undertake some basic trade analysis such as determining the impact of a tariff, etc.There are possibilities in WITS to be linked with other trade databases such as TRAINS and WTO statistics.

International Trade Centre (ITC)

As part of its mission to promote trade for developing countries, ITC has developed a series of online tools to make global trade more transparent and facilitate access to markets: Trade Map, Market Access Map, Investment Map, Trade Competitiveness Map, Standards Map, and Procurement Map. Some of these tools such as Trade Map and Market Access Map are very suited for trade policy analysis because they provide direct access to import and export data but also tariffs and non-tariff barriers. The data is available to all countries to conduct up-to-date market analysis, with users from developing countries, least developed countries and countries in transition being able to access all the data free of charge.

Centre d'Etudes Prospectives et de Prospectives et d'Informations Internationales (CEPII)

CEPII is a French research center in international economics which produces studies, research, **databases** and analyses on the world economy and its evolution. It was founded in 1978. Data bases provided by CEPII are wide ranging. They include data bases not only on trade flows but also on macreconomic indicators, foreign direct investments, tariffs and non-tariff barriers. Moreover, CEPII has also technical database dealing with distance between countries and economic geography that could be very useful for gravity modelling. Access to these databases can only be obtained through subscription.

Chapter 4: Implementing and analyzing CGE-based policy scenarios

Four applications are provided and discussed in this chapter to illustrate the implementation and assessment of CGE-based policy scenarios. The first one summarizes the main findings of a study undertaken by Chemingui and Dessus (2008) on assessing non-tariffs barriers in Syria. In this first application, a single-country CGE model is used. The second application deals with a quantitative analysis of the effects of multilateral agricultural liberalization in Africa (Chemingui et al., 2006). A global CGE model is employed in this second study. The third application (Chemingui and Thabet, 2016) compares the impacts of alternative water policy management scenarios on the Tunisian and Moroccan economies using water-dynamic computable general equilibrium models for both countries. For the three applications, we adopt the same exposition to present the main findings and conclusions of the implemented policy scenarios: The CGE model that is used is first presented; it is then followed by a description of the implemented policy scenarios and finally the main findings are provided.

4.1: First application: Assessing non-tariffs barriers in Syria

International trade in Syria is highly regulated through a combination of tariffs and non-tariff barriers. At 8 percent of the value of imports on average, effective tariffs were relatively low. However, non-tariff barriers to trade actually make Syria's trade restrictiveness very high. Comparing world and domestic prices of imports indeed suggests that non-tariff barriers increase the domestic price of imported goods by 17 percent on average, notably the result of significant quantitative restrictions. Using a computable general equilibrium model, the costs of non-tariff barriers (NTB) on the Syrian economy are assessed. Simulations suggest that reallocation gains resulting from a complete removal of NTBs could be substantial.

This study tries to measure the impact of NTBs on Syrian economic activity. In order to do so, the impacts of their removal are simulated, using a static CGE model. NTBs can be considered similar to import taxes (or subsidies). Hence, thinking of NTBs as instruments altering relative prices entails looking at them from an allocative perspective, where gains from trade would come from a better allocation of existing resources following a realignment of domestic and world prices. In turn, the extent to which the removal of NTBs will be ultimately trade-creating or not (and hence welfare-enhancing or not) will then give some indication of their current cost / benefit for the society.

Estimating such costs is a complex undertaking, not only because it requires some knowledge on households' demand behavior in response to relative price changes (between imports and domestic products, between various products), but also because the impact on producers' marginal costs (and hence on factors incomes, wages and the remuneration of capital) should be accounted for. Removing NTBs on certain imported inputs could actually increase the relative competitiveness of some Syrian sectors, notably those that are highly depending on imported inputs in their production process. But it could also threaten the viability of other sectors unable to compete with cheaper imported products. A third theoretical complexity stems from the fact that - unlike import tariffs or export taxes whose proceeds accrue directly to the government treasury – rents created by quantitative restrictions can be captured by private agents (exclusive importers for instance). As a result, abolishing these restrictions could directly affect their incomes, thereby further complicating the political economy of the reform.

4.1.1- The model

To address these various interrelated issues, a static CGE model is needed. As explained earlier (see Section 1.4 and Chapter 2), its main advantage lies in the possibility of combining detailed and consistent databases with a theoretically sound framework, able to capture feedback effects and market interdependencies that may either mute or accentuate first-order effects. Prices are endogenous on each market (goods and factors) and equalize supplies (imports; Syrian production for the domestic market; factors supply) and demands (final demand from households, the government, investors and the rest of the world; intermediate demand from producers; factors demand), so as to obtain the equilibrium. The equilibrium is general in the sense that it concerns all the markets simultaneously. For instance, a decrease in Quantitative restrictions (QR) will affect the demand for imports of both final and intermediate goods. This will in turn affect the supply of domestic goods, and the demand of factors in each activity. This will equally affect the price of goods and the income of households, which will in turn affect their demand, etc.

The model uses the information contained in the Social Accounting Matrix built by the authors for the year 1999, extending previous work from Lucke (2002). It considers one representative Syrian household, 23 economic sectors and 18 products. Each product can be produced by more than one sector, and each sector can produce more than one product.[40] The model also distinguishes five different trading partners.

Supply is modeled using nested constant elasticity of substitution (CES) functions, which describe the substitution and complement relations among the various inputs. Producers are cost-minimizers and constant return to scale is assumed. Output results from two composite goods: intermediate consumption and value added, combined in fixed proportions. The intermediate aggregate is obtained by combining all products in fixed proportions. The value-added is then decomposed in two substitutable parts: labor and capital, which are both fully employed. Labor is fully mobile but capital is largely immobile across sectors.

Income from labor and capital accrue to the representative household, as well as all rents created by QRs accrue to the same representative household. In the absence of more specific information, this last assumption insures the greatest neutrality of results. Household total demand is derived from maximizing the utility function, subject to the constraints of available income and consumer price vector. Household utility is a positive function of consumption of the various products and savings, with income elasticity for each product being set to unity. Government and investment demands are disaggregated in sectoral demands once their total value is determined according to fixed coefficient functions.

The model assumes imperfect substitution among goods originating from different geographical areas. Import demand results from a CES aggregation function of domestic and imported goods. Export supply is symmetrically modeled as a constant elasticity of transformation function. Producers decide to allocate their output to domestic or foreign markets responding to relative prices. At the second stage, importers (exporters) choose the optimal choice of demand (supply) across regions, again as a function of the relative imports (exports) prices and the degree of substitution across regions. Substitution elasticity between domestic and imported products is set at 2.2, and at 5.0 between imported products according to origin. The elasticity of transformation between products intended for the domestic market and products for export is 5.0, and 8.0 between the different destinations for export products.[41]

[40] The model assumes full substitutability between similar products from different sectors, and imperfect transformation possibility between different products within a given sector (the elasticity of transformation between products is set at 0.5).

[41] Trade elasticities come from the empirical literature devoted to CGE models. They are not specific to Syria. Devarajan et al. (1999) estimated econometrically substitution elasticities for Syria, and obtain results close to 0.1 for both Armington and CET elasticities. These elasticities are not distinguished by product, which explain to a large extent their low levels. They are not either statistically significant.

Several macro-economic constraints are introduced in this model. First, the small country assumption holds, the Syrian economy being unable to change world prices; thus, its imports and exports prices are exogenous. Capital transfers are exogenous as well, and therefore the trade balance is fixed, so as to achieve the balance of payments equilibrium. Second, the model imposes a fixed real government deficit, and fixed real public expenditures. Public receipts thus adjust endogenously in order to achieve the predetermined net government position, by shifting households' income tax.[42] Third, investment is determined by the availability of savings, from households, government and abroad. Since government and foreign savings are exogenous in this model, changes in investment volumes reflect changes in household savings and changes in the price of investment.

Policy impacts are compared to the situation observed in 1999, in terms of macro-economic aggregates, trade volumes, sectoral outputs and households' welfare. The chosen yardstick for welfare is the assessment of equivalent variation, which is the sum of two terms. The first one measures the gain (or the loss) of disposable income caused by the reform (producers surplus), and the second one measures the income needed after the reform to obtain the same level of utility as before the reform (consumers surplus).

