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Send correspondence to:
Chahir Zaki
Faculty of Economics and Political Sciences, Economics Department, Cairo University
chahir_zaki@yahoo.com

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Abstract

This paper provides an attempt to model trade facilitation in a multi-regional and multi-sectoral computable general equilibrium (CGE) model, MIRAGE. Following Decreux and Fontagné (2009) in modeling trade facilitation, administrative barriers are assumed to be the tip of the iceberg in terms of cost. I extend their model using more accurate ad-valorem equivalents (AVEs) of red tape costs, computed from a gravity model, and introduced in the CGE model. The novelty of those AVEs is that they take into account the effect of bureaucracy, internet coverage, corruption and geographical barriers on the time to trade. The results show that, on the regional level, developing countries in Africa and Asia, especially Sub-Saharan countries, the Middle East and North Africa gain much more from trade facilitation than developed ones. They benefit from significant export diversification thanks to such a process. On the sectoral level, vegetables, textiles and electronics witness a more important expansion than other products since they are more time-sensitive. Finally, effects of trade facilitation in the long-run are much higher than in the short run.

ملخص

تقدم هذه الورقة محاولة لتسهيل التجارة من خلال نموذج توازن متعدد الإقليمية ومتعددة القطاعات العامة MIRAGE (CGE) ، . وباتباع Decreux Fontagné (2009) في مجال تيسير التجارة والنمذجة ، يفترض أن تكون الحواجز الإدارية قمة الجبل الجليدي من حيث التكلفة .أقدم نموذجهم باستخدام معايير حسب القيمة أدق من تكاليف الروتين، محسوبة من خلال نموذج الجاذبية ، والتي أدخلت على نموذج (CGE) . حداثة تلك المعايير حسب القيمة هو أنها تأخذ بعين الاعتبار تأثير كل من البيروقراطية ، والفساد، وتغطية الإنترنت والحواجز الجغرافية في وقت التجارة .وأظهرت النتائج أن المكاسب أكثر بكثير من الحصول على تسهيل التجارة من البلدان المتقدمة ، خاصةعلى المستوى الإقليمي، والبلدان النامية في أفريقيا وآسيا، ولا سيما بلدان أفريقيا جنوب الصحراء والشرق الأوسط وشمال أفريقيا .تأتى استفادتهم بفضل تنويع الصادرات لهذه العملية .وعلى المستوى القطاعي، والخضار والمنسوجات والالكترونيات تشهد توسعا أكثر أهمية من غيرها من المنتجات نظرا لحساسيتها الاكثر تجاه الوقت .أخيرا، وتكون آثار تيسير التجارة في المدى الطويل أعلى بكثير مما كانت عليه في المدى القصير.

1. Introduction

The World Trade Organization (WTO) negotiations aim to boost international trade through trade liberalization. Recently, a new aspect concerning "*trade facilitation*" has been added to these negotiations. The intuition behind this addition is simple: once formal trade barriers (both tariff and non-tariff) have been reduced, other issues, including administrative barriers, become the most serious impediments to trade (Njinkeu et al., 2007). Trade facilitation is defined as a process encompassing many aspects that can be summarized in five main points: (i) simplification of trade procedures and documentation; (ii) harmonization of trade practices and rules; (iii) more transparent information and procedures for international flows; (iv) the recourse to new technologies promoting international trade; and (iv) more secured means of payment for international commerce (more reliable and quicker). Many efforts have been deployed in order to liberalize trade but less attention has been given to impediments. Hoekman and Konan (1999) define deep trade integration as the explicit government actions aiming to reduce the market segmenting effect of domestic regulatory policies (health and safety regulation, competition laws, licensing and certification regimes, and administrative procedures such as customs clearance) through coordination and cooperation. This definition shows to what extent trade facilitation encompasses various aspects and deals with a wide range of issues.

From a trade policy point of view, trade facilitation is important for two reasons. First, after reducing tariff and non-tariff barriers, administrative barriers and red tape costs still impeded trade (OECD, 2002). Moreover, with the increased commercial regimes' complexity (often referred to as a "Spaghetti Bowl") and the increased interdependency of supply chains, the delays of imported inputs delivery have turned into a severe constraint on production. Second, the expenditure caused by red tape is very high accounting for 2 to 15% of the value of the traded goods (OECD, 2002). A number of previous papers have provided evidence about the importance of non-visible barriers. For instance, Cernat (2001) supports the idea that the solution to the African trade enigma lies in trade facilitation. Third, the welfare arising from the elimination of these barriers is greater when the restrictions that are being eased deal with the waste of real resources rather than those that generate rents that are captured by interest groups (quota rents) or governments (tariff revenues). Hence, adminstrative barriers constitute red tape and are largely resource wasting and redundant. Further since they do not induce any losses in terms of either rents and/or revenues, underlying benefits to elminating these barriers would be greater than if these measures had been creating rents. This is why their removal is likely to have a higher impact on trade than the reduction of classical barriers (Denis, 2006).

At the empirical level, the literature on the assessment of trade facilitation in multinational models is not very abundant. While Ferrantino (2006) simulated the effect of non-tariff barriers on welfare, most of the other work on trade facilitation relied on the GTAP model[1]. Hertel et al. (2001) modified the model in their analysis of the Japan-Singapore free trade agreement by introducing time costs as a technical shift in the Armington import demand function. Similarly, by introducing an import-augmenting technical change, Fox et al. (2003) simulated the removal of an iceberg tariff on welfare by applying a positive shock to the technical efficiency of the trade flow. APEC (1999) modeled trade facilitation, through an increase in the productivity of the international transportation sector to capture the downward shift in the supply line of imports resulting from the implementation of cost-reducing measures. Their main result shows that both trade liberalization and facilitation increase real GDP by 0.16% and 0.25% respectively for APEC countries and by 0.1% and 0.15% for the rest of the world. Francois et al. (2003 and 2005) showed that trade facilitation generates one

[1]Global Trade Analysis Project.

third of the gains taking into account that such barriers are a "pure deadweight loss", especially for Asia-Pacific developing countries. Finally, Decreux and Fontagné (2009) introduced an iceberg cost in the MIRAGE model and estimated that trade facilitation would add an annual US$99 billion to world GDP in the long run.

Following Decreux and Fontagné (2009) in modeling trade facilitation, administrative barriers are assumed to be an iceberg cost. I extend their model using more accurate ad-valorem equivalents (AVEs) of red tape costs. Therefore, this paper contributes to the empirical literature on trade facilitation in two ways. First, it captures the complexity of the trade facilitation by using AVEs of administrative barriers estimated from a gravity model (Zaki, 2009). It is worthwhile to mention that AVEs of the time to export and import take into account many aspects of trade facilitation: bureaucracy, corruption, the internet coverage as a proxy for customs computerization and the geographical impediments that may increase time to trade. Therefore they are more accurate and more exhaustive than other AVEs of time to trade (Hummels, 2001 and Minor and Tsigas, 2008). These AVEs were already used by Zaki (2010) to assess the impact of trade facilitation on the Egyptian economy. Despite the inclusion of many indicators in our AVEs, other aspects are not taken into account, especially the harmonization of trade and customs standards. This feature is very important because it increases the time as well as the cost of transactions. In the case where the government does not trust foreign certification systems or considers foreign standards to be unacceptable, products will be subject to testing and certification at point of entry, imposing additional costs on imports. Thanks to such harmonization, negotiation of mutual recognition agreements (MRA) may be a mechanism through which transactions costs can be further reduced. Despite its importance, such an aspect is difficult to measure and to introduce in a CGE model but it is still on my future research agenda. Second, adopting the methodology of Decreux and Fontagné (2009), this paper explicitly introduces trade facilitation in the multi-regional and multi-sectoral CGE model, MIRAGE. The latter is very adequate to study the impact of trade facilitation for two reasons. Being a multi-regional model, it should determine who are the largest winners from facilitating trade, especially that the spectrum of administrative barriers is different between developed and emerging economies. In addition, being a multi-sectoral model, MIRAGE allows taking into account the specificities of various sectors and their response to more facilitated trade.

I perform two main simulations. First, a partial removal of the administrative barriers is simulated by reducing trade costs by 50% for all countries. Second, in order to compare the effects of trade facilitation with those of trade liberalization, a similar shock is done for tariffs.

This exercise confirms that, on the regional level, developing countries in Africa and Asia, especially Sub-Saharan Africa, the Middle East and North Africa gain much more than developed ones. They witness important export diversification thanks to such a process. On the sectoral level, food, textiles and electronics benefit more than other products.

The remainder of the paper is organized as follows. Section 2 is devoted to a brief overview of trade facilitation. Section 3 displays the theoretical framework of MIRAGE. Section 4 presents the data. Section 5 discusses the results. Section 6 concludes.

2. Trade Facilitation Overview

There are two main features related to trade facilitation. First, they are complex as they include various aspects: infrastructure, logistics, time.etc. Second, they are quite different for developed than for developing economies. Table 1 shows that high-income countries perform better than low-income ones in the "Logistics Performance Index", which is 3.7 for the former and 2.3 for the latter. A careful analysis shows that developed countries have better

infrastructure, logistics and timeliness (3.5, 3.5, 4 respectively) than developing ones (2, 2.5, 2.7 respectively).

The huge divergence in terms of trade facilitation among different sectors and countries is confirmed by the estimated AVEs. Figures 1 and 2 display the average AVE of administrative barriers to trade for the best and the worst ten countries. The first group mainly includes developed countries (USA and many European countries), whereas the second one includes African and Asian developing countries, pointing out to the fact that they should benefit the most from the elimination of such barriers.

A deeper look on the sectoral characteristics of the AVEs suggests that the least time-sensitive products appear on the lower bound of the AVEs values. Regarding the time to export, the lowest values of the AVEs (almost 0%) are those associated with tobacco, footwear and wood products for Japan, USA and Canada. Chad, Kazakhstan, Kirghizistan and Rwanda have the highest AVEs for chemicals, transports and electrical machines that are quite time-sensitive with an average AVE equivalent to 112%. As to time to import, figures are higher than those of time to export since Chad and Rwanda have an AVE equal to 200% for textiles, garments and non-ferrous metals.

Bearing in mind the importance and the complexity of the trade facilitation process, it is worthwhile to assess its effects on the world economy to determine which countries gain the most from it.

3. Model

3.1 Structure and Assumptions

MIRAGE is a multi-region and multi-sector CGE model with some major characteristics[2]. It incorporates imperfect competition and product differentiation by variety and by quality, in a sequential dynamic framework allowing us to take into account the adjustment period following the removal of administrative barriers to trade. Imperfect competition is introduced in an oligopolistic framework *à la Cournot*. As to product differentiation, both different varieties and qualities are taken into account. The former are implemented through a modeling of a horizontal product differentiation. The vertical differentiation is captured through two ranges of qualities: goods produced in a developing country are assumed to belong to a different quality range than those produced in a developed one. Such differentiation is modeled through a nested Armington - Dixit - Stiglitz utility function in many tiers as will be shown below.

Regarding the supply side, in the first level, production in each sector is represented through a Leontief function between intermediate consumption and value added. In the second level, intermediate goods are complementary through a Constant Elasticity of Substitution (CES) function. Value-added function is also modeled through a CES function among unskilled labor, land, natural resources and a composite bundle of capital and skilled labor. In the third level, a CES function between capital and skilled labor is modeled (Figure 3).

Figure 4 displays the demand structure. A representative agent maximizes his utility function through many tiers. The first tier assumes a fixed share of the regional income that is allocated to savings, while the rest is used to purchase final consumption goods. The second one is associated with a Linear Expenditure - Constant Elasticity of Substitution (LES-CES) function. The third tier distinguishes two different quality regions where imports coming from developing countries are considered less substitutable with those coming from developed ones, than with those coming from the same region with an elasticity of

[2] For further details regarding the model structure and assumptions, see Bchir et al. (2002) and Decreux and Valin (2007).

substitution σ_{GEO}. Thus, this tier captures the vertical differentiation which is gaining more importance in international trade theory (Fontagné and Freudenberg, 1997). In the fourth level, local and foreign goods are differentiated through the Armington assumption (Armington, 1969). Imported goods originating from the same region or the other region are modeled through a CES with an elasticity of substitution σ_{IMP}. Finally, the last level of this nested demand models the horizontal differentiation where goods are imperfect substitutes through a CES and an elasticity of substitution σ_{VAR}[3]. Countries are related to each others through investment flows and external trade.