4.1.2 – Scenario description and simulations results

Using the CGE model, the impact of three sets of policy reforms was simulated

Scenario 1: The complete removal of tariffs
Scenario 2: The complete removal of import subsidies and export taxes stemming from the existence of a multiple exchange rate system
Scenario 3: The complete removal of quantitative restrictions

Most important results are reported in Table 12 below. Simulations results suggest a number of interesting features.

The amplitude of changes resulting from the cancellation of QRs far exceeds that of tariff barriers, which is not surprising given the estimated magnitude of QRs as a percentage of GDP compared with that of tariffs[43]. Interestingly, tariffs and QRs are in most cases consistent in terms of sectoral protection. In all the 14 manufacturing sectors but one - the chemical public industry, canceling QRs has a relative impact on outputs of the same sign (positive or negative) than that of canceling tariffs. But, while tariff and non-tariff trade policies go hand in hand at the sectoral level, their relative impact differs widely across sectors. This is revealed by comparing output changes (reflecting factors reallocation) across sectors in the two scenarios.

[42] This closure policy can be understood as a net transfer from households to government (or the reverse). With one representative household, it is considered the most neutral way to assess trade reform. Other closures could be tested (e.g. adjusting indirect taxes for instance) but would bear the risk to introduce new distortions, thereby making more difficult to conceptually isolate the impact of the trade policy.
[43] Total tariff as a percentage of GDP is equal to 2.3% while the same figure for QRs (expressed in tariff-equivalents) is 5.4%.

Table 12. Simulations results on assessing NTBs in Syria

	Scenario 1: Dismantling tariffs	Scenario 2: Harmonizing exchange rates	Scenario 3: Eliminating quantitative restrictions
Gross Domestic Product	0.5%	0.1%	1.6%
Private consumption	0.2%	0.1%	0.9%
Investment	1.8%	0.3%	5.4%
Exports	2.3%	1.5%	7.3%
Imports	2.8%	2.0%	9.0%
Welfare gain (as % GDP)	0.1%	0.1%	0.3%
Transition costs (*)	0.4%	0.4%	1.8%
Output			
Agriculture	-0.6%	0.2%	-2.3%
Mining	0.0%	0.2%	0.0%
State Owned Manufacturing Sectors	-0.4%	6.0%	0.9%
Textiles	-0.5%	9.0%	-17.9%
Wood Products	-2.2%	2.2%	-25.9%
Food Products	-0.8%	0.8%	-2.4%
Chemicals	-0.5%	10.0%	6.3%
Non Metallic Products	0.9%	0.7%	2.2%
Metallic Products	-0.5%	0.4%	0.1%
Other Manufactured Products	0.2%	1.3%	4.0%
Private Manufacturing Sectors	0.4%	0.9%	2.4%
Textiles	3.5%	0.9%	20.3%
Wood Products	-2.2%	0.9%	-17.8%
Food Products	-0.5%	0.1%	-1.9%
Chemicals	0.1%	1.1%	0.6%
Non Metallic Products	0.4%	1.0%	1.3%
Metallic Products	-0.3%	1.4%	-1.0%
Other Manufactured Products	-0.7%	1.4%	-2.5%
Services (*)	0.4%	-0.6%	1.0%

Source: Authors' calculation.(*) Transition costs are measured by the share of labor force in sectors where labor demand is contracting. (**) The service sector is actually disaggregated into seven different sectors in the model: Energy and Water, Construction, Commerce, Transport and Communication, Finance, Social Services, Public Services.

Removing QRs entail a large restructuring of the manufacturing sectors through gains of specialization. While total output grows by 0.4 percent, the average relative change is plus or minus 6.6 percent in each sector. Accordingly, transition costs (measured as the share of labor force in sectors where labor demand is contracting) are also much higher than for tariff removal. Some sectors, like private textiles, tremendously benefit from the elimination of quantitative restrictions. Others, like wood products in the public and private sectors, do suffer, with outputs declining by more than 15 percent. On the contrary, removing tariff barriers only entail small factors reallocation. On average, the relative change is plus or minus 1.0 percent, with only one sector – private textiles, seeing its output varying by more than 3 percent. In total, small gains of specialization are achieved through tariff abatement.

This comparison between two policy outcomes suggests that non-tariff barriers entail much greater price distortions than do tariff barriers in Syria. This, not only because the magnitude of QRs is greater than that of tariffs, but also because the distribution of QRs across sectors is less equitably spread across sectors. From this observation can be understood the differentiated impact of both policies at the macro-economic level. Removing tariffs does not permit to generate important gains of specialization. Trade volumes augment (as a result of cheaper imports), but the impact on total real private consumption is minimal, given the low level of initial distortions. In turn, households' welfare gains are also marginal. Households see the price of their consumption decreasing, but this effect is offset by a decline in their net disposable income, stemming from increased transfers to the government (fiscal cost) to compensate for tariff revenue loss. On the contrary, removing QRs generate positive welfare gains (+0.3 percent of GDP). Gains of specialization more than offset households' loss of rents and private consumption significantly increases (+0.9 percent).

Other results warrant particular attention. First, private manufacturing sectors are disfavored by both tariffs and QRs compared with public manufacturing sectors, as the former benefit more from their removal than the latter. In the case of QRs, though, both the public and the private sector benefit from their removal. Second, investment greatly benefit from trade liberalization, the domestic price of imported equipment being particularly distorted by tariff and non-tariff barriers.

Finally, it is interesting to pay some attention to the impact of implicit subsidies and taxes originating from the use of a multiple exchange rate system. Import subsidies obviously favor imports while export taxes discourage exports. But export taxes seem more binding than import subsidies, as the removal of both tend to raise exports *and* imports. This, because the indirect impact of higher exports proceeds on (higher) imports is stronger than the direct impact of lower import subsidies on (lower) imports. Nevertheless, macro-impacts are moderate, and maybe the most important outcome of harmonizing exchange rates is to favor public sectors. Indeed, public sectors output goes up by 6 percent against 1 for private sectors.

4.2: Second application: Impact of multilateral agricultural liberalization for Africa

In this second application of CGE modeling, Chemingui et al. (2006) examined the implications of possible outcomes from the ongoing agriculture negotiations in the Doha Round on African economies. The paper defines scenarios that capture key elements of the modalities negotiations and undertakes simulations using a global dynamic general equilibrium model to examine the impact of multilateral agricultural trade reforms on African economies. The scenarios vary in their level of ambition in the market access pillar through both the level of tariff cuts in the different tiers and the level of sensitive sectors defined both for developed and developing economies. The results show that ambitious coefficients in the market access pillar remain the best result for Africa. Even what might seem to be insignificant definition of sensitive products for developed countries erodes potential benefits from deep tariff cuts for African countries. This suggests that utilizing sensitive products tariff lines by the developed countries not only dampens the expected positive outcomes for agriculture negotiations in favor of Africa but also could actually wipe out such gains. The results further confirm findings of other studies showing that tariff cuts for agricultural goods yield higher gains than elimination of subsidies, and this applies mainly to net food importing developing countries. Thus, reduction of subsidies should go hand-in-hand with agricultural tariff reductions in order to ensure win-win outcomes.

4.2.1 The model

The empirical analysis of the implications of the various agriculture negotiations options on African economies is conducted using the MIRAGE model. The model is a relatively standard neo-classical model of economic activity. The version of the model used to simulate the different simulation scenarios presented herein is based on the version 6.0 of the GTAP database. Policy scenarios are compared to a baseline, or business-as-usual, scenario. As far as dimensions are concerned, there are three essential dimensions for the MIRAGE model. The table below provides a complete description. Due to the existence of a flexible aggregation facility, the regional and sectoral definitions of the model are easy to modify. In Box 2 are presented the main characteristics of the model, pertaining to the modeling of demand, supply, capital, markets clearing and macroeconomic closure, and its dynamic dimension. While an agricultural version of MIRAGE was developed by Bouet et al. (2004), which integrates a detailed modeling of the instruments of domestic support applied by the EU and USA, we resorted to using a simpler way of modeling domestic support given the non-linearity of Bouet's version. This non-linearity could not allow running the dynamic version of MIRAGE. The approach used here for modeling domestic support follows the one developed by Walsh (2007)[44]. The results of the distribution of producer support estimates (PSE) are presented in Table 13.

4.2.2 - The scenarios

After calibrating the baseline scenario that represents the business as usual growth path, we implemented a number of alternative trade scenarios. Each scenario seeks to provide insights into possible trade deals on agricultural products under the DDA. In particular, we perform four alternative scenarios. The main difference between the scenarios is only on the market access pillar. The domestic support and the export competition pillars are the same in all the four scenarios. Therefore, the differences that are seen with respect to economic impacts, have got more to do with the market access pillar than with the other pillars although the economic impacts should be read as the combined outcome of market access, domestic support, and export competition liberalization. Market access commitments associated with each scenario are presented in Table while a definition of each of them is given below.

Scenario 1: This scenario has the deepest cuts for developed countries (akin to US proposal) but conservative cuts for developing countries (akin to ACP proposal). The sensitive products are fixed at 1% of agriculture tariff lines for developed countries and at 20% of agriculture tariff lines for developing countries. The sensitive and/or special products were defined for each country to be the percentage of lines representing the highest MFN rates. Numerically, this scenario consists of commitments presented at the top part of Table 14 :

Scenario 2**:** This scenario captures the G-20 proposal. In this simulation, we consider that sensitive and/or special products represent 2% of agriculture tariff lines for developed countries and 20% of agriculture tariff lines for developing countries. The different commitments to be

Box 2: Main characteristics of the MIRAGE model used by Chemingui et al. (2006)

[44] In the GTAP database, the direct payments reported in the GTAP model are allocated to four different categories: output subsidies, intermediate input subsidies, land-based payments and capital-based payments. The source of the agricultural support data for non-market price support protection in industrialized countries is based on the estimation of the Producer Support Equivalent (PSE) carried out by the OECD (2002). Walsh et al. (2007) dispatch the amount allocated to each category of subsidies among the three boxes defined by the WTO.

Demand
The demand side is modeled in each region through a representative agent, whose utility function is intra-temporal, with a fixed share of the regional income allocated to savings, the rest used to purchase final consumption. Below this first-tier Cobb-Douglas function, consumption trade-off across sectors is represented through a LES-CES function. Each sectoral sub-utility function is a nesting of CES functions, comparable to the standard nested Ahrmington – Dixit-Stiglitz function (see e.g. Harrison et al., 1997), with two exceptions. Firstly, domestic products are assumed to benefit from a specific status for consumers, making them less substitutable to foreign products than foreign products between each other. Secondly, products originating in developing countries and in developed countries are assumed to belong to different quality ranges.
Supply
Production makes use of five factors: capital, labor (skilled and unskilled), land and natural resources. The first three are generic factors; the last two are specific factors. The production function assumes perfect complementarity between value added and intermediate consumption. The sectoral composition of the intermediate consumption aggregate stems from a CES function. For each sector of origin, the nesting is the same as for final consumption, meaning that the sector bundle has the same structure for final and intermediate consumption. The structure of value added is intended to take into account the well-documented skill-capital relative complementarity. These two factors are thus bundled separately, with a lower elasticity of substitution (0.6), while a higher substitutability (elasticity 1.1) is assumed between this bundle and other factors. Constant returns to scale and perfect competition are assumed to hold in agricultural sectors.
Capital, markets clearing and macroeconomic closure
The capital good is the same whatever the use sector, and capital is assumed to be perfectly mobile across sectors within each region. At the region-wide level, capital stock is assumed to be constant in the core simulations of this paper. Natural resources are also perfectly immobile and may not be accumulated. Both types of labor, as well as land, are assumed to be perfectly mobile across sectors. Production factors are assumed to be fully employed. All production factors are immobile internationally. As to macroeconomic closure, the current balance is assumed to be exogenous (and equal to its initial value in real terms), while real exchange rates are endogenous.
Dynamics
In a typical recursive dynamic framework, the time path of the model is solved as a sequence of static equilibrium in each year. In other words, the solution in any given year is not a function of forward looking variables, though it may be an explicit function of past variables, though known and therefore exogenous. While there are drawbacks in the recursive dynamic framework, particularly in the modeling of saving and investment behavior, its one key advantage is that it is much easier to set up and solve (van der Mensbrugghe, 1998). There are several backward linkages linking one period to another: population growth, productivity increases, and capital accumulation. Most of these linkages can be resolved outside of the modeling framework, or in other words, in between solution periods. One of the exceptions is the capital accumulation function. Before running any policy simulations in a dynamic framework, it is often required to define some sort of reference scenario, or as it is sometimes called, a business-as-usual scenario (BaU). The BaU scenario makes some assumptions about a broad range of dynamic variables — population and labor supply growth rates, the growth rate of factor productivity, and other exogenous variables. If all productivity variables are pre-determined, as well as the population growth rates, the growth rate of real GDP is endogenous. However, the path trend in real GDP growth may be unrealistic, or at least inconsistent with the assumed trend from other studies or prospective outlooks. One way to resolve this dilemma is to make the growth of real GDP exogenous in the reference scenario, and to allow some other variable pick up the slack. In subsequent simulations, i.e. in simulations with policy shocks, the growth rate of capital and labor productivity, are exogenous, and it is the growth of real GDP and the capital-labor ratio, which are endogenous.

Table 13: Results of Distributing Agricultural Domestic Support

	EU25	USA	Japan
Output Subsidies			
Amber	96.1	92.9	30.1
Blue	0.0	0.0	33.9
Green	3.9	7.1	36.0
Intermediate subsidies			
Amber	89.7	90.5	74.3
Blue	1.8	0.0	0.0
Green	8.5	9.5	25.7
Land-based Payments			
Amber	0.5	3.1	93.1
Blue	79.8	0.0	0.0
Green	19.7	96.9	6.9
Capital-based Payments			
Amber	6.5	91.6	84.6
Blue	51	0	0
Green	42.5	8.4	15.4

Source Walsh et al. (2007).
Note: data are in percentage of distribution of domestic support among the three components for each county and each category.

implemented by developed, developing, and less developing countries are displayed in the second upper part of Table 14 .

Scenario 3. This scenario defines higher thresholds for the four tiers but applies the same tariff cuts as in scenario 1. Under this simulation, sensitive products represent now 8% of agriculture tariff lines for developed countries and 20% of agriculture tariff lines for developing countries.

Scenario 4: This scenario has higher threshold for developing countries and slightly lesser cuts for the same. Similar to the first scenario, sensitive products represent only 1% of agriculture tariff lines for developed countries and 20% of agriculture tariff lines for developing countries. Commitments by developed and developing countries are summarized in at the bottom part of Table 14.

For all scenarios, we also assume that only developed countries will reduce their domestic support pillar. The date of implementation is 2007 over 5 years. Table 7 describes the reduction schema. Furthermore, we assume that the export subsidies will be eliminated at 2013 for developed countries. Finally, and regarding market access commitments, we consider that the liberalization of agricultural products is supposed to be implemented as from 2007 in a linear manner during five years for developed countries and seven years for developing countries for all simulations.

On the basis of the contents of each of the four scenarios described above, the first one, which includes only 1% of sensitive products and with deep cuts for developed countries, could be considered as the most ambitious scenario. However, the third scenario presents the lower ambition in the market access given the high rate of sensitive products among the agriculture tariff lines for these countries. The second scenario is less ambitious than the first scenario but

Table 14 : Different market access commitments under Scenarios 1 to 4

Market access commitments under Scenario 1			
Tariff band (%)	Cuts by developed countries	Cuts by developing countries	LDC
0-20%	65%	20%	No liberalization
20-40%	75%	25%	
40-60%	85%	28%	
Above 60%	90%	30%	
Market access commitments under Scenario 2			
Tariff band (%)	Cuts by developed countries	Cuts by developing countries	LDC
0-20%	20%	15%	No liberalization
20-40%	30%	20%	
40-60%	35%	25%	
Above 60%	42%	30%	

Market access commitments under Scenario 3				
Developed countries		*Developing countries*		LDC
Tariff threshold	Cuts	Tariff threshold	Cuts	
0-20%	65%	0-20%	20%	No liberalization
20-40%	75%	20-40%	25%	
40-60%	85%	40-60%	28%	
Above 60%	90%	Above 60%	30%	
Market access commitments under Scenario 4				
Developed countries		*Developing countries*		LDC
Tariff threshold	Cuts	Tariff threshold	Cuts	
0-20%	65%	0-50%	25%	No liberalization
20-40%	75%	50-100%	30%	
40-60%	85%	100-150%	35%	
Above 60%	90%	Above 150%	40%	

Table 15: Reduction Schema

Final Bound Total AMS Bands	Thresholds (US$ billion)	Developed countries cuts
1	0-10	70%
2	10-60	75%
3	>60	80%
Amber Box Bands	Thresholds (US$ billion)	Developed countries cuts
1	0-12	60%
2	12-25	70%
3	>25	83%

more ambitious than the third and the fourth one. Essentially, the motivation behind scenario 2 is to show the implication of a 1-percentage point increase of the sensitive products for developed countries on potential gains by African countries from the liberalization.