The dynamics of the model is driven by total factor productivity assumptions, accumulation of capital under a putty-clay framework and by projections of population taken from the United Nations statistics. The model's dynamics is exclusively of a sequential nature: the equilibrium can be solved successively for each period. Time span is chosen to be 15 years (betweem 2004 and 2020).

The closure of the model is based on the following assumptions. First, the share of current account in GDP is considered as exogenous. Therefore, the real effective exchange rate adjusts in order to harmonize the change in exports, imports and FDI. Second, natural resources are fixed, savings rates are fixed and the GDP deflator is the *numéraire*[4]. Production factors are assumed to be fully employed and internationally immobile. Natural resources are considered to be perfectly immobile while land is imperfectly mobile through a Constant Elasticity of Transformation (CET). Both types of labor are perfectly mobile across different sectors.

3.2 Incorporating Trade Facilitation

To take into account trade facilitation in a multinational CGE model, I adopt the methodology developed by Decreux and Fontagné (2009). They model the cost associated with administrative barriers as an iceberg cost (Samuelson, 1954) since it is one of the most tractable ways of modeling transport costs and it does not have an impact on other markets[5]. For the sake of simplicity, I present here the equations related to trade facilitation. Appendix 4 presents the mathematical statement of the model.

The AVEs are introduced in the prices and the transport sector equations. The free on board (FOB) price $PFOB_{i,r,s,t}$ depends upon the iceberg cost $tcost_{i,r,s,t}$, the producer price $PY_{i,r,s,t}$, the perceived elasticity of demand $EP_{i,r,s,t}$ and some taxes (production tax rate $txp_{i,r,s,t}$, export tax rate $texp_{i,r,s,t}$ and the export tax equivalent to Multi-Fibre Agreement quotas $txamf_{i,r,s,t}$).

$$PFOB_{i,r,s,t} = (1+tcost_{i,r,s,t})(\frac{PY_{i,r,s,t}}{1+EP_{i,r,s,t}})(1+txp_{i,r,s,t})(1+texp_{i,r,s,t}+txamf_{i,r,s,t}) \qquad (1)$$

The cost insurance and freight (CIF) price $PCIF_{i,r,s,t}$ is modeled in the following way:

$$PCIF_{i,r,s,t} = PFOB_{i,r,s,t} + (1+tcost_{i,r,s,t})\mu_{i,r,s}PTr_{i,r,s,t} \qquad (2)$$

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[3] As mentioned in Decreux and Valin (2007), substitution elasticities are linked through the following relations: $\sigma_{ARM}-1=\sqrt{2}(\sigma_{GEO}-1)$, $\sigma_{IMP}-1=\sqrt{2}(\sigma_{ARM}-1)$ and $\sigma_{VAR}-1=\sqrt{2}(\sigma_{IMP}-1)$.

[4] For further details on the model's notation and equations, see Appendix 4

[5] In MIRAGE, different agents are not modeled explicitly but they are introduced through a representative agent that includes households, government and firms. Hence, modeling trade facilitation in the same way it was done in Zaki (2010) requires a quite important modification of the model as well as a host of additional data in order to take into account corruption. This is why I stick to Decreux and Fontagné (2009)'s model.

where $\mu_{i,r,s,t}$ is the demand of transport per unit of traded volume and $PTr_{i,r,s,t}$ is the price of transport.

The demand for transport $Tr_{i,r,s,t}$ takes into account the iceberg cost added to the trade flow $Trade_{i,r,s,t}$:

$$Tr_{i,r,s,t} = \mu_{i,r,s}(1+tcost_{i,r,s,t})Trade_{i,r,s,t} \quad (3)$$

This means that the $tcost_{i,r,s,t}$ parameter is introduced as a deadweight loss, because the demand for transport services increases by a percentage equal to the trade facilitation barriers AVEs, while the volume of transport services actually received is equal to $\mu_{i,r,s}\, Trade_{i,r,s,t}$. It is worthwhile to note that this specification rests upon the following implicit assumption : resources dilapidated because of the trade facilitation barriers are consumed according to the transport sector technologies; and the specific input consumption structure depends on the regions where the associated transport services are produced. Furthermore, the regions from which the dilapidated resources are taken are those where the associated transport services are produced. In fact, this amounts to reducing the productivities of the transport sectors in all regions. Although there may be other ways to model the trade facilitation barriers, I opt for this way for the sake of its simplicity. In addition, introducing explicitly the AVEs in the model captures in a more direct way the effect of trade facilitation on the world economy. Those AVEs are computed by taking the average of the AVE of time to export and to import that have been estimated at both sectoral and countries level in Zaki (2009) as it will be shown later.

4. Data

4.1. CGE Data

This study employs the GTAP 7 (Badri and Walmsley, 2008) database that has a 2004 reference year and includes 57 sectors and 113 regions. This dataset has several sources. Macroeconomic data come from the World Bank and international trade come from COMTRADE. Tariffs are originating from MacMAP's[6] constructed by the CEPII based on raw data from the International Trade Center (UNCTAD-WTO, Geneva). The business as usual (BAU) scenario is run to take into account the changes that took place in the world economy between 2004 and 2008. Afterwards, the World Bank and the International Monetary Fund projections have been used to simulate the evolution of the economy without any chock in order to generate the reference scenario.

GTAP dataset has been aggregated to the MIRAGE level of regions and sectors where 19 regions and 21 sectors are taken into account. Regional and sectoral aggregation are shown in Tables 2 and 3.

A couple of remarks are worth noting.. First, Egypt has been intentionally selected in order to compare the benefits from trade facilitation using MIRAGE with respect to what I obtained when using a mono-country model (Zaki, 2010). Second, such an aggregation allows to take into account developing regions which have a poor performance in trade facilitation so that their benefits can be assessed.

4.2. Estimating Tariff Equivalents for Administrative Barriers

In order to better evaluate the impact of trade facilitation, tariff equivalent for administrative barriers to trade should be calculated. To do so, I follow the methodology adopted by Kee, Nicita and Olarreaga (2009) where ad-valorem tariff equivalent for non-tariff barriers are

[6]Market Access Map (MAcMap) is a database developed jointly by ITC (UNCTAD-WTO, Geneva) and CEPII (Paris). It provides a disaggregated, exhaustive and bilateral measurement of applied tariff duties. It also takes regional agreements and trade preferences exhaustively into account.

estimated based on a gravity model. Similarly, I rely on a gravity model (Zaki, 2009) that determines the impact of trade facilitation on bilateral trade in two steps. First, the time to export and to import are regressed on their determinants which are the number of documents to export and to import ($Doc_{exp,j}$ *and* $Doc_{imp,i}$), the internet coverage ($Internet_j$ *and* $Internet_i$), corruption (Cor_j *and* Cor_i), geographic variables (being landlocked $Land_j$ *and* $Land_i$ or an island $Isld_j$ *and* $Isld_i$) and other institutional variables ($Proc_j$ *and* $Proc_i$). A dummy variable Tar_{ij} is added to determine whether there is any tariff barrier between two barriers or not.

$$\ln(Time_{exp,j}) = \ln(Doc_{exp,j}) + \ln(Internet_j) + \ln(Proc_j) + \ln(Cor_j) + Land_j + Isld_j + \omega_j$$

$$\ln(Time_{imp,i}) = \ln(Doc_{imp,i}) + \ln(Internet_i) + \ln(Proc_i) + \ln(Cor_i) + Land_i + Isld_{,i} + Tar_{ij} + \omega_i$$

Secondly, once the time to export and to import are estimated, their predicted values are introduced in the gravity model. The rationale behind this to take into account the part of the transaction time that is only explained by trade facilitation aspects. The gravity outcome is used to compute ad valorem equivalents for these two variables. Following Head and Mayer (2002), my estimable equation is:

$$\ln(\frac{m_{ij}}{m_{ii}}) = \ln(\frac{v_j}{v_i}) - \sigma \ln(\frac{p_j}{p_i}) + \delta(1-\sigma)\ln(\frac{d_{ij}}{d_{ii}}) + (1-\sigma)\ln(1+t_{ij}) + (\sigma-1)\lambda L_{ij}$$

$$-(\sigma-1)(\theta-\eta)PTA_{ij} + (\sigma-1)[\rho_1 Col + \rho_2 Comcol + \rho_3 Conti_{ij}]$$

$$+(1-\sigma)\mu_1 \ln(Time_{imp,i}) + (1-\sigma)\mu_2 \ln(Time_{exp,j}) + \beta + \varepsilon_{ij}$$

where (m_{ij}/m_{ii}) is bilateral imports relative to internal flows, (v_j/v_i) relative production of *i and j*, relative prices, bilateral distance between the countries *i* and *j* (d_{ij}) relative to internal distance, bilateral tariff between *i* and j, some dummies capturing whether the two countries share a common language $Lang_{ij}$, a commom border $Conti_{ij}$, one country was a colony of the other at some point in time *Col*, whether the two have been colonized by a same third country (*Comcol*), the presence of a Preferential Trade Agreement (PTA_{ij}) between *i* and *j* (equals 1 if *i* and *j* belong to the same *PTA*), β the constant and ε the discrepancy term[7].

As Kee et al. (2009) argue, to make trade facilitation aspects comparable with ad valorem equivalents, the quantity impact of such barriers should be transformed into price equivalents. This yields the ad valorem equivalent of one day to export and to import. To determine the AVE specific to each country, the AVE of one day is multiplied by the number of days to export and to import available in the "Doing Business" dataset. Since those tariff equivalents take into account other administrative barriers such as the number of documents, internet coverage, corruption, as well as the geographic impediments to trade, they can be perceived as more exhaustive AVE of "trade facilitation". I have calculated the AVE at the ISIC 3-digits level for 138 countries[8] that have been aggregated to the MIRAGE level of regions and sectors where 19 regions and 21 sectors are taken into account. Those AVEs are computed by taking the average of the AVE of time to export and to import that have been estimated using the gravity model presented above.

It is quite obvious that some sectors have higher ad valorem tariffs than others. For instance, food and beverages (perishable goods), garments and textiles (seasonal goods), machines (used as inputs in the production process) and professional and scientific equipment (high value added products) are characterized by higher AVE than wood products or footwear.

[7] To see the whole derivation of the model, see Head and Mayer (2002) and Zaki (2009).

[8] All ad valorem tariff equivalent for the whole sample are available upon request

5. Empirical Results

Two main simulations are performed. First, a partial removal of the administrative barriers is simulated by reducing trade cost by 50% for all countries. Second, in order to compare the trade facilitation effects with the trade liberalization ones, a similar shock is introduced for tariffs. Here, while the short run means the immediate static change implied by each simulation, the long run means the change implied in 2020.

Trade facilitation yields positive gains for the whole world especially developing countries. In the developed world, the only country that loses from such a process is Japan due to the deterioration of its terms of trade. As displayed in Table 4, welfare gains[9] are mainly explained by gains in terms of trade. In the short run, while welfare increases only by 0.31% in U.S.A., it rises by 1.39% in the European Union (E.U.). Such a difference is explained by the fact that the U.S.A., is considered in my sample, to be the best practice. Therefore, facilitating its trade will not generate important gains. By contrast, since the E.U. includes a bunch of heterogenous countries having different status in trade facilitation issues (from the most efficient such as Germany to the least efficient such as Greece and Eastern-European countries), its benefits are relatively important.

Among developing countries, sub-saharan African (4.67%), other Asian (5.19%), Middle East (3.14%) and North African countries (2.94%) experience higher benefits from trade facilitation. Egypt's gains are less than other Middle East countries since the former has a better performance in facilitation issues[10]. Comparing my findings for Egypt with respect to what I have found in Zaki (2010), the conclusion is interesing. While welfare gains increase by 1.62% when Egypt removes 90% of its trade costs in a unilateral way, a multilateral (and partial) trade facilitation yields a welfare expansion by 1.46%. Therefore, for a 90% reduction of administrative barriers in a multilateral way, higher gains should be expected. This highlights that it is more beneficial for a country to undertake trade facilitation in a multilateral framework. Reducing tariffs by 50% yields lower gains for all countries. On average, while welfare is boosted by 1.79% with trade facilitation, trade liberalization improves it only by some 0.11%.