4.2.3 - Discussion and main findings

The issue of quantifying the specific effects of the expected agricultural trade reforms on poor countries, such as Africa, remains important to understanding the solutions to the development challenges that this continent faces. This study tries to provide preliminary answers on a different plausible scenarios of implementing DDA on agricultural trade. This study's results show that the overall impact of the reforms is an increase of the international prices of agricultural products and especially the most protected ones, such as cereals and sugar. The increase is much higher when exports subsidies are phased out than in the other reforms. The overall gains for each country depends on its capacity to exploit the new situation by increasing domestic production and exports vis-à-vis the increase in import bills of agricultural and food products. Sectoral value added improvements seem to occur in those countries that succeed in increasing their domestic production to higher levels.

Overall, the simulation results show that ambitious coefficients in agriculture remain the best result for Africa with sensitive products weakening or even overriding those gains. Consequently, any trade-off by the advanced developing countries on market access, which inevitably would reduce ambition, may not be in Africa's interest.

Notwithstanding the results of the four scenarios, the anticipated effects of implementing commitments for more transparency in international trade of agricultural products appear to be relatively low given the low diversification of the African countries and the dominance of few activities in GDP and exports. The countries likely to benefit most from ambitious reforms are those that are more horizontally and vertically diversified within the agricultural sector and related agro-industries. This study confirms results and conclusions from other studies that have shown and suggested that a comprehensive tariff reduction strategy covering agricultural and non-agricultural goods is better than a partial approach.

To perform reduction in domestic support in the alternative scenarios, three major steps were forwarded. The first step consist of computing the new bound domestic support level and then the level of applied support, which is defined as the minimum between the new bound level and the current applied level. This step is justified by the fact that formulas cuts have to be applied on the bound support. The second step consists of taking into account the differences existing between the 2001 domestic support level, which is notified to WTO, and the level of support existing in the GTAP database. In order to address this issue, we simply computed the rate of increase of applied support as notified in the WTO and then we applied the rate of cut to the support level figured in the GTAP database. Finally, the implementation of the cut is done through endogenizing domestic support and exogenizing the new level of support.

4.3. Third application: Economywide analysis of alternative water management policies: a comparative analysis for Morocco and Tunisia

In this application, Chemingui and Thabet (2016) comparted the impacts of alternative water policy management scenarios on the Tunisian and Moroccan economies. A dynamic computable general equilibrium model has been developed for each country and used to explore the likely effects of alternative water policies on a variety of macroeconomic and sectoral variables.

4.3.1. the model

This model is based directly on the prototype developed by the OECD Development Centre (Beghin et al., 1996) which has been applied to many developing countries, including Tunisia (Chemingui and Dessus, 1999; Chemingui and Thabet, 2001). Additional features have been incorporated in the original version for the purpose of this study. For the purpose of water policy analysis, a particular feature of CGE models is that land, water or both are usually included as a factor of production in the specification. In these models, water is entered as a factor of production (like physical capital, labor, or land). The production block follows the typical specification considered in many other types of CGE models which allows for substitution between various factors of production such as labor, capital, land and water. The model focuses more on production than on private demand, given the predominance of agricultural water uses. Typically, government and investment demands are not the major focus of CGE models. However, and given the importance of public investments in water mobilization and distribution (Horridge et al. 2005), public investment spending is assumed to be exogenous to the model once separated from total investment. This assumption is particularly important as it allows performing policy changes in terms of both the structure and the volume of public investment.

Wages, rents and returns on factor supplies are determined endogenously. The interplay of the producing sectors' demands for factors such as water, land and the owner's (household's) supplies of these factors will determine the price so that the market clears. Factor mobility decisions, often referred to as 'closures', are very influential in CGE simulation results. The degree of inter-sectoral mobility of labor and capital, as well as of water, is an important dimension of the models used here. In particular, when the issue involves water trading between urban and rural groups, assumptions regarding labor mobility are important too. A high degree of mobility may mean that workers leave the agricultural area if agricultural water use decreases, while a lack of mobility may mitigate negative rural economic impacts from reduced agricultural activity when the worker remains and is employed in a non-agricultural sector (Sung et al. 1998). Inclusion of non-irrigated agricultural activities may also allow alternative uses of labor, land and capital as water prices rise. Factors are often modeled as perfectly or partially mobile between irrigated and non-irrigated agricultural sectors. In the present model, water is perfectly mobile across agricultural activities. However, in modeling water trade between rural and urban activities, we assume that water is not mobile between the agricultural sectors and the drinking water supply sector. Accordingly, sectors which do not have mobility of water between them will be separate markets with separate equilibrium prices. In other terms, the model assumes two categories of water with different prices that are specific to production activities.

The model determines prices endogenously by equating supply and demand in a Walrasian general equilibrium framework. This process assumes a perfectly competitive market, but it is often the case that observed water prices reflect government policies rather than the workings of a marketplace. In Tunisia and Morocco, water is available to agricultural sectors at a lower level than market price. In a competitive market without any distortions, the shadow price will be equal to the market price, but this is not the typical case for water in both countries. The model developed here already specifies a market for water as a factor of production regardless of whether there is an existing market or not. Yet, two alternative approaches exist. The first consists of deducing the sectoral rents related to water ownership from the gross operating surpluses. Water rights sales prices can be annualized for this purpose. Sometimes the difference in productivity between non-irrigated and irrigated lands is used to proxy water rents. In other cases, a short-term market does exist and average lease price can be used (Goodman 2000, Watson and Davies 2011). The second approach is to model changes in administratively-set prices. The aim is to assess or analyze how changes in water tariffs can bring about a triple dividend of reduced water use, reduced overall tax distortion and increased income for poor households; thus, the price of water is a tariff imposed by the government and the water factor is a non-market commodity. For the purpose of this paper, the second approach has been adopted.

Production is modeled using nested CES functions which describes the substitution and complement relations among the various inputs. Producers are cost-minimizers and constant returns to scale are assumed. Demand for physical capital makes a distinction between "old" and "new" capital. Accelerating investment therefore strengthens the capacity for adjustment of the productive sector to match changes in relative prices.

The model considers a large set of policy instruments, some of which have been mentioned above: production subsidies (by type of activity), consumption subsidies (by product), value added taxes (by activity), other indirect taxes (by activity), tariff barriers (by imported product), direct taxes (by household and taxes on corporate profits). The modeling of these different policy instruments is conventional; it defines each instrument as a tax on the relevant resource. For example, a production subsidy is modeled as a negative tax on production price.

The two models have been constructed and calibrated using information contained in the two SAMs for 2005, assembled specifically for the purpose. These SAMs contain 15 productive sectors and their 15 corresponding commodities[45], 3 types of work (farmers, paid-skilled workers and paid-unskilled workers), 3 types of capital (physical capital, irrigated land, and non-irrigated land), two types of water (drinking water and irrigation water), 2 household categories (urban and rural) and one trade partner (the rest of the world). Production and trade elasticities come from the empirical literature devoted to CGE models. They are not specific to Tunisia or Morocco[46].

4.3.2 - The scenarios

After calibrating the baseline scenarios that represent the business as usual growth paths for both countries, we implemented a number of alternative water management scenarios that might be envisaged by the two countries as part of their ongoing reforms to reduce public deficits and improve resource allocation. The first scenario – reductions in subsidies on irrigation water prices by 50% - is among the options already being considered by both countries in order to progressively remove subsidies on water distribution and accordingly allocate all public spending (subsidies) to water mobilization projects. The second scenario reflects, more or less, the current need of public investments for water mobilization in both countries to satisfy the increasing demand of water both for rural and urban uses, and involves a doubling of public spending on water mobilization. Initially, each of the two reforms is assessed separately in an attempt to evaluate and define their intrinsic impacts on the economies and agriculture sectors of Tunisia and Morocco. A third simulation combines the first two where additional public investment will be partially financed through reduction in subsidies on water distribution. The scenarios are the following:

- Scenario 1 Cutting subsidies on water prices by 50% progressively over the period 2014-2020 (7.14% per year);
- Scenario 2: Doubling public spending on water mobilization progressively over the period 2014-2020 (14.3% per year);
- Scenario 3: Both above scenarios implemented simultaneously.