As shown in Table 5, in the long run, welfare gains are amplified as a result of higher capital accumulation. In Asian countries, capital accumulation and other gains yield large positive welfare gains (8%). Some developing economies are not highly affected by trade facilitation especially Brazil (0.37%) because it already enjoys a relatively efficient environment of goods clearance and delivery. The effects of trade liberalization effects are much lower than those of trade facilitation even in the long run, since, on average, the latter increases welfare by 2.80%, whereas the former increases it only by 0.26%. Last but not least, while welfare gains emerging from trade liberalization are explained by a more efficient allocation of resources, those arising from trade facilitation are due to an increase in terms of trade.

Developing countries' trade is much more affected by trade facilitation than developed ones. Table 6 shows that Sub-Saharan African, Asian, Latin American Countries (LACs) and the Middle East exports increase by 22.28%, 16.18%, 16.20% and 13.66% respectively. Imports are boosted by almost the same figures since the macroeconomic closure of the model evokes a constant current account: *ceteris paribus*, an increase in exports should be coupled by an increase in imports. While developed countries exports and imports increase modestly (the USA exports increase only by 3.9%, Japan by 2.1% and Canada by 5%), the E.U. ones

[9] Welfare is computed as a percentage of the agents' income on the basis of the equivalent variation. Then, these gains are decomposed into 4 main components: terms of trade gains (thanks to the change in trade prices), capital gains (explained by higher capital accumulation), allocation efficiency gains (given a better specialization scheme) and other gains (the residual). For further details, see Bchir et al. (2002).

[10] Only Israel and United of Arab Emirates have better status in trade facilitation issues.

increase more (by 10.6%) since it includes some countries whose performance in trade facilitation is quite poor (Bulgaria, Poland and Czech Republic). It is also worth mentioning that, thanks to the removal of administrative barriers to trade, developing countries witness an improvement in their terms of trade as shown in Table 6, in particular Egypt by 1.21%, Middle East by 2.34%, North Africa by 3.86% and Sub-Saharan Africa by 2.33%. By observing the effects of trade liberalization, it is worthwhile to mention that, first, both exports and imports are less affected when tariffs are removed than when trade is facilitated for all countries except India, Japan and Brazil that are characterized by a fairly high protection. Second, when trade is liberalized, a term of trade deterioration is experienced in all countries with the exception of Australia and New-Zealand, the Middle East and Japan since import prices decline severely with respect to export prices.

Since a multilateral trade facilitation is simulated, the higher the barriers, the larger the effect of their removal, and the more countries should trade. This is why both intra and inter-regional trade is not affected in the same magnitude in all regions. Table 7 confirms this since trade is boosted first among different developing countries and second within each developing region. To begin with, the removal of red tape expenses boosts intra-regional trade in Asia by 19.49%, in North Africa by 22.08%, in LACs by 33.48%, in the Middle East by 45.09% and in Sub Saharan African by 77.23%. Such a result illustrates the fact that trade facilitation is crucial to increase the South-South trade.

As per trade with developed countries, the E.U. increases its imports from the Middle East by 14.82%, Sub-Saharan Africa by 28.64%, North Africa by 13.63%. Even with the rest of Europe and Turkey, intra-European trade is boosted by 12.43%. Second, the USA imports more from South Africa, the Middle East and Asian countries. Interestingly, the USA also imports more from Mexico (up by 10.24%) showing that, even between integrated countries like the USA and Mexico, behind-the-border procedures do matter. Finally, Japan's imports increase significantly with Asian countries (by 11.13%), with Sub-Saharan ones (by 10.55%) and with India (by 5.09%) to the detriment of other countries (such as Brazil, Egypt, North Africa and LACs).

Moving to a detailed analysis of the trade facilitation effects, it is observed that each region increases its trade in some sectors more than others. Once trade is facilitated, each country will produce more of the goods that are mainly sensitive to trade facilitation. As displayed in Table 8, Australia and New Zealand increase their production of agricultural products by 1.98% where they have a comparative advantage, North Africa and Middle East increase their production of garments and textiles by 23.85% and 19.96% respectively. The production of electronics is highly boosted in Asian countries (up by 45.41%). Last but not least, LACs experience an increase of textiles and vegetables by 6.21% and 5.93% respectively.

Table 9 shows that developing countries witness a remarkable diversification of exports. The majority of gains are reaped by Sub-Saharan Africa whose exports increase by 138.7% in electronics, 185.35% in machinery, 320.97% in metallic products and 151.77% in textiles and garments. Benefits are lower for the Middle East, North Africa, LACs and the Rest of Asia. For instance, in the Middle East, exports of textiles and garments, electronics and chemicals increase by 58.01%, 43.51% and 40.33% respectively. Same changes are observed in North Africa but in a more pronouced way (chemicals by 63.99%, textile and garments by 69.91% and electronics by 44.46%). LACs gains are diversified among the following sectors: vegetables (23.31%), chemicals (31.16%), textiles (48.14%), metal products (57.59%) and electronics (62.70%). Finally, Asian countries increase their exports of electronics, metallic products and vegetables. The empirical literature on trade facilitation has evidenced that seasonal (garments) and perishable (vegetables) products as well as those with a short market-lifetime (electronics) are more affected than others. Figure 5 displays the Herfindahl-

Hirschman index that measures exports concentration before and after the simulation (negative variation shows less concentration and more diversification). It is obvious that the rest of Africa, Middle East, North Africa and Latin American countries experience a significant diversification thanks to trade facilitation.

The model runs under neoclassical closure, so that resources are fully employed. Given that the supply the factors of production is exogenous, it is the same as in the benchmark scenario. As trade facilitation affects sectors in different ways, employment is impacted also differently as displayed in Table 10. Since manufacturing sector expands in developing countries, industrial (and services) employment increases in Sub-Saharan Africa (by 2.69%), in the Middle East and North Africa (by 0.35%). By contrast, Australia and New-Zealand, Brazil, Egypt, India and South Africa experience an increase in the agricultural employment thanks to the expansion of primary goods that become more competitive once trade is facilitated.

As a consequence of trade facilitation, sectoral production changes and employment as well as factors remuneration are also modified. Table 11 presents the changes in the return to capital[11], land, natural resources, skilled and unskilled labor in different regions. In the same line as the trade liberalization effects, skilled wages are positively affected by trade facilitation higlighting the fact that the increase in the skill premium is primarily driven by skilled-biased technological change after period of trade liberalization or facilitation, especially in developing countries. In addition, as many sectors that are intensive in unskilled labor expand, the demand for this type of labor is boosted and therefore its wage rate. Developed countries experience a modest change in their returns since the shock effect is rather weak. Land returns increase chiefly in countries where agriculture expands especially in Australia and New-Zealand, Brazil, Egypt, South Africa and the USA. Finally, the return to capital decreases almost everywhere except in Sub-Saharan African countries and the Rest of Asia where it increases moderately. While growth in the supply of labor remains unchanged, the relative abundance of capital increases and therefore its rental rate falls relatively to the wage rate. In addition, it is important to mention that capital is sector-specific, hence it is not affected by the expansion of some activities.

6. Conclusion

This paper attempted to model trade facilitation in a multi-regional and multi-sectoral computable general equilibrium (CGE) model, MIRAGE. Following Decreux and Fontagné (2009) in modeling trade facilitation, administrative barriers are assumed to be an iceberg cost. I extend their model using more accurate ad-valorem equivalents (AVEs) of red tape costs. The latter are estimated using a gravity model and introduced in the CGE model. The novelty of those AVEs is that they take into account the effect of bureaucracy, internet coverage, corruption and geographical barriers on time to trade. My main findings show that, on the regional level, developing countries in Africa and Asia, especially Sub-Saharan countries, the Middle East and North Africa gain much more than developed countries. Moreover, they witness significant export diversification thanks to such a process. On the sectoral level, being more sensitive to time, food, textiles and electronics witness a more important expansion than other products.

From a policymaking perspective, this paper illustrates some important implications for the current WTO negotiations. First, as the trade facilitation process is beneficial for all concerned parties, it can be perceived as one of the factors that could help concluding the Doha Development Round in 2010(?). Since there are no concessions such as in agriculture

[11] The rental rate of capital is the price paid by a firm to use one unit of capital for one period when there are no taxes. In other words, it is the gross (before depreciation) income received by the owner of the capital per period and per unit.

or sensitive products, agreement on trade facilitation could be easily reached and put some flesh onto the bones of the Doha Development negotiations. Second, trade facilitation will not only boost trade, but it will increase the economic efficiency of different countries because infrastructure, customs and the business environment are improved. This is why trade facilitation reforms can be promoted as a necessary tool for growth and development rather than as a concession paid to others. Third, trade facilitation is crucial for developing countries who would be amongst the primary losers if reforms should be undertaken only by developed ones. Heydon (2006) argues that the resulting trade diversion would cause a 3% income drop in developing countries if trade facilitation is conducted solely by industrialized countries. Last but not least, a remaining challenge is that trade facilitation requires large financing, technical assistance and capacity building to be implemented. Yet, this problem can be resolved via two mechanisms: first, through aid for trade and an increase in the government revenues to fund new projects. The latter is explained by the fact that efficiency in the collection of revenues as well as customs effectiveness will improve once trade is facilitated.

My future research includes two potential areas to improve trade facilitation modeling. First, it will be more appropriate to take into account the different costs of implementing the trade facilitation measures. In addition, it would be more suitable to consider the corruption aspects, as I have done in Zaki (2010), which can reduce the gains coming from trade facilitation since the latter is not a pure deadweight loss.

References

Asia Pacific Economic Co-operation (APEC) (1999) "Assessing APEC Trade Liberalization and Facilitation: 1999 Update", Economic Committee, September. APEC: Singapore.

Armington, P. (1969) "A Theory of Demand for Products Distinguished by Place of Production", *International Monetary Fund Staff Papers*, XVI (1969), 159-78.

Badri, N. and Walmsley, T., Editors (2008) "Global Trade, Assistance, and Production: The GTAP 7 Data Base", Center for Global Trade Analysis, Purdue University.

Bchir, M., Decreux, Y., Guérin, J-L. and Jean, S. (2002) "MIRAGE, a Computable General Equilibrium Model for Trade Policy Analysis", *CEPII Working Papers*, No 2002 - 17, December.

Cernat, L. (2001) "Assessing Regional Trade Arrangements: Are South-South More Trade Diverting?", Division on International Trade in Goods and Services, and Commodities, Study Series}, No. 16, UNCTD, New York and Geneva.

Decreux, Y. and Fontagné, L. (2009) "Economic Impact of potential outcome of the DA", *CEPII Research Reports*, No 2009 - 01, May.

Decreux, Y. and Valin, H. (2007) "MIRAGE, Updated Version of the Model for Trade Policy Analysis: Focus on Agriculture and Dynamics", *CEPII Working Papers*, No 2007 - 15, May.

Dennis, A. (2006) "The Impact of Regional Trade Agreements and Trade Facilitation in the Middle East North Africa Region", *World Bank Policy Research Working Paper* 3837, February.

Ferrantino, M. (2006) "Evaluation Quantitative des Effets Economiques et Commerciaux des Mesures Non-Tarifaires", *Working Paper on Trade Policy* No. 28, Working Party of the Trade Committee, OECD, TD/ TC/ WP(2005)26/ FINAL, March.

Fontagné, L., and Freundenberg, M. (1997). "Intra-Industry Trade : Methodological Reconsidered", *CEPII Working Papers* No. 1997-01.

Fox, A., Francois, J. and Londoo-Kent, P. (2003) "Measuring Border Crossing Costs and their Impact on Trade Flows: The United States-Mexican Trucking Case.", Document presented at the sixth conference on Global Economic Analysis, LaHaye, Pays-Bas.

http://www-personal.umich.edu/~alanfox/gtap/bcc/MeasuringBCC.pdf

Francois, J., van Meil, H. and van Tongeren, F. (2003)"Economic Benefits of the Doha Round for the Netherlands." Project Report, Agricultural Economics Research Institute, La Haye. https://www.gtap.agecon.purdue.edu/resources/download/1255.pdf

Francois, J., van Meil, H. and van Tongeren, F. (2005) "Trade Liberalization under Doha development round", *CEPR discussion papers*, no 4032.

Head, K. and Mayer, T. (2002) "Effet frontière, intégration Economique et Forteresse Europe", *Economie et Prévision*, vol. 152-153(1-2), pages 71-92.

Hertel, T., Walmsley, T. and Itakura, K. (2001) "Dynamic Effect of the "New Age" Free Trade Agreement between Japan and Singapore.", *Journal of Economic Integration* v16, n4: p. 446-84.

Heydon, K. (2006) "After the WTO Hong Kong Ministerial Meeting: What is at Stake?", OECD Trade Policy Working Paper No. 27.