In all scenarios, one financing variable clears the government budget, while three others remain fixed and are updated depending on the adopted closure rule. Foreign transfers from abroad clear the government budget in the baseline scenario. This rule changes under alternative scenarios where the financing mechanism becomes domestic borrowing (DBO), domestic taxation (DTA) or foreign borrowing (FBO) implying that one of these three becomes the clearing variable of the budget.

[45]The 15 activities and their corresponding commodities considered in the two national SAMs are the following: wheat, barley, other cereals, tomato, other vegetables, citrus, other fruits, livestock, other agricultural products, forestry, fishing, food processing industries, other manufacturing industries, non-manufacturing industries, and services.

[46] see for instance Burniaux et al. (1992) and Gallaway et al. (2000).

4.3.3. Main findings

Increasing water prices are expected to lead to irrigation practices that cause less waste of water resources. However, the adoption of those practices may require significant investments from farmers. The reform of water subsidies can take several forms: It can either be achieved through an outright elimination or a phased elimination of the subsidy. In the case of outright elimination, the substitution of crops with less water intensive crops can be used as a flanking measure - if financial support and technical advice aimed at such substitution are provided by the authorities to farmers simultaneously with subsidy elimination. Alternatively, if a phased elimination is chosen, authorities can direct crop selection towards less water intensive crops by providing financial support and technical advice without eliminating the subsidies immediately, and wait for the impact on water consumption. This would slow down the progress of improving water efficiency as compared to the subsidy elimination scenario, since imposed substitution of crops might not be feasible. Nevertheless, such an approach involves a smaller threat to farmers' income.

However, the total elimination of subsidies can have significant impacts on farmers' income, at least in the short and medium term. The results of the simulations show that in this case, rural welfare will decrease by about 1% by 2020 compared to the baseline scenario for both countries. They also show that the aggregate or net impacts on rural households' welfare depend not only on the level of subsidy reduction but also on other policies and technical practices employed by farmers. In fact, when subsidy reductions were implemented with an increase in public spending on water mobilization and distribution, welfare of rural households rose as a result of combined effects: efficiency and size. Moreover, the overall impact on the economy depends also on the macroeconomic management of the savings to be realized from either the reduction in subsidies or the sources of additional public spending.

Negative impacts can be addressed through two means. The first involves flanking measures that support the elimination of water subsidies, reducing the negative impact this elimination might have on farmers' incomes. The second includes sustainable compensatory measures that make up for farmers' loss in income following the elimination of water subsidies. Measures that address negative economic impacts through production changes (e.g., adoption of new technologies and production processes, introduction of new crops with crop replacement and crop diversification) that improve farmers' competitiveness and, consequently, support farmers' income should be preferred to the ones that primarily address farmers' income. This is because the former tend to be transitory, enabling individuals to recover or improve their initial income without further support in the medium term, while the latter tend to delay the adaptation to the new conditions.

4.4 Summary and concluding remarks

The three applications of CGE models to three Arab countries (Tunisia, Morocco and Syria) and for the various African countries show clearly the scope and utility of developing and using CGE models for policy advocacy on the best options to be followed in the negotiations of trade agreements. Although no in-depth discussion of the simulation results is offered, it is hoped that the strategy adopted to explain and discuss these two applications would give a fair idea what has to be done when CGE models are applied to analyze and assess the economy-wide effects of trade policies.

Appendix 1- The three-country partial equilibrium model: Presentation of the model in EXCEL

MODEL PARAMETERS		ENDOGENOUS VARIABLES				MODEL RELATIONSHIPS	
DESIGNATION	VALUES	DESIGNATION	BASE VALUES	SIMULATED VALUES	VARIATION (%)	DESIGNATION	EQUATIONS
DOMESTIC SUPPLY ELASTICITY (Country A)	0.69	DOMESTIC SUPPLY (Country A)	6.4	6.40	0.00%	DOMESTIC SUPPLY (Country A) (EQSUPA)	6.40
DOMESTIC DEMAND ELASTICITY (Country A)	-0.28	DOMESTIC DEMAND (Country A)	7.8	7.80	0.00%	DOMESTIC DEMAND (Country A) (EQDEMA)	7.80

DOMESTIC SUPPLY ELASTICITY (Country B)	0.81	NET TRADE (Country A)	-1.4	-1.40	0.00%	DOMESTIC SUPPLY (Country B) (EQSUPB)	10.80
DOMESTIC DEMAND ELASTICITY (Country B)	-0.79	DOMESTIC PRICE (Country A)	22.0	22.00	0.00%	DOMESTIC DEMAND (Country B) (EQDEMB)	5.60
DOMESTIC SUPPLY ELASTICITY (Country C)	0.69	DOMESTIC SUPPLY (Country B)	10.8	10.80	0.00%	DOMESTIC SUPPLY (Country C) (EQSUPC)	9.60
DOMESTIC DEMAND ELASTICITY (Country C)	-0.49	DOMESTIC DEMAND (Country B)	5.6	5.60	0.00%	DOMESTIC DEMAND (Country C) (EQDEMC)	13.40
DOMESTIC SUPPLY SLOPE COEFFICIENT (Country A)	0.20	NET TRADE (Country B)	5.2	5.20	0.00%	NET TRADE (Country A) (IDENTA)	-1.40
DOMESTIC DEMAND SLOPE COEFFICIENT (Country A)	-0.10	DOMESTIC PRICE (Country B)	22.0	22.00	0.00%	NET TRADE (Country B) (IDENTB)	5.20
DOMESTIC SUPPLY SLOPE COEFFICIENT (Country B)	0.40	DOMESTIC SUPPLY (Country C)	9.6	9.60	0.00%	NET TRADE (Country C) (IDENTC)	-3.80
DOMESTIC DEMAND SLOPE COEFFICIENT (Country B)	-0.20	DOMESTIC DEMAND (Country C)	13.4	13.40	0.00%	SUPPLY-DEMAND MARKET EQUILIBRIUM (IDENTD)	0.00
DOMESTIC SUPPLY SLOPE COEFFICIENT (Country C)	0.30	NET TRADE (Country C)	-3.8	-3.80	0.00%	PRICE EQUATION (Country A) (PRICEA)	22.00
DOMESTIC DEMAND SLOPE COEFFICIENT (Country C)	-0.30	DOMESTIC PRICE (Country C)	22.0	22.00	0.00%	PRICE EQUATION (Country B) (PRICEB)	22.00
DOMESTIC SUPPLY INTERCEPT (Country A)	2.0	WORLD PRICE	22.0	22.00	0.00%	PRICE EQUATION (Country C) (PRICEC)	22.00
DOMESTIC DEMAND INTERCEPT (Country A)	10.0	**WELFARE ANALYSIS**					
DOMESTIC SUPPLY INTERCEPT (Country B)	2.0	PRODUCER SURPLUS (Country A)	92.4	92.40	0.00%		
DOMESTIC DEMAND INTERCEPT (Country B)	10.0	CONSUMER SURPLUS (Country A)	304.2	304.20	0.00%		
DOMESTIC SUPPLY INTERCEPT (Country C)	3.0	CONSUMER SURPLUS (Country A)	304.2	304.20	0.00%		
DOMESTIC DEMAND INTERCEPT (Country C)	20.0	PRODUCER SURPLUS (Country B)	140.8	140.80	0.00%		
POLICY INSTRUMENTS		CONSUMER SURPLUS (Country B)	78.4	78.40	0.00%		
AD VALOREM TARIFF (Country A)	0.0	PRODUCER SURPLUS (Country C)	138.6	138.60	0.00%		
EXPORT SUBSIDY (Country B)	0.0	CONSUMER SURPLUS (Country C)	299.3	299.27	0.00%		
EXPORT TAX (Country B)	0.0						
PRODUCTION QUOTA (Country B)	0.0						
AD VALOREM TARIFF (Country C)	0.0						
OUTPUT SUBSIDY (Country B)	0.0						