Hoekman, B. and Konan, D. (1999) "Deep Integration, Nondiscrimination, and Euro-Mediterranean Free Trade", *World Bank Policy Research Working Paper* no. 2130, Washington: World Bank.

Hummels, D. (2001) "Time as a Trade Barrier.", Department of Economics, Indiana: Purdue University, *mimeo*.

http://www.krannert.purdue.edu/faculty/hummelsd/research/time3b.pdf

Kee, H., Nicita, A. and Olarreaga, M. (2009) "Estimating Trade Restrictiveness Indices", *Economic Journal*, Royal Economic Society, vol. 119(534), pages 172-199, 01.

Minor, P. and Tsigas, M. (2008) "Impacts of Better Trade Facilitation in Developing Countries: Analysis with a New GTAP Database for the Value of Time in Trade", *mimeo*, June. https://www.gtap.agecon.purdue.edu/resources/res_display.asp?RecordID=2762

Njinkeu, D., Wilson, J. and Fosso, B. (2007) "Trade facilitation: What is it and how does it help?", paper prepared for AERC collaborative research project on Supply Response, July.

http://www.aercafrica.org/documents/export_supply_working_papers/NjinkeuD_Trade18DB34.pdf

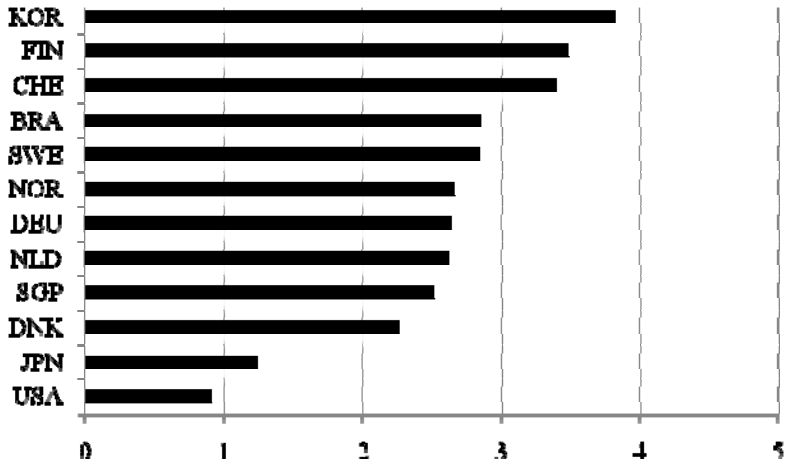
O.E.C.D. (2002), "La Relation entre les Accords Commerciaux Régionaux et le Système Commercial Multilatéral: Facilitation des Echanges", prepared by Evokia Moisé, Working Party of the Trade Committee, TD/TC/WP(2002)17/FINAL, June.

Samuelson, P. (1954) "The Transfer Problem and Transport Costs, II: Analysis of Effects of Trade Impediments" *Economic Journal* 64, p. 264-289.

Zaki, C. (2010) "Towards an Explicit Modeling of Trade Facilitation in CGE models: Evidence from Egypt", *ERF Working Paper 515*, April.

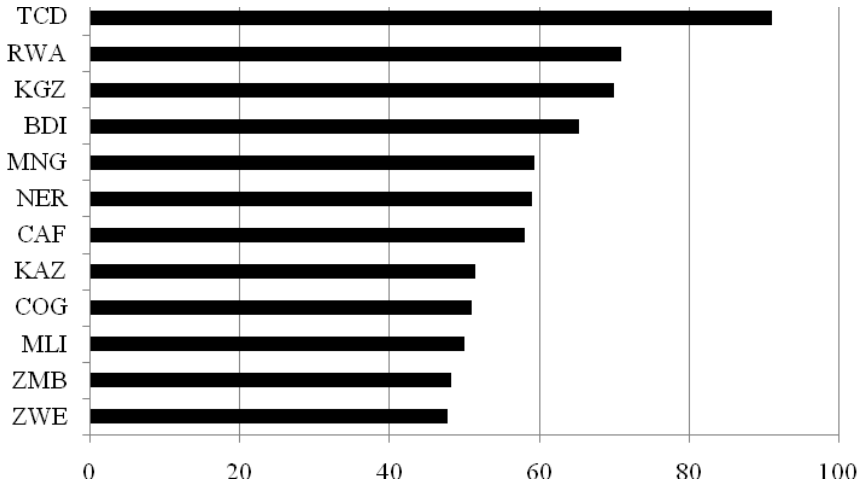
Zaki, C. (2009) "Does Trade Facilitation Matter in Bilateral Trade", *ERF Working Paper 472*, March.

Figure 1: Ad-Valorem equivalents of the Administrative Barriers to Trade: Best Ten Countries (in percent)



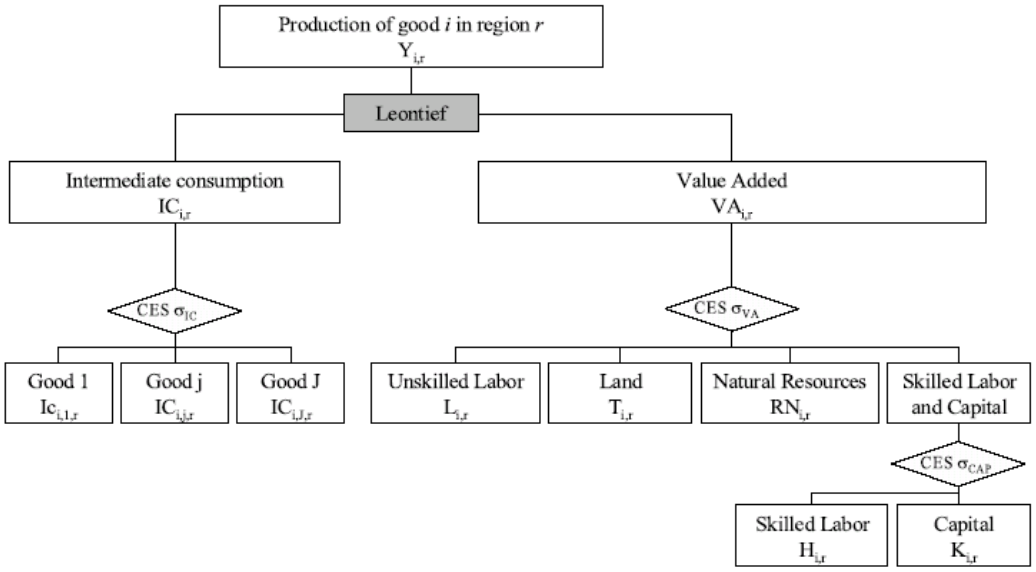
Source: Constructed by the author.

Figure 2: Ad-Valorem equivalents of the Administrative Barriers to Trade: Worst Ten Countries (in percent)



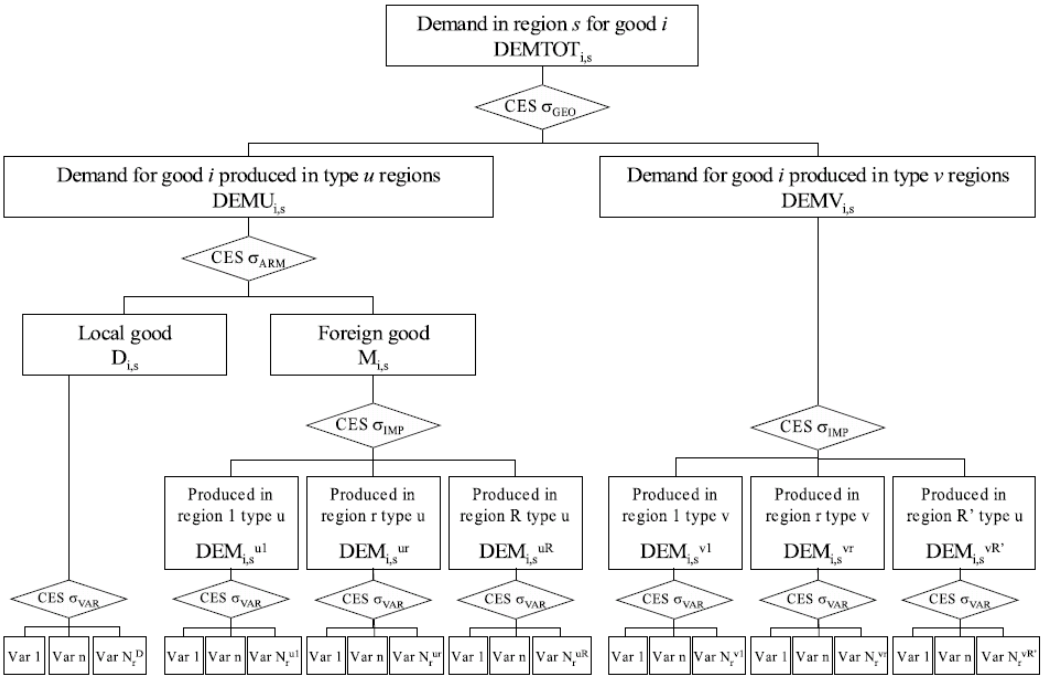
Source: Constructed by the author.

Figure 3: Structure of the Model: Production Side



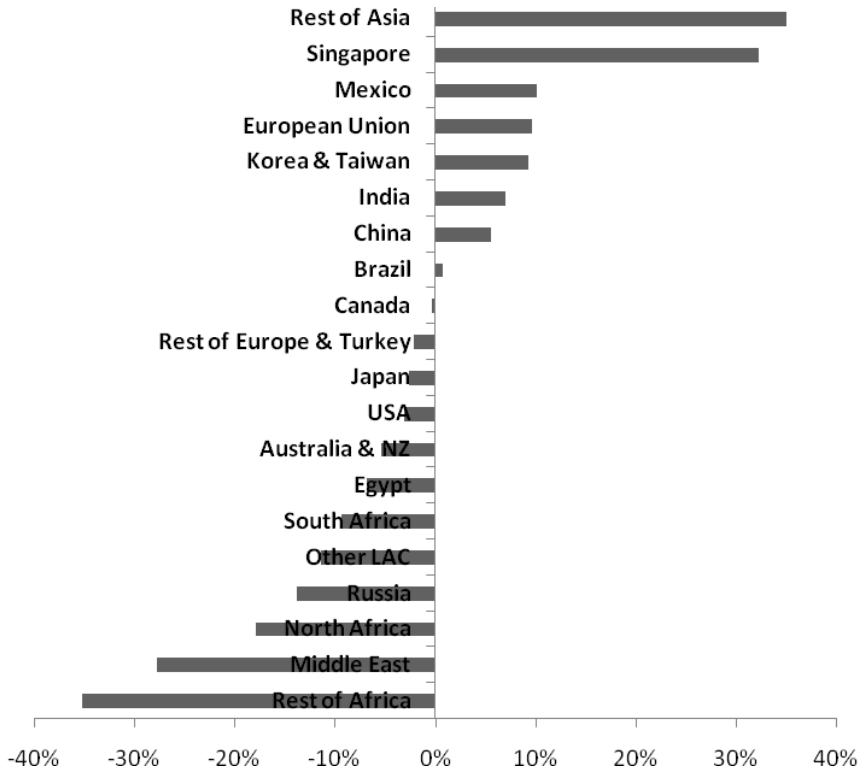
Source: Bchir et al. (2001)

Figure 4: Structure of the Model: Demand Side



Source: Bchir et al. (2002)

Figure 5: Change in Exports Concentration (%)



Notes: i. Exports concentration is measured by the Herfindahl-Hirschman Index – HHI. Negative variation shows less concentration and more diversification. ii. Figures presented here show the impact of a 50% decrease in the trade facilitation barriers on export concentration.
Source: Constructed by the author using the simulations results.

Table 1: Logistics Performance Indicators and Development Level

Aspect	LPI	Customs	Infrastructure	International shipments	Logistics competence	Tracking & tracing	Domestic logistics cost	Timeliness
High income: all	3.67	3.45	3.66	3.52	3.64	3.71	2.58	4.05
Upper-mid. inc	2.85	2.64	2.7	2.84	2.8	2.83	2.94	3.31
Lower-mid. Inc.	2.47	2.31	2.27	2.48	2.4	2.45	3.01	2.93
Low income	2.29	2.12	2.06	2.32	2.29	2.25	2.99	2.71

Note: The LPI index is ranked from 1 to 4. The higher the index, the better the country's performance. This dataset can be found at (http://info.worldbank.org/etools/tradesurvey/mode1b.asp)
Source: Constructed by the author from "Logistics Performance Indicators", 2007.

Table 2: Regional Aggregation

Developed	Developing
Australia and New Zealand	Brazil
Canada	China
European Union	Egypt
Japan	India
Korea and Taiwan	Mexico
Rest of Europe and Turkey	Middle East
USA	North Africa
	Other LAC
	Rest of Africa
	Rest of Asia
	Russia
	South Africa

Source: Constructed by the author.

Table 3: Sectoral Aggregation

Primary	Vegetal agriculture
	Animal agriculture
	Other primary products
	Oil and gas
Secondary	Food industry and fishing
	Textile Leather and Clothing
	Wood products
	Paper Chemicals and Mineral products
	Petroleum products
	Metals
	Metal products
	Cars and trucks
	Other transport equipment
	Electronic equipment
	Machinery and other equipment
	Other manufactures
Tertiary	Construction
	Trade
	Transport
	Business services
	Other services

Source: Constructed by the author.

Table 4: Decomposition of the Short Run Regional Welfare Gains (percentage change with respect to the BAU)

	Trade Facilitation				Trade Liberalization			
	Capital accumulation	Terms of trade gains	Other gains	Welfare	Capital accumulation	Terms of trade gains	Other gains	Welfare
Australia and NZ	0.06	0.37	0.32	0.75	0.02	0.10	0.00	0.12
Brazil	0.03	0.01	0.20	0.24	0.02	0.03	-0.01	0.04
Canada	0.06	0.04	0.81	0.91	-0.00	-0.03	0.08	0.05
China	0.12	-0.61	1.65	1.16	0.03	0.01	-0.03	0.00
Egypt	0.09	0.55	0.83	1.46	0.01	-0.34	0.22	-0.11
European Union	0.07	0.04	1.29	1.39	0.00	0.01	0.09	0.10
India	0.09	-0.14	0.67	0.61	0.02	-0.42	0.68	0.28
Japan	0.01	-0.09	-0.06	-0.14	-0.00	0.10	0.15	0.25
Korea and Taiwan	0.12	-0.97	2.33	1.47	0.02	0.14	0.54	0.70
Mexico	0.06	-0.50	1.75	1.30	0.00	-0.20	0.12	-0.07
Middle East	0.36	0.38	2.40	3.14	0.04	0.09	-0.03	0.09
North Africa	0.20	0.87	1.87	2.94	0.02	-0.45	0.32	-0.11
Other LAC	0.12	-0.05	2.03	2.10	0.02	-0.10	0.16	0.07
Ro Africa	0.35	1.01	3.31	4.67	0.03	-0.29	0.29	0.03
Ro Asia	0.39	0.17	4.63	5.19	0.04	0.19	0.22	0.45
Ro Eur. and Turkey	0.15	0.25	2.23	2.63	0.00	-0.01	0.20	0.20
Russia	0.21	0.36	1.32	1.88	0.02	0.06	0.00	0.08
South Africa	0.14	-0.29	2.15	1.99	-0.00	-0.25	0.12	-0.13
USA	0.02	0.20	0.09	0.31	0.00	-0.00	0.03	0.03

Source: Author's calculations using MIRAGE

Table 5: Decomposition of the Long Run Regional Welfare Gains (percentage change with respect to the BAU)

	Trade Facilitation				Trade Liberalization			
	Capital accumulation	Terms of trade	Other gains	Welfare	Capital accumulation	Terms of trade	Other gains	Welfare
Australia and NZ	0.47	0.45	0.37	1.29	0.11	0.04	0.08	0.23
Brazil	0.25	0.05	0.07	0.37	0.17	-0.02	0.00	0.15
Canada	0.45	0.16	0.80	1.41	-0.00	0.07	0.01	0.08
China	0.54	-0.87	1.78	1.45	0.13	-0.03	-0.05	0.05
Egypt	0.81	0.56	0.87	2.24	0.07	0.21	-0.31	-0.03
European Union	0.62	0.06	1.36	2.04	0.01	0.09	0.01	0.11
India	0.48	-0.44	0.87	0.91	0.18	0.61	-0.48	0.32
Japan	0.07	-0.10	-0.09	-0.12	0.01	0.13	0.11	0.25
Korea and Taiwan	0.89	-1.26	2.56	2.18	0.19	0.55	0.06	0.80
Mexico	0.56	-0.43	2.34	2.47	0.06	0.17	-0.18	0.06
Middle East	2.50	1.08	2.08	5.66	0.35	-0.02	0.33	0.65
North Africa	1.60	1.63	1.22	4.44	0.23	0.30	-0.09	0.43
Other LAC	0.98	-0.01	2.10	3.07	0.14	0.20	-0.13	0.21
Ro Africa	2.80	1.16	3.32	7.28	0.28	0.32	-0.08	0.52
Ro Asia	3.22	-0.42	5.17	7.97	0.33	0.19	0.17	0.69
Ro Eur. and Turkey	1.24	0.33	2.19	3.75	0.03	0.18	0.03	0.24
Russia	0.99	1.20	0.64	2.83	0.14	-0.05	0.22	0.31
South Africa	1.44	-0.31	2.23	3.36	0.01	0.13	-0.29	-0.15
USA	0.16	0.23	0.16	0.55	0.01	0.04	-0.00	0.05

Source: Author's calculations using MIRAGE

Table 6: Long Run Change in Regional Exports and Imports (percentage change with respect to the BAU)

	Trade Facilitation			Trade Liberalization		
	Exports	Imports	Terms of Trade	Exports	Imports	Terms of Trade
Australia and NZ	7.97	7.47	1.15	5.93	5.45	0.14
Brazil	4.38	5.43	0.15	7.55	10.21	-0.30
Canada	5.00	5.28	-0.02	1.14	1.32	-0.21
China	8.83	9.51	-2.27	7.34	7.96	-0.32
Egypt	8.33	8.42	1.21	6.29	6.33	-1.24
European Union	10.60	10.54	-0.70	1.68	2.00	-0.19
India	9.56	8.81	-3.02	13.18	11.72	-2.29
Japan	2.10	2.96	-1.09	5.00	6.22	0.46
Korea and Taiwan	8.18	9.41	-2.16	6.55	7.62	-0.11
Mexico	11.79	11.94	-2.00	2.87	2.93	-0.88
Middle East	13.66	15.12	2.34	3.91	4.44	0.38
North Africa	11.21	12.14	3.86	7.85	8.59	-0.71
Other LAC	16.20	17.28	-0.29	7.54	8.14	-0.71
Ro Africa	22.28	22.45	2.33	5.47	5.57	-0.42
Ro Asia	16.18	17.08	-1.36	4.25	4.97	-0.31
Ro Europe and Turkey	14.69	15.04	0.07	2.91	3.35	-0.15
Russia	7.88	10.12	3.82	3.80	5.11	-0.07
South Africa	17.93	19.27	-1.04	4.01	4.32	-1.22
USA	3.90	3.44	0.60	3.17	2.40	-0.21

Source: Author's calculations using MIRAGE

Table 7: Regional Trade Matrix, Long Run (percentage change with respect to the BAU)

	Aust NZ	Brazil	Canada	China	Egypt	EU	India	Japan	Kor-Tai	Mex	Mid East	No Afr	Oth LAC	Ro Afr	Ro Asia	Ro Eu Tur	Russia	So Afr	USA
Aust NZ	17.79	2.85	8.52	5.98	4.51	8.95	7.47	1.66	2.87	15.14	9.42	12.5	13.5	11.3	7.16	6.64	16.05	32.5	1.48
Brazil	0.31	0	1.49	10.55	7.82	4.95	9.36	-0.84	5.85	21.36	1.66	3.03	9.87	-0.88	10.59	15.95	32.65	16.53	-3.72
Canada	11.66	-0.78	0	6.8	8.19	9.06	4.99	2.38	5.6	14.52	8.22	3.75	23.96	20.22	7.12	3.11	6.8	9.13	3.28
China	2.96	2.78	6.11	14.12	3.26	8.09	8.8	-1.05	9.5	14.62	10.42	4.23	11.91	3.3	20.74	4.9	6.03	7.82	0.41
Egypt	1.57	8.78	2.56	11.27	0	6.3	11.21	-1.46	1.37	8.32	33	6.4	3.94	83.12	11.38	8.28	9.51	22.98	1.51
EU	11.9	2.38	7.62	8.28	8.34	11.63	6.34	1.44	7.13	13.64	14.82	13.63	15.7	28.64	10.82	12.43	4.99	13.62	3.83
India	3.36	8.16	3.94	17.48	6.65	8.23	0	1.74	5.96	6.64	8.2	47.73	5.1	5.29	14.36	3.11	16.96	20.41	0.59
Japan	-0.4	-2.24	-0.52	3.33	-2.66	0.71	5.09	0	3.58	5.49	2.68	-0.42	-1.75	10.55	11.13	-1.28	5.66	10.39	-2.45
Kor Tai	6.09	1.53	11.55	11.67	4.04	12.62	8.82	7.36	14.78	10.65	4.9	8.63	6.33	24.07	16.62	9.34	6.59	5.64	5.92
Mex	11.43	11	9.8	29.1	7.58	12.31	16.33	5.2	17.61	0	26	15.45	28.84	30.36	34.15	12.1	33.92	19.55	6.21
Mid East	9	9.94	8.54	9.22	17.59	12.26	13.17	2.59	2.62	14.47	45.09	28.08	16.68	93.74	8.08	17.47	17.26	20.05	5.77
No Afr	14.02	9.54	6.2	13.5	26.88	11.26	8.14	2.56	-1.39	9.51	30.03	22.08	12.17	33.82	15.29	12.36	11.67	15.47	4.93
Oth LAC	11.82	11.95	12.7	21.09	14.28	15.18	19.02	6.75	8.14	29.12	23.27	15.11	33.48	17.22	17.77	18.16	13.35	30.54	4.76
Ro Afr	16.2	6.72	15.95	14.8	15.39	18.88	10.61	11.19	6.66	11.21	36.57	29.85	25.33	77.23	12.17	25.66	23.87	30.32	11.03
Ro Asia	15.01	11.14	15.24	21.1	15.81	15.28	17.16	5.21	17.43	24.41	8.24	20.94	27.92	35.73	19.49	14.23	16.79	24.27	8.44
RoEu Tur	15.19	4.83	10.71	10.05	14.14	14.69	8.24	5.52	10.1	15.1	26.48	11.94	26.9	92.09	12.57	34.72	9.94	5.51	7.84
Russia	1.64	1.64	-0.96	1.1	4.38	-0.75	3.88	-7.66	-7.72	9.86	41.43	3.5	18.1	29.66	2.78	48.03	0	11.41	0.56
So Afr	11.02	9.85	9.02	16.21	18.34	16.52	13.91	6.44	8.67	28.25	4.95	15.1	17.15	73.76	15.91	10.91	16.68	0	3.81
USA	3.53	-3.47	3.85	0.75	-2.04	1.44	0.61	-2.33	0.57	10.24	9.24	-2.33	8.82	7.28	9.08	3.34	5.36	15.58	0

Source: Author's calculations using MIRAGE.