Appendix 2: Theoretical foundations of the Armington model

Given a composite good q_1, the consumption of which is obtained by purchasing either imported quantities q_{1F} or domestically produced quantities q_{1D}. This composite good generates a utility level U_1 for the representative consumer that is given by the following CES functional form[47]:

$$U_1 = \left[b_{1F}q_{1F}^{-\rho_1} + b_{1D}q_{1D}^{-\rho_1}\right]^{-\frac{1}{\rho_1}} \qquad (1)$$

where b_{1D} and b_{1F} are positive, $\rho_1 \geq -1$ and $b_{1D} + b_{1F} = 1$.
The elasticity of substitution σ which is equal to $\frac{1}{\rho_1+1}$ takes values ranging from 0 to +∞. When $\sigma = 0$, the imported and domestically produced quantities q_{1D} and q_{1F} are purchased in fixed proportions, thus implying that the underlying indifference curves of the representative consumer are formed by right angles. On the other hand, when $\sigma \to +\infty$, q_{1D} and q_{1F} are perfect substitutes and the representative consumer does not make any distinction between the imported and domestically produced product. This latter case is tantamount to the homogenous product situation analyzed earlier.

The representative consumer has at his/her disposals a sum of money R_1, to purchase q_{1D} and q_{1F} . To determine how much he/she will purchase q_{1D} and q_{1F}, the representative consumer resolves the following optimization program:

$$Max\ U_1 = \left[b_{1F}q_{1F}^{-\rho_1} + b_{1D}q_{1D}^{-\rho_1}\right]^{-\frac{1}{\rho_1}} \qquad (2a)$$

subject to the following constraint:

$$p_{1F}q_{1F} + p_{1D}q_{1D} = R_1 \qquad (2b)$$

Solving the above constrained optimization program yields the following reduced-form equation:

$$\frac{q_{1D}}{q_{1F}} = \left[\frac{b_{1D}}{b_{1F}}\frac{p_{1F}}{p_{1D}}\right]^{\sigma_1} \qquad (3)$$

Marshallian demand functions for q_{1D} and q_{1F} can be obtained by combining expression (3) and constraint (2b) to obtain[48]:

$$q_{1D} = \frac{b_{1D}^{\sigma_1}p_{1D}^{-\sigma_1}R_1}{b_{1D}^{\sigma_1}p_{1D}^{1-\sigma_1} + b_{1f}^{\sigma_1}p_{1F}^{1-\sigma_1}} \qquad (4a)$$

and

[47] Using the elasticity of substitution σ the CES utility function can be re-written as follows:

$$U_1 = \left[b_{1F}(q_{1F})^{\frac{\sigma_1-1}{\sigma_1}} + b_{1D}(q_{1D})^{\frac{\sigma_1-1}{\sigma_1}}\right]^{\frac{\sigma_1}{\sigma_{1-1}}}$$

[48] The Marhsallian demand functions could also be expressed in terms of budget shares s_{1D} and s_{1F}:

$$s_{1D} = \frac{p_{1D}q_{1D}}{R_1} = \frac{b_{1D}^{\sigma_1}p_{1D}^{1-\sigma_1}}{b_{1D}^{\sigma_1}p_{1D}^{1-\sigma_1} + b_{1f}^{\sigma_1}p_{1F}^{1-\sigma_1}} \text{ and } s_{1F} = \frac{p_{1F}q_{1F}}{R_1}\frac{b_{1F}^{\sigma_1}p_{1F}^{1-\sigma_1}}{b_{1D}^{\sigma_1}p_{1D}^{1-\sigma_1} + b_{1f}^{\sigma_1}p_{1F}^{1-\sigma_1}}$$

It can be seem that the budget shares are only a function of the prices of imported and domestically produced product.

$$q_{1F} = \frac{b_{1F}^{\sigma_1} p_{1F}^{-\sigma_1} R_1}{b_{1D}^{\sigma_1} p_{1D}^{1-\sigma_1} + b_{1f}^{\sigma_1} p_{1F}^{1-\sigma_1}} \qquad (4b)$$

Replacing q_{1D} and q_{1F} by their respective expressions in the utility function (1) leads to the determination of the indirect utility function[49] and then to the expenditure function obtained by inverting the indirect utility function. The expenditure function given by:

$$E_{1=}\left[b_{1F}^{\sigma_1} p_{1F}^{1-\sigma_1} + b_{1D}^{\sigma_1} p_{1F}^{1-\sigma_1}\right]^{\frac{1}{1-\sigma_1}} U_1 \qquad (5)$$

Because of the linear homogeneity of degree one of the utility function U_1 with respect to its arguments q_{1D} and q_{1F} , it is possible to express the expenditure function as follows:

$$E_1 = P_1 \times U_1 \qquad (6)$$

where P_1 is an aggregated price of good 1 obtained by the following expression:

$$P_1 = \left[b_{1D}^{\sigma_1} p_{1D}^{1-\sigma_1} + b_{1F}^{\sigma_1} p_{1F}^{1-\sigma_1}\right]^{\frac{1}{1-\sigma_1}} \qquad (7)$$

P_1 is also called an "**aggregate CES price index**" linking the individual prices p_{1D} et p_{1F} to the price of good 1. Since the sum of money (R_1) allocated to the purchase of products q_{1D} q_{1D} and q_{1F} q_{1F} is fully spent, it implies that:

$$E_1 = R_1 \quad \text{and} \quad U_1 = \frac{E_1}{P_1} = \frac{R_1}{P_1}. \qquad (8)$$

Based on expression (8), Based on expression (8), the level of utility U_1 can be viewed as a **quantity index**[50] measuring the volume level of the quantity demanded for the composite good q_1. This observation is strictly intuitive and is not demonstrated rigorously. We can however state that this aggregate quantity index can be derived and defined because of the linear homogeneity of the utility function U_1 . Thus, we can obtain the following relationships:

$$q_1 = U_1 = \left[b_{1F}(q_{1F})^{\frac{\sigma_1-1}{\sigma_1}} + b_{1D}(q_{1D})^{\frac{\sigma_1-1}{\sigma_1}}\right]^{\frac{\sigma_1}{\sigma_1-1}} \qquad (9)$$

A closer examination of the various terms making up expressions (4a) and (4b) clearly shows a further simplification of the Marshallian demand functions which can be expressed as a function of the price P_1 and the volume of the composite good q_1. This, after some manipulations and rearrangement of the various terms results in the following demand functions for the imported and domestically-produced products[51]:

[49] After some manipulation and rearrangement of its various terms, the indirect utility function is given by

$$U_1 = \frac{R_1}{\left[b_{1F}^{\sigma_1} p_{1F}^{1-\sigma_1} + b_{1D}^{\sigma_1} p_{1F}^{1-\sigma_1}\right]^{\frac{1}{1-\sigma_1}}}$$

[50] As U_1 and q_1 are identical, it also means that the utility index U_1 is measurable. When utility is measurable, we can then say that we develop a cardinal measure of utility.

[51] Expression (4a) is modified in the following way:

$$\frac{q_{1D}}{q_1} = b_{1D}^{\sigma_1}\left[\frac{p_{1D}}{P_1}\right]^{-\sigma_1} \tag{10a}$$

and

$$\frac{q_{1F}}{q_1} = b_{1F}^{\sigma_1}\left[\frac{p_{1F}}{P_1}\right]^{-\sigma_1} \tag{10b}$$

Expressions (10a) and (10b) are the basic Armington functions explaining the ratios of demand for imported and domestically-produced products over the demand for composite good is a function of relative prices. These two expressions could also be expressed in terms of budget shares.

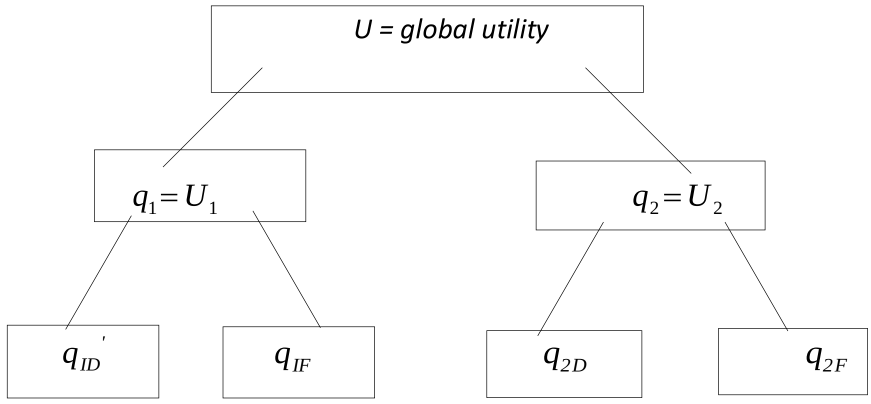
In computable general equilibrium model (CGEM) the Armington model specification is developed using a separable consumer preference structure characterized by a two (or several) stage decision process. Such a structure in the case of two consumer goods can be represented Figure 1. When we examine this figure more carefully, we note that the representative consumer first maximizes his (her) a global utility function, the arguments of which are the consumed and composite (aggregated) quantities of goods q_1 and q_2 To purchase these composite (aggregated) goods, the consumer has at his (her) disposals an income level R . It also means that this optimization program corresponds to the upper stage of the separable structure of the consumer's preferences. The composite (aggregated) quantities q_1 and q_2 that the representative consumer purchases depend upon the levels of aggregated prices p_1 and p_2 , and the income level R . In a second stage, the representative consumer can "satisfy" the levels of composite goods 1 and *2* by using two sources of supplies that differ among each other according to their geographical origin (Armington specification).

$$q_{1D} = \frac{b_{1D}^{\sigma_1}\ p_{1D}^{-\sigma_1}\ R_1}{b_{1D}^{\sigma_1}\ p_{1D}^{1-\sigma_1} + b_{1f}^{\sigma_1}\ p_{1F}^{1-\sigma_1}} = \frac{P_1\, b_{1D}^{\sigma_1}\, p_{1D}^{-\sigma_1} U_1}{\left[b_{1D}^{\sigma_1}\ p_{1D}^{1-\sigma_1} + b_{1f}^{\sigma_1}\ p_{1F}^{1-\sigma_1}\right]} = \frac{\left[b_{1D}^{\sigma_1}\, p_{1D}^{1-\sigma_1} + b_{1f}^{\sigma_1}\ p_{1F}^{1-\sigma_1}\right]^{\frac{1}{1-\sigma_1}} b_{1D}^{\sigma_1}\ p_{1D}^{-\sigma_1}\ U_1}{\left[b_{1D}^{\sigma_1}\, p_{1D}^{1-\sigma_1} + b_{1f}^{\sigma_1}\ p_{1F}^{1-\sigma_1}\right]}$$

$$q_{1D} = \left[b_{1D}^{\sigma_1}\, p_{1D}^{1-\sigma_1} + b_{1f}^{\sigma_1}\ p_{1F}^{1-\sigma_1}\right]^{\frac{\sigma_1}{1-\sigma_1}} b_{1D}^{\sigma_1} p_{1D}^{-\sigma_1}\ U_1 = [P_1]^{\sigma_1}\, b_{1D}^{\sigma_1}\ p_{1D}^{-\sigma_1}\ U_1 = b_{1D}^{\sigma_1}\left[\frac{p_{1D}}{P_1}\right]^{-\sigma_1} q_1$$

A similar procedure can be applied for the demand for imported product q_{1F}.

Figure A2.1 : A two-stage consumer preference structure associated to the Armington model.



Appendix 3: Presentation and layout of the 4×4 GSSIM model

Table A3.1: Presentation and layout of GSSIM in EXCEL

INPUTS

trade at world prices:

h	Origin	destination				Totals
		USA	JAPAN	EU	ROW	
	USA	0	50	200	300	550
	JAPAN	500	0	150	200	850
	EU	300	100	200	200	800
	ROW	50	100	110	20	280
	Totals	850	250	660	720	

initial import tariffs

origin	destination			
	USA	JAPAN	EU	ROW
USA	1	1.21	1.41	1.22
JAPAN	1.37	1	1.31	1.23
EU	1.32	1.36	1	1.18
ROW	1.57	1.41	1.25	1.15

final import tariffs

origin	destination			
	USA	JAPAN	EU	ROW
USA	1	1.21	1.41	1.22
JAPAN	1.37	1	1.31	1.23
EU	1.32	1.36	1	1.18
ROW	1.57	1.41	1.25	1.15

Elasticities:

		USA	JAPAN	EU	ROW
Em	Import Demand	-1.25	-1.25	-1.25	-1.25
Ex	Export Supply	1.5	1.5	1.5	1.5
Es	Substitution	5	5	5	5

Table A3.2: Calibration and solutions of the GSIM model

Calibrated values

θ Import shares at internal prices

		destination			
		USA	JAPAN	EU	ROW
origin	USA	0.00000	0.17926	0.34559	0.42021
	JAPAN	0.59077	0.00000	0.24081	0.28243
	EU	0.34153	0.40296	0.24510	0.27095
	ROW	0.06770	0.41778	0.16850	0.02641
	SUM	1	1	1	1

ϕ Export shares at world prices

		destination				
		USA	JAPAN	EU	ROW	SUM
origin	USA	0.0000	0.0909	0.3636	0.5455	1
	JAPAN	0.5882	0.0000	0.1765	0.2353	1
	EU	0.3750	0.1250	0.2500	0.2500	1
	ROW	0.1786	0.3571	0.3929	0.0714	1

N(i,v),(r,r) Own price elasticities

		destination			
		USA	JAPAN	EU	ROW
Origin	USA	-5.0000	-4.3278	-3.7040	-3.4242
	JAPAN	-2.7846	-5.0000	-4.0970	-3.9409
	EU	-3.7193	-3.4889	-4.0809	-3.9839
	ROW	-4.7461	-3.4333	-4.3681	-4.9010

N(i,v),(r,s) Cross price elasticities

		destination			
		USA	JAPAN	EU	ROW
origin	USA	0.0000	0.6722	1.2960	1.5758
	JAPAN	2.2154	0.0000	0.9030	1.0591
	EU	1.2807	1.5111	0.9191	1.0161
	ROW	0.2539	1.5667	0.6319	0.0990

MODEL SOLUTIONS

MARKET CLEARING CONDITIONS

Relative price changes

		benchmark prices	new prices	change in supply	change in demand	Excess Demand
origin	USA	0.0000	0.0000	0.0000	0.0000	0.0000
	JAPAN	0.0000	0.0000	0.0000	0.0000	0.0000
	EU	0.0000	0.0000	0.0000	0.0000	0.0000
	ROW	0.0000	0.0000	0.0000	0.0000	0.0000

Table A3.3: GSIM model results

OTHER RESULTS

trade values and quantities

trade quantities: percent change

		destination			
		USA	JAPAN	EU	ROW
origin	USA	0.0	0.0	0.0	0.0
	JAPAN	0.0	0.0	0.0	0.0
	EU	0.0	0.0	0.0	0.0
	ROW	0.0	0.0	0.0	0.0

Trade at world prices: new values

		destination			
		USA	JAPAN	EU	ROW
origin	USA	0.0	50.0	200.0	300.0
	JAPAN	500.0	0.0	150.0	200.0
	EU	300.0	100.0	200.0	200.0
	ROW	50.0	100.0	110.0	20.0

Trade at world prices: change in values

		destination			
		USA	JAPAN	EU	ROW
origin	USA	0.0	0.0	0.0	0.0
	JAPAN	0.0	0.0	0.0	0.0
	EU	0.0	0.0	0.0	0.0
	ROW	0.0	0.0	0.0	0.0

Proportional change in internal prices

		destination			
		USA	JAPAN	EU	ROW
origin	USA	0.0000	0.0000	0.0000	0.0000
	JAPAN	0.0000	0.0000	0.0000	0.0000
	EU	0.0000	0.0000	0.0000	0.0000
	ROW	0.0000	0.0000	0.0000	0.0000
	Composite price	0.0000	0.0000	0.0000	0.0000

Tariff revenue and consumer surplus

		destination			
		USA	JAPAN	EU	ROW
	Tariff revenue	0.0	0.0	0.0	0.0
	Consumer surplus	0.0	0.0	0.0	0.0

Total welfare effects

		A	B	C	D=A+B+C
		Producer surplus	Consumer surplus	Tariff revenue	Net welfare effect
Country	USA	0.0	0.0	0.0	0.0
	JAPAN	0.0	0.0	0.0	0.0
	EU	0.0	0.0	0.0	0.0
	ROW	0.0	0.0	0.0	0.0

References:

Anderson J. E. and E. van Wincoop. E. (2003). Gravity with gravitas: A solution ot the border puzzle. *The American Economic Review*. Vol. 69(1): 101-116.