Table 8: Long Run Change in Volume of Production by Region and by Sector (percentage change with respect to the BAU)

	Aust NZ	Brazil	Canada	China	Egypt	EU	India	Japan	Kor Tai	Mex	Mid East	No Afr	Oth LAC	Ro Afr	Ro Asia	Ro Eu Tur	Russia	So Afr	USA
Anm agr	1.47	2.17	-1.16	0.58	2.49	0.66	0.82	0.78	-0.81	0.26	1.73	2.84	0.27	0.24	1.47	0.8	1.85	2.6	0.92
Business	0.29	1.12	-0.02	2.02	-0.25	0.98	2.59	0.48	0.08	-3.45	2.68	1.78	-0.1	-1.46	-1.98	-0.58	3.24	1.83	0.69
Cars trucks	0.31	4.44	2.47	0.56	4.33	3.63	0.61	3.41	-1.15	6.39	8.33	2.38	2.72	62.17	6.63	20.16	4.65	10.14	0.75
Construct	1.77	1.03	1.83	1.99	3.2	2.23	1.27	0.3	2.72	2.35	7.07	5.48	3.53	8.27	8.17	3.87	4.3	4.26	0.73
Electronic	-14.83	-10.24	5.15	5.34	-13.82	-4.76	-14.03	-9.53	10.2	-1.32	8.34	-7.53	5.14	-10.48	45.41	-10.39	-19.26	-4.25	-10.4
Food fish	1.42	2.7	-1.57	0.87	2.46	1.51	1.43	0.65	-0.62	0.88	2.46	1.87	0.53	-0.29	-0.78	0.65	2.84	2.06	0.75
Machi other	-2.08	-1.12	11.3	-0.84	34.25	3.89	0.91	1.54	5.36	21.31	18.69	13.78	0.82	34.73	13.95	17.33	-11.85	8.16	-3.96
Metal prod	-2.25	-1.07	-0.35	3.42	1.1	0.48	2.16	0.04	2.51	3.3	9.42	-3.35	-0.5	4.13	3.12	6.21	-6.73	0.48	-2.15
Metals	1.68	-3.88	-0.22	-2.24	-1.17	-3.2	-2.72	-0.29	-1.96	1.55	41.36	2.03	8.38	127.62	2.18	7.35	2.83	-0.79	-3.09
Oil gas	0.22	0.25	0.22	0.09	0.16	0.24	0.18	0.49	0.07	0.09	0.08	0.27	0.03	-0.11	-0.1	0.04	0.14	0.02	0.4
Oth manuf	-2.45	-2.37	-1.58	7.52	-15.86	-2.08	12.25	-2.73	-1.89	0.17	33.97	-4.3	-3.26	-0.99	1.94	2.64	-9.82	5.15	-8.16
Oth prim	-0.02	0.27	-0.67	-0.09	-0.04	0.95	0.06	0.83	-0.63	-0.86	1.14	0.46	-0.18	0.55	-0.63	-0.65	0.3	-0.38	0.18
Oth serv	0.86	0.28	0.55	0.71	1.31	0.66	0.55	0.05	0.67	1.02	2.49	1.64	0.95	2.93	1.9	0.42	1.08	1.56	0.71
Oth transp	6.56	-0.84	-1.82	-0.72	6.27	1.31	-2.72	2.63	-4.61	5.08	24.12	-7.23	22.06	159.85	-7.68	30.96	6.32	37.15	1.03
Paper Chem	-0.08	-3.03	2.85	-0.6	-2.78	3.53	-2.14	0.13	-0.8	4.17	2.74	-0.7	-1.78	-9.69	-0.91	2.93	6.6	4.92	-1.54
Petrol prod	-0.46	-2.52	2.97	-1.56	-0.04	0.51	-0.99	-2.06	-1.24	0.65	9.08	-2.05	8.27	3.64	-0.99	9.38	1.12	-0.75	-2.59
Tex Lea Clo	-3.7	1.34	-8.01	3.02	2.47	-3.08	1.79	0.39	-0.17	-1.76	19.96	23.85	6.21	20.82	-1.18	7.29	-2.22	-6.54	-2.75
Trade	0.73	0.35	0.52	0.92	0.9	0.18	0.81	0.17	0.6	2.64	5.02	2.58	1.58	5.93	2.22	1.32	3.47	1.46	0.06
Transport	0.35	-0.23	-0.15	0.65	0.6	0.88	0.07	0.95	-0.56	3.26	2.89	0.44	1.24	5.82	0.34	-0.01	2.23	0.7	0.43
Veg agr	2.5	2.46	-0.25	0.16	1.43	-0.56	1.01	0.9	-1.1	-0.88	0.1	0.55	5.93	-2.09	0.16	-1.42	-0.73	4.67	1.65
Wood prod	-0.41	3.04	-1.54	1.96	2.65	0.09	-1.4	-0.34	-5.63	-3.77	1.81	1.77	3.59	34.03	-0.92	-1.1	-5.98	3.75	-0.14

Source: Author's calculations using MIRAGE.

Table 9: Long Run Change in Value of Exports by Region and by Sector (percentage change with respect to the BAU)

	Aust NZ	Brazil	Canada	China	Egypt	EU	India	Japan	Kor Tai	Mex	Mid East	No Afr	Oth LAC	Ro Afr	Ro Asia	Ro Eu Tur	Russia	So Afr	USA
Anm agr	5.4	6.6	1.63	2.9	17.38	3.41	10.34	11.31	4.24	-4.72	3.89	7.99	1.78	-2.09	5.4	15.55	14.78	11.4	7.88
Business	1.51	10.05	0.16	7.83	1.98	2.64	5.4	11.53	-1.89	-4.28	-0.96	0.02	-2.51	-8.12	-7.09	-6.21	8.4	-1.08	10.21
Cars trucks	10.83	7.14	1.95	1.44	16.8	7.85	-1.89	3.58	-2.78	5.22	33.1	40.43	27.66	186.77	10.04	47.08	36.55	39.43	3.98
Construct	1.68	12.43	0.43	5.38	5.87	3.02	4.26	11.11	-0.87	-0.6	1.17	0.92	-1.37	0.07	-3.24	-3.1	9.05	1.17	8.18
Electronic	14.24	-2.35	13.67	13.18	26.1	7.92	-10.69	-11.94	9.89	8.23	43.51	44.46	62.7	138.7	37.29	19.52	45.5	61.06	-4.74
Food fish	4.84	9.49	-2.97	2.71	18.59	12.64	9.71	8.6	-4.52	-2.6	24.61	14.43	5.19	12.89	0.6	11.9	18.12	10.71	4.75
Machi other	28.91	6.01	22.13	6.76	52.49	16.32	8.59	3.04	15.03	37.61	65.46	81.85	61.08	185.35	23.04	26.52	55.14	66.87	-0.09
Metal prod	18.02	6.37	9.83	17.32	51.11	18.31	13.43	7.59	10.33	5.57	86.33	101.95	57.59	320.97	20.02	42.6	42.24	23.26	4.85
Metals	8.06	-5.8	3.08	7.9	11.16	2.28	5.46	3.65	5.4	-5.37	87.9	20.2	14.8	172.02	8.17	14.16	6.64	2.96	3.81
Oil gas	3.79	11.57	1.12	6.71	9.52	3.02	5.92	4.74	3.67	2.55	-0.19	3.96	-1.87	2.36	3.63	1.85	2.24	2.38	7.78
Oth manuf	70.68	-8.93	39.69	14.25	32.38	20.59	25.39	10.34	11.19	-3.5	98.87	146.83	104.21	307.94	21.11	34.64	46.31	129	11.3
Oth prim	0.07	1.33	0.65	0.86	2.12	5.63	-0.33	1.35	-0.18	-0.95	1.04	-2.04	-0.78	-3.13	0.22	-0.25	0.56	0.5	3.47
Oth serv	3.4	13.99	0.92	9.18	6.62	1.87	9.27	13.21	-2.09	1.65	-3.06	0.34	-0.49	-8.09	-7.19	-6.67	9.67	1.15	13.01
Oth transp	57.03	-6.52	-1.18	-2.36	11.82	9.37	-5.21	4.47	-3.58	17.91	64.45	19.29	102.32	310.61	0.63	74.44	51.43	82.31	4.12
Paper Chem	28.5	6.25	10.96	15.89	11.95	18.84	16.4	3.94	9.26	24.04	40.33	63.99	31.16	37.74	7.8	22.66	58.81	47.78	0.66
Petrol prod	10.22	-5.29	15.34	-2.44	1.55	9.01	14.56	5.46	3.56	-7.16	24.58	-2.42	32.07	92.54	1.9	41.64	-0.72	-3.25	1.04
Tex Lea Clo	13.02	8.18	-4.39	5.54	12.28	11.56	4.99	8.68	5.67	2.02	58.01	69.91	48.17	151.77	5.29	21.45	24.7	22.33	5.61
Trade	2.24	9.44	-0.69	3.69	0.98	2.76	6.08	13.02	-2.84	1.45	-1.77	-0.38	-2.57	-7.19	-8.62	-6.2	10.53	-1.61	10.45
Transport	1.61	6.28	0.51	4.12	1.22	2.36	4.38	10.8	-1.81	4.56	-0.87	-1.12	0.53	-1.24	-3.69	-2.65	5.43	-0.36	7.94
Veg agr	7.37	4.93	2.5	4.61	13.28	6.39	8.48	12.6	0.41	-4.3	10.93	8.77	23.31	-7.31	11.49	3.07	12.05	10.64	6.29
Wood prod	10.8	4.14	-1.08	2.6	21.25	11.25	-1.86	8.4	-1.68	-3.57	45.31	47.31	24.61	135.77	1.61	31.11	22.22	22.98	3.88

Source: Author's calculations using MIRAGE.

Table 10: Long Run Change in Employment (percentage change with respect to the BAU)

	Agriculture		Industry	
	Initial Share (%)	Variation (%)	Initial Share (%)	Variation (%)
Australia and NZ	3.93	1.15	96.07	-0.05
Brazil	3.91	2.03	96.09	-0.08
Canada	1.05	-1.97	98.95	0.02
China	15.71	-0.12	84.29	0.02
Egypt	18.65	0.42	81.35	-0.1
E.U.	2.82	-0.96	97.18	0.03
India	18.79	0.26	81.21	-0.06
Japan	1.43	0.83	98.57	-0.01
Kor Tai	2.32	-2.04	97.68	0.05
Mexico	12.43	-1.68	87.57	0.24
Middle East	12.02	-2.54	87.98	0.35
North Africa	18.17	-1.52	81.83	0.34
Other LAC	9.76	2.01	90.24	-0.22
Ro Africa	41.61	-3.78	58.39	2.69
Ro Asia	12.84	-1.62	87.16	0.2
Ro Eur Tur	6.06	-2.86	93.94	0.18
Russia	11.21	-0.59	88.79	0.07
South Africa	2.20	0.97	97.80	-0.02
USA	0.76	1.32	99.24	-0.01

Source: Author's calculations using MIRAGE.

Table 11: Long Run Change in Real Returns to Factors of Production (percentage change with respect to the BAU)

	Real Return to capital	Real Return to Land	Skilled wages	Unskilled wages	Real Return to nat. resources
Aust NZ	-0.79	1.62	1.89	1.23	1.39
Brazil	-0.67	5.34	0.62	0.08	5.16
Canada	-0.83	-1.20	2.18	1.39	2.42
China	-0.76	1.07	2.38	1.38	0.75
Egypt	-0.23	3.25	2.97	1.96	2.59
E.U.	-0.36	-0.12	3.04	2.12	3.64
India	-1.34	0.82	1.42	0.76	1.80
Japan	-0.39	1.88	0.09	-0.03	3.21
Kor Tai	-0.72	-2.03	3.16	2.11	-2.99
Mexico	-0.24	-0.91	3.79	2.25	3.41
Middle East	-0.78	3.22	10.46	7.59	1.73
North Africa	-1.68	1.22	7.47	4.87	3.08
Other LAC	-0.26	3.01	4.27	3.23	0.51
Ro Africa	0.35	-0.85	13.57	7.77	-0.58
Ro Asia	0.26	1.97	10.79	7.43	-1.68
Ro Eur Tur	-0.83	-0.31	5.66	4.04	-0.01
Russia	-2.08	0.57	3.19	1.36	4.57
South Africa	-0.78	2.95	5.12	3.15	-2.06
USA	-0.66	3.44	0.58	0.21	5.31

Source: Author's calculations using MIRAGE.