Armington P. S. (!969a) A theory of demand for products distinguished by place of production. *IMF Staff Papers*. Vol XVI(2): 160-179.

Armington P. S. (!969b) The geographic pattern of trade and the effects of price changes. *IMF Staff Papers*. Vol XVI (2): 179-201.

Bachetta m., C. Beverelli, O. Cadot, M. Fugazza, J.-M. Grether, M. Helbe, A. Nicita and R. Piermartini (2012). *A Practical Guide to Trade Policy Analysis*. World Trade Organization (WTO) and United Nations Conference on Trade and Development (UNCTAD). Geneva. 272 pages.

Bchir M. H, Y. Decreux, J.L Guérin and S. Jean. "MIRAGE, A Computable General Equilibrium Model for Trade Policy Analysis". CEPII Working paper N° 2002-17.

Ben Hammouda H., M. H. Bchir, M. Mimouni and X. Pichot (2007). How North Africa could benefit from the Euromediterranean Parthership: The Necessity to balance the Barcelona Process, African Trade Policy Centre, Discussion Paper No 59. Economic Commisison for Africa. Addis Abeba. 39 pages.

Brooke, T., D. Kendrick and A. Meeraus (1988). *GAMS: A User's Guide*, The Scientific Press, Redwood City, California.

Brown D. K (1987). Tariffs, terms of trade and national product differentiation. *Journal of Policy Modeling*. Vol 9(3):509-526.

Chemingui M.A., H. Lofgren and S. Robinson, (2004).A detailed specification of the Standard Static Computable General Equilibrium Model for Kuwait. Technical Report N°3, Kuwait Institute for Scientific Research.

Chemingui M.A., M. H. Bchir, H. Ben Hammouda and S. N. Karingi (2006). Multilateral agricultural liberaliation: What in it for Africa? Workling paper No. 38. African Trade Policy Centre. Economic Commission for Africa. Addis Abea. 50 pages.

Chemingui M.A. and S. Dessus (2008). Assessing non-tariff barriers in Syria. *Journal of Policy Modeling*. Vol 30: 917-928.

Devarajan S. D., D. Go and H. Li (1999). Quantifying the fiscal effects of trade reform: A general equilibrium model estimated for 60 countries, mimeo, the World Bank. Washington.

Disdier A. and K. Head (2008). The puzzling persistence of the distance effect on bilateral trade. The Review of Economics and Statistics, Vol. 90(1): 37-48.

Elbehri, A. and Hertel, T.W. (2003): Economic Integration and Market Structure: Analysis of the EU-Morocco FTA vs. Multilateral Liberalization. *Global Trade Analysis Project (GTAP) Working Paper n° 30,* Purdue University, West Lafayette, USA

Feenstra R. C., J. R. Markusen and A. K. Rose (2001). Using the gravity equation to differentiate among alternative theories of trade. *Canadian Journal of Economics*. Vol. 34(2): 430-437.

Fofana I., A. Lemelin and J. Cockburn (2005). Alancing a social accounting matrix: Theory and application. Centre Universitaire sur le Risque, les Politiques Ëconomiques et l'Emploi (CIRPEE). Université Laval, Québec, Canada. 14 pages.

Francois J. F. and K. A. Reinert (1997). *Applied Methods for Trade Policy Analysis. A Handbook*. Cambridge University Press. Cambridge, United Kingdom

Gopinath G., E. Helpmann and K. Rogoff (2014) *Handbook of International Economics*, Volume 4. Elsevier North Holland, Amsterdam.
Harrison, G. W., Rutherford, T. F. and Tarr, D. G., 1997. Quantifying the Uruguay Round. *The Economic Journal* 107 (444), 1405-1430.

Head K. and T. Mayer (2014). Gravity equations: Workhorse, toolkit and cookbook. In Gopinath hG., E. Helpman and K. Rogoff (Eds). Handbook of International Economics. Volume 4. Chapter 3 (pp. 131-196). Amsterdsam: North Holland-Elsevier.

Horridge Mark and J.B. de Souza F. Filho (2003). Linking GTAP to national models: Some highlights and a practical approach. GTAP resource paper # 1262. Available at https://www.gtap.agecon.purdue.edu/resources/res_display.asp?RecordID=1262

Houck, J. (1986). *Elements of Agricultural Trade Policies*. New York, MacMillan Publishing Company.

Koo Won. W. and P. Lynn Kennedy (2005). *International Trade and Agriculture*. Oxford: Blackwell Publishing.

Koutsoyannis, A. (1978) *Modern Microeconomics*. London: MacMillan Press LTD.

Larch M. and Y. V. Yotov (2016). General equilibrium trade policy analysis with structural gravity. Economic Research and Statistics Division. WTO. Geneva. 84 pages

McDonald, S., Thierfelder, K. and Walmsley, T., (2013). 'Globe v2: A SAM Based Global CGE Model using GTAP Data'.

Oskan, A J. and G. Meester (2006). How useful is the PSE in determining agricultural support ? *Food Policy*, Vol 31:123-141.

Organisation for Economic Cooperation and Development (OECD) (2015a). Produicer and consumer support price estimates. OECD database. 1986-2002. OECD. Paris.

Organisation for Economic Cooperation and Development (OECD) (2015a). Aglink-Cosimo model documentation. A partial equilibrium model of world agricultural markets. OECD, Paris. 41 pages.

Organisation for Economic Cooperation and Development (OECD) (2015b). OECD-FAO agricultural outlook 2015-2024. OECD, Paris. 140 pages.

Organisation for Economic Cooperation and Development (OECD) (2015c). METRO version I model: Documentation. Working paper. Trade and Agricultural Directorate Trade Committee. Working party of the Trade Committee. TAD/TC/WP(2014)24/FINAl. 70 pages. Paris. France

Peters R. and D. Vanzetti (2004). *User manual and Handbook on the Agricultural Trade policy Simulation Model (ATPSM)*. Policy Issues in International Trade and Commodities Study Series No 24. United Nations Conference on Trade and Development (UNCTAD). Geneva. 53 pages.

Piermartini R. and R. Teh (2005) Demystifying modelling methods for trade policy. WTO discussion papers. No 10. World Trade Organization. Geneva

Pyatt, G and J. Round (1989). Accounting and fixed price multipliers in a social accounting fraemework. *Economic Journal*, Vol 89: 850-873.

Robinson S., D. Mason-d'Croz, S. Islam,. T. B. Sulser, R. Robserston, T. Zhu, A. Gueneau, G. Pitois and M. Rosegrant (2015). The International Model for Policy Analysis of Agricultural Commodities and Trade (IMPACT). Model description for Version 3. IFPRI Discussion Paper 01483. International Food Policy Research Institute (IFPRI), Washington. DC. 116 pages.

Sadoulet E. and De Janvry A. (1995). *Quantitative Development Policy Analysis*. The John Hopkins University Press.

Stone R. (1986). Nobel Memorial Lecture 1984: The accounts of Society. *Journal of Applied Econometrics*. Vol 1(1): 5-28.

Surry, Y., N. Herrard and Y. Le Roux (2002). Modelling trade in processed food products: An econometric investigation with French data. *European Review of Agricultural Economics*, Vol. 29(1):.1-27.

Tinbergen J. (1962). Shaping the world economy: Suggestions for an international economic policy. Twentioeth Century Fund. New York.

Van Tongeren F, H. van Meijl and Y. Surry (2001). Global models applied to agricultural and trade policies: a review and assessment. *Agricultural Economics*, Vol 26(2), pp. 149-172.

Walsh K., M. Brockmeier and A. Matthews (2007). Implications of domestic support disciplines for further agricultural trade liberalization. *Journal of International Agricultural Trade and Development*. Vol 3(2): 173-199.

Zhang, X. G. (2006): Armington elasticities and terms of trade effect sin global CGE models. Staff working paper. Porductivity Commission. Australian Government. Camberra. 41 pages.