Appendix

Appendix 1: List of Countries in GTAP Database

Table A1: List of countries included in GTAP

Number	Code	Description	Number	Code	Description
1	AUS	Australia	57	IRL	Ireland
2	NZL	New Zealand	58	ITA	Italy
3	XOC	Rest of Oceania	59	LVA	Latvia
4	CHN	China	60	LTU	Lithuania
5	HKG	Hong Kong	61	LUX	Luxembourg
6	JPN	Japan	62	MLT	Malta
7	KOR	Korea	63	NLD	Netherlands
8	TWN	Taiwan	64	POL	Poland
9	XEA	Rest of East Asia	65	PRT	Portugal
10	KHM	Cambodia	66	SVK	Slovakia
11	IDN	Indonesia	67	SVN	Slovenia
12	LAO	Lao People's Democratic Republic	68	ESP	Spain
13	MMR	Myanmar	69	SWE	Sweden
14	MYS	Malaysia	70	GBR	United Kingdom
15	PHL	Philippines	71	CHE	Switzerland
16	SGP	Singapore	72	NOR	Norway
17	THA	Thailand	73	XEF	Rest of EFTA
18	VNM	Vietnam	74	ALB	Albania
19	XSE	Rest of Southeast Asia	75	BGR	Bulgaria
20	BGD	Bangladesh	76	BLR	Belarus
21	IND	India	77	HRV	Croatia
22	PAK	Pakistan	78	ROU	Romania
23	LKA	Sri Lanka	79	RUS	Russian Federation
24	XSA	Rest of South Asia	80	UKR	Ukraine
25	CAN	Canada	81	XEE	Rest of Eastern Europe
26	USA	United States of America	82	XER	Rest of Europe
27	MEX	Mexico	83	KAZ	Kazakhstan
28	XNA	Rest of North America	84	KGZ	Kyrgyzstan
29	ARG	Argentina	85	XSU	Rest of Former Soviet Union
30	BOL	Bolivia	86	ARM	Armenia
31	BRA	Brazil	87	AZE	Azerbaijan
32	CHL	Chile	88	GEO	Georgia
33	COL	Colombia	89	IRN	Iran, Islamic Republic of
34	ECU	Ecuador	90	TUR	Turkey
35	PRY	Paraguay	91	XWS	Rest of Western Asia
36	PER	Peru	92	EGY	Egypt
37	URY	Uruguay	93	MAR	Morocco
38	VEN	Venezuela	94	TUN	Tunisia
39	XSM	Rest of South America	95	XNF	Rest of North Africa
40	CRI	Costa Rica	96	NGA	Nigeria
41	GTM	Guatemala	97	SEN	Senegal
42	NIC	Nicaragua	98	XWF	Rest of Western Africa
43	PAN	Panama	99	XCF	Rest of Central Africa
44	XCA	Rest of Central America	100	XAC	Rest of South Central Africa
45	XCB	Caribbean	101	ETH	Ethiopia
46	AUT	Austria	102	MDG	Madagascar
47	BEL	Belgium	103	MWI	Malawi
48	CYP	Cyprus	104	MUS	Mauritius
49	CZE	Czech Republic	105	MOZ	Mozambique
50	DNK	Denmark	106	TZA	Tanzania
51	EST	Estonia	107	UGA	Uganda
52	FIN	Finland	108	ZMB	Zambia
53	FRA	France	109	ZWE	Zimbabwe
54	DEU	Germany	110	XEC	Rest of Eastern Africa
55	GRC	Greece	111	BWA	Botswana
56	HUN	Hungary	112	ZAF	South Africa
			113	XSC	Rest of South African Customs Union

Appendix 2: List of Sectors in GTAP Database

Table A2: List of sectors included in GTAP

Number	Code	Description	Number	Code	Description
1	PDR	Paddy rice	29	LEA	Leather products
2	WHT	Wheat	30	LUM	Wood products
3	GRO	Cereal grains nec	31	PPP	Paper products, publishing
4	VF	Vegetables, fruit, nuts	32	PC	Petroleum, coal products
5	OSD	Oil seeds	33	CRP	Chemical, rubber, plastic products
6	CB	Sugar cane, sugar beet	34	NMM	Mineral products nec
7	PFB	Plant-based fibers	35	IS	Ferrous metals
8	OCR	Crops nec	36	NFM	Metals nec
9	CTL	Bovine cattle, sheep, goats, horses	37	FMP	Metal products
10	OAP	Animal products nec	38	MVH	Motor vehicles and parts
11	RMK	Raw milk	39	OTN	Transport equipment nec
12	WOL	Wool, silk-worm cocoons	40	ELE	Electronic equipment
13	FRS	Forestry	41	OME	Machinery and equipment nec
14	FSH	Fishing	42	OMF	Manufactures nec
15	COA	Coal	43	ELY	Electricity
16	OIL	Oil	44	GDT	Gas manufacture, distribution
17	GAS	Gas	45	WTR	Water
18	OMN	Minerals nec	46	CNS	Construction
19	CMT	Bovine meat products	47	TRD	Trade
20	OMT	Meat products nec	48	OTP	Transport nec
21	VOL	Vegetable oils and fats	49	WTP	Water transport
22	MIL	Dairy products	50	ATP	Air transport
23	PCR	Processed rice	51	CMN	Communication
24	SGR	Sugar	52	OFI	Financial services nec
25	OFD	Food products nec	53	ISR	Insurance
26	BT	Beverages and tobacco prod.	54	OBS	Business services nec
27	TEX	Textiles	55	ROS	Recreational and other services
28	WAP	Wearing apparel	56	OSG	Public Admin., Defense, Educ, Health
			57	DWE	Dwellings

Appendix 3: The Model Notation

Notations

i and j	Sectors
r and s	Regions
t	Periods

Parameters definition

1- Elasticities of Substitution

σ^{VAj}	Elasticity of substitution in value added function
σ^{CAPj}	Elasticity of substitution in production function
σ^{C}	Elasticity of substitution in utility function
σ^{IC}	Elasticity of substitution in intermediate consumption function
σ^{KG}	Elasticity of substitution in capital good demand function
σ^{GEOi}	Elasticity of substitution between groups of regions
σ^{ARMi}	Elasticity of substitution Armington
σ^{IMPi}	Elasticity of substitution of imported goods
σ^{VARi}	Elasticity of substitution between varieties

2- Production

$a_{VAR,i,r}$	Share of the value added in the production (Leontief) of sector i
$a_{CNTER,i,r}$	Share of intermediary consumption in the production Leontieff) of sector i
$a_{L,i,r}$	Share of unskilled labor in the value added
$a_{TE,i,r}$	Share of land in the value added
$a_{RN,i,r}$	Share of natural resources in the value added
$a_{Q,i,r}$	Share of composite capital and skilled labor in the value added
$a_{H,i,r}$	Share of skilled labor in the composite factor Q
$a_{K,i,r}$	Share of capital in the composite factor Q
$a_{H,i,r}$	Share of skilled labor in the composite factor Q

3- Consumption and Utility function

$cmin_{i,r}$	Minimal consumption of good i in the utility function of region r
epa_r	Saving rate in region r

4- Transport Sector

$\mu_{i,r,s}$	Transport demand per volume
θ_r	Value share of region r transport sector in the world production of transport
a_T	Cobb Douglas scale coefficient of the transport of commodities sector
$t\cos t_{i,r,s,t}$	Iceberg cost

5- Tax rates

$tp_{i,r}$	Production tax rate applied on sector i in region r

$te_{i,r,s}$	Export tariff rate in region r applied on product i going to region s
$tc_{i,s}$	Tax rate on final consumption of i in region s
$tic_{i,j,s}$	Tax rate on intermediate consumption of i in region s
$tkg_{i,s}$	Tax rate on capital good i in region s
$DD_{i,r,s,t}$	Ad valorem tariff rate applied by region s on its imports from r in period t

6- Imperfect Competition

$cf_{j,r}$	Fixed cost per unit of output in imperfectly competitive sectors

7- Others

α	Elasticity of investment to capital return rate
δ	Depreciation rate of capital

Variables definition

1- Production

$VA_{j,r,t}$	Value added of sector j in region r
$Y_{j,r,t}$	Production of sector j in region r
$CNTER_{j,r,t}$	Aggregate intermediate consumption of sector j in region r
$Q_{j,r,t}$	Aggregate human capital and physical capital used in sector j
$L_{j,r,t}$	Unskilled labor used is sector j
$TE_{j,r,t}$	Land used is sector j
$RN_{j,r,t}$	Natural resources used in sector j
$H_{j,r,t}$	Skilled labor used in sector j
$K_{j,r,s,t}$	Capital stock originating from region s used in sector j of region r
$KTOT_{j,r,t}$	Total capital stock used in sector j of region r

2- Factors of production

$Lbar_{r,t}$	Total Supply of unskilled labor
$TEbar_{r,t}$	Total Supply of land
$Hbar_{r,t}$	Total Supply of skilled labor
$Kbar_{r,t}$	Total capital stock

3- Investment

$INV_{i,r,s,t}$	Investment originating from region s in region r
$INVTOT_{r,t}$	Total investment in region r
$B_{r,t}$	Adjustment variable between saving and investment

4- Demand

$BUDC_{r,t}$	Budget allocated to consumption in region r

$C_{i,r,t}$	Consumption of good i in region r
$IC_{i,r,s,t}$	Intermediate consumption of good i used in the production of sector j in region r
$KG_{i,r,t}$	Capital good demand of good i in region r
$DVAR_{i,s,t}$	Demand for a domestic variety of good i
$DEMTOT_{i,r,t}$	Total demand of good i in region r
$DEMU_{i,r,t}$	Total demand in region r of good i originating from regions with the same development level than region r (including region r)
$DEMV_{i,r,t}$	Total demand in region r of good i originating from regions with a different development level than region r
$DEMERT_{i,r,t}$	Total demand, in region r, of good i originating from regions with the same development level than region r other than region r
$DEM_{i,r,s,t}$	Demand in region s of good i originating from region r
$DEMVAR_{i,r,s,t}$	Demand in region s of good i produced by firms in region r

5- Trade

$TRADE_{i,r,s,t}$	Exports to region s of industry i coming from region r

6- Transport

$TR_{i,r,s,t}$	Transport demand
$MONDTR_{j,t}$	World supply of international transportation j
$TRM_{j,r,t}$	Supply of international transportation by region r

7- Monopolistic Competition

$Profit_{i,r,t}$	Profit of firm i in region r
$EP_{i,r,s,t}$	Perceived price elasticity of total demand
$NB_{i,r,t}$	Number of varieties (=1 in perfect competition)
$SE_{i,r,s,t}$	Share of imports from r to s in total imports of i by s (r and s in the same quality region)
$SH_{i,r,s,t}$	Share of imports from r to s in total demand of i
$SV_{i,r,s,t}$	Share of imports from r to s in total imports of i by s (r and s in different quality region)
$SU_{i,r,s,t}$	Share of imports from r to s in total demand of i by s (r and s in the same quality region)

8- Tax revenues[12]

$RECPROD_{i,r,t}$	Revenues of production tax
$RECDD_{i,r,t}$	Revenues of tariffs
$RECCONS_{i,r,t}$	Revenues of consumption tax
$RECEXP_{i,r,t}$	Revenues of exports tax
$RQUOTA_{r,s,t}$	Implicit transfers due to quotas
$RECTAX_{r,t}$	Fiscal tax receipts
$REV_{r,t}$	Regional revenues for final demand and investment

[12]Tax revenues may be negative as they can be subsidies

9- Prices

$P_{r,t}$	Shadow price of utility
$PTR_{i,r,s,t}$	Transport of commodity prices
$PY_{i,r,t}$	Price of output
$PCIF_{i,r,s,t}$	CIF price
$PFOB_{i,r,s,t}$	FOB price
$PVA_{i,r,t}$	Price of value added
$PCNTER_{i,r,t}$	Price of intermediate consumption
$PL_{i,r,t}$	Price of unskilled labor
$PTE_{i,r,t}$	Price of land
$PRN_{i,r,t}$	Price of natural resources
$PQ_{i,r,t}$	Price of human and physical capital
$PK_{i,r,t}$	Price of capital
$PH_{i,r,t}$	Price of skilled labor
$PC_{i,r,t}$	Price of consumption
$PIC_{i,j,r,t}$	Price of intermediate consumption good i for sector j
$PICT_{i,j,r,t}$	Price of intermediate consumption good i for sector j (imp. cpm.)
$PKG_{i,r,t}$	Price of capital good i consumption
$PDEMTOT_{i,r,t}$	Price of total demand
$PDEMU_{i,r,t}$	Price of i coming from regions with the same development level (with r)
$PDEMV_{i,r,t}$	Price of i coming from regions with a different development level
$PDEM_{i,r,s,t}$	Price of good i in region s coming from region r
$PDEMETR_{i,r,t}$	Price of i coming from regions with the same development level (without r)
$PDEMVAR_{i,r,s,t}$	Price of variety i in region s coming from r
$PINVTOT_{r,t}$	Price of total investment
$WK_{j,r,t}$	Capital return rate in sector j of region r

10- Closure

$SOLD_{r,t}$	Current account balance of region r
$GDP_{r,t}$	Gross domestic product of region r

The Model Equations

1- Supply:

First tier: Leontieff between value added and intermediate consumption

-Sectors with imperfect competition and increasing return to scale

$$NB_{i,r,t}(Y_{i,r,t} + cf_{i,r,t}) = a_{VA,i,r} VA_{i,r,t} \quad (1)$$

$$NB_{i,r,t}(Y_{i,r,t} + cf_{i,r,t}) = a_{CNTER,i,r} CNTER_{i,r,t} \quad (2)$$

$$NB_{i,r,t}PY_{i,r,t}(Y_{i,r,t}+cf_{i,r,t})=PVA_{i,r,t}VA_{i,r,t}+PCNTER_{i,r,t}CNTER_{i,r,t} \quad (3)$$

-Sectors with perfect competition and constant return to scale

$$Y_{i,r,t}=a_{VA,i,r}VA_{i,r,t} \quad (4)$$

$$Y_{i,r,t}=a_{CNTER,i,r}CNTER_{i,r,t} \quad (5)$$

$$PY_{i,r,t}Y_{i,r,t}=PVA_{i,r,t}VA_{i,r,t}+PCNTER_{i,r,t}CNTER_{i,r,t}+ \quad (6)$$

Second tier: CES between endowments

$$L_{i,r,t}=a_{L,i,r}VA_{i,r,t}[\frac{PVA_{i,r,t}}{PL_{i,r,t}}]^{\sigma_{VA,i}} \quad (7)$$

$$TE_{i,r,t}=a_{TE,i,r}VA_{i,r,t}[\frac{PVA_{i,r,t}}{PTE_{i,r,t}}]^{\sigma_{VA,i}} \quad (8)$$

$$RN_{i,r,t}=a_{RN,i,r}VA_{i,r,t}[\frac{PVA_{i,r,t}}{PRN_{i,r,t}}]^{\sigma_{VA,i}} \quad (9)$$

$$Q_{i,r,t}=a_{Q,i,r}VA_{i,r,t}[\frac{PVA_{i,r,t}}{PQ_{i,r,t}}]^{\sigma_{VA,i}} \quad (10)$$

Third tier: CES between capital and skilled labor

$$KTOT_{i,r,t}=a_{K,i,r}Q_{i,r,t}[\frac{PQ_{i,r,t}}{PK_{i,r,t}}]^{\sigma_{CAP,i}} \quad (11)$$

$$H_{i,r,t}=a_{H,i,r}Q_{i,r,t}[\frac{PQ_{i,r,t}}{PH_{i,r,t}}]^{\sigma_{CAP,i}} \quad (12)$$

Equilibrium

$$PVA_{i,r,t}VA_{i,r,t}=PL_{i,r,t}L_{i,r,t}+PTE_{i,r,t}TE_{i,r,t}+PRN_{i,r,t}RN_{i,r,t}+PQ_{i,r,t}Q_{i,r,t} \quad (13)$$

$$PQ_{i,r,t}Q_{i,r,t}=PK_{i,r,t}KTOT_{i,r,t}+PH_{i,r,t}H_{i,r,t} \quad (14)$$

$$KTOT_{i,s,t}=\sum_{r}K_{i,r,s,t} \quad (15)$$

2- Demand

First tier: LES - CES

$$C_{i,r,t}-cmin_{i,r}=a_{C,i,r}[\frac{P_{r,t}}{PC_{i,r,t}}]^{\sigma^C} \quad (16)$$

$$BUDC_{r,t}=\sum_{i}PC_{i,r,t}C_{i,r,t} \quad (17)$$

$$IC_{i,j,r,t}=a_{IC,i,j,r}CNTER_{j,r,t}[\frac{PCNTER_{j,r,t}}{PIC_{i,j,r,t}}]^{\sigma^{IC}} \quad (18)$$

$$PCNTER_{j,r,t}CNTER_{j,r,t} = \sum_i PIC_{i,j,r,t}IC_{i,j,r,t} \quad (19)$$

$$KG_{i,r,t} = a_{KG,i,r}INVTOT_{r,t}[\frac{PINVTOT_{r,t}}{PKG_{i,r,t}}]^{\sigma^{KG}} \quad (20)$$

$$PINVTOT_{r,t}INVTOT_{r,t} = \sum_i PKG_{i,r,t}KG_{i,r,t} \quad (21)$$

Second tier: Regions Groups

$$DEMU_{i,r,t} = a_{U,i,r}DEMTOT_{i,r,t}[\frac{PDEMTOT_{i,r,t}}{PDEMU_{i,r,t}}]^{\sigma^{GEO}} \quad (22)$$

$$DEMV_{i,r,t} = a_{V,i,r}DEMTOT_{i,r,t}[\frac{PDEMTOT_{i,r,t}}{PDEMV_{i,r,t}}]^{\sigma^{GEO}} \quad (23)$$

$$DEMTOT_{i,r,t}PDEMTOT_{i,r,t} = DEMU_{i,r,t}PDEMU_{i,r,t} + DEMV_{i,r,t}PDEMV_{i,r,t} \quad (24)$$

Third tier: Armington

$$DEM_{i,r,t} = a_{LOC,i,r}DEMU_{i,r,t}[\frac{PDEMU_{i,r,t}}{PDEM_{i,r,t}}]^{\sigma^{ARM,i}} \quad (25)$$

$$DEMETR_{i,r,t} = a_{ETR,i,r}DEMU_{i,r,t}[\frac{PDEMU_{i,r,t}}{PDEMETR_{i,r,t}}]^{\sigma^{ARM,i}} \quad (26)$$

$$PDEMU_{i,r,t}DEMU_{i,r,t} = PDEMETR_{i,r,t}DEMETR_{i,s,t} + PDEM_{i,r,t}DEM_{i,r,t} \quad (27)$$

Fourth tier: Regions

$$DEM_{i,r,s,t} = a_{IMP,i,r,s}DEMETR_{i,s,t}[\frac{PDEMETR_{i,s,t}}{PDEM_{i,r,s,t}}]^{\sigma^{IMP,i}} \quad (28)$$

$$PDEMETR_{i,s,t}DEMETR_{i,s,t} = \sum_{r \in Etra(s)} PDEM_{i,r,s,t}DEM_{i,r,s,t} \quad (29)$$

$$DEM_{i,r,s,t} = a_{IMP,i,r,s}DEMV_{i,s,t}[\frac{PDEMV_{i,s,t}}{PDEM_{i,r,s,t}}]^{\sigma^{IMP,i}} \quad (30)$$

$$PDEMV_{i,s,t}DEMV_{i,s,t} = \sum_{r \in V(s)} PDEM_{i,r,s,t}DEM_{i,r,s,t} \quad (31)$$

Fifth tier: Varieties

$$DEMVAR_{i,r,s,t} = DEM_{i,r,s,t}NB_{i,r,t}^{1-\frac{1}{\sigma^{VAR,i}}} \quad (32)$$

$$PDEM_{i,r,s,t} = PDEMVAR_{i,r,s,t}NB_{i,r,t}^{\frac{1}{1-\sigma^{VAR,i}}} \quad (33)$$

Equilibrium

$$DEMTOT_{i,r,t} = C_{i,r,t} + \sum IC_{i,j,r,t} + KG_{i,r,t} \quad (34)$$

$$Y_{i,r,t} = \sum_{s} DEMVAR_{i,r,s,t} \quad (35)$$

3- Revenues

$$Profit_{i,r,t} = NB_{i,r,t} PY_{i,r,t} \sum_{s} \frac{DEMVAR_{i,r,s,t}}{1 + EP_{i,r,s,t}} - (PVA_{i,r,t} VA_{i,r,t} + PCNTER_{i,r,t} CNTER_{i,r,t}) \quad (36)$$

$$RECPROD_{i,r,t} = tp_{i,r} PY_{i,r,t} NB_{i,r,t} \sum_{s} \frac{DEMVAR_{i,r,s,t}}{1 + EP_{i,r,s,t}} \quad (37)$$

$$RECEXP_{i,r,t} = tp_{i,r} PY_{i,r,t} NB_{i,r,t} \sum_{s} te_{i,r,s} \frac{DEMVAR_{i,r,s,t}}{1 + EP_{i,r,s,t}} \quad (38)$$

$$RECDD_{i,r,t} = \sum_{s} DD_{i,r,s,t} PCIF_{i,r,s,t} NB_{i,r,t} DEMVAR_{i,r,s,t} \quad (39)$$

$$RQUOTA_{r,s,t} = \sum_{i \in TQUOTA_{i,r,s}} TQUOTA_{i,r,s,t} PCIF_{i,r,s,t} NB_{i,r,t} DEMVAR_{i,r,s,t} \quad (40)$$

$$RECCONS_{i,s,t} = PDEMTOTi,s,t(tc_{i,s} C_{i,s,t} + tkg_{i,s} KG_{i,s,t} + \sum_{i,j,s} tic_{i,j,s} IC_{i,j,s,t}) \quad (41)$$

$$RECTAX_{s,t} = \sum_{i} RECPROD_{i,r,t} + \sum_{i} RECEXP_{i,r,t} + \sum_{i} RECDD_{i,r,t} + \sum_{i} RECCONS_{i,s,t} \quad (42)$$

$$BUDC_{r,t} = (1 - epa_{r}) REV_{r,t} \quad (43)$$

4- Trade

- Sectors with imperfect competition and increasing return to scale

$$TRADE_{i,r,s,t} = NB_{i,r,t} DEMVAR_{i,r,s,t} \quad (44)$$

- Sectors with perfect competition and constant return to scale

$$TRADE_{i,r,s,t} = DEM_{i,r,s,t} \quad (45)$$

5-Transport

- Demand

$$TR_{i,r,s,t} = \mu_{i,r,s} (1 + tcost_{i,r,s,t}) TRADE_{i,r,s,t} \quad (46)$$

$$MONDTR_{t} = \sum_{i,r,s} TR_{i,r,s,t} \quad (47)$$

- Supply

$$PY_{TRT,r,t} (1 + tp_{TRT,r}) TRM_{r,t} = \theta_{r} PT_{t} MONDTR_{t} \quad (48)$$

$$Y_{TRT,r,s,t} = \sum_{s} TRADE_{TRT,r,s,t} + TRM_{r,t} \tag{49}$$

$$MONDTR_t = a_T \prod_{r} TRM_{r,t}^{\theta_r} \tag{50}$$

6- Prices

$$P_{r,t} = \sum_{i} PC_{i,r,t}(C_{i,r,t} - cmin_{i,r}) \tag{51}$$

$$PDEM_{i,r,s,t} = PCIF_{i,r,s,t}(1 + DD_{i,r,s,t}) \tag{52}$$

$$PC_{i,r,t} = PDEMTOT_{i,r,t}(1 + tc_{i,r}) \tag{53}$$

$$PKG_{i,r,t} = PDEMTOT_{i,r,t}(1 + tkg_{i,r}) \tag{54}$$

$$PIC_{i,j,r,t} = PDEMTOT_{i,r,t}(1 + tic_{i,j,r}) \tag{55}$$

(56)

- FOB Prices for Sectors with imperfect competition and increasing return to scale

$$PFOB_{i,r,s,t} = (1 + tcost_{i,r,s,t})(\frac{PY_{i,r,s,t}}{1 + EP_{i,r,s,t}})(1 + txp_{i,r,s,t})(1 + texp_{i,r,s,t} + txamf_{i,r,s,t}) \tag{57}$$

- FOB Prices for Sectors with perfect competition and constant return to scale

$$PFOB_{i,r,s,t} = (1 + tcost_{i,r,s,t})PY_{i,r,s,t}(1 + txp_{i,r,s,t})(1 + texp_{i,r,s,t} + txamf_{i,r,s,t}) \tag{58}$$

$$PCIF_{i,r,s,t} = PFOB_{i,r,s,t} + (1 + tcost_{i,r,s,t})\mu_{i,r,s}PTr_{i,r,s,t} \tag{59}$$

7- Imperfect competition

$$SE_{i,r,s,t} = \frac{PDEM_{i,r,s,t}DEM_{i,r,s,t}}{\sum_{rr \in Etra(s)} PDEM_{i,rr,s,t}DEM_{i,rr,s,t}} \tag{60}$$

$$SU_{i,r,s,t} = \frac{PDEM_{i,r,s,t}DEM_{i,r,s,t}}{\sum_{rr \ni V(s)} PDEM_{i,rr,s,t}DEM_{i,rr,s,t}} \tag{61}$$

$$SV_{i,r,s,t} = \frac{PDEM_{i,r,s,t}DEM_{i,r,s,t}}{\sum_{rr \in V(s)} PDEM_{i,rr,s,t}DEM_{i,rr,s,t}} \tag{62}$$

$$SH_{i,r,s,t} = \frac{PDEM_{i,r,s,t}DEM_{i,r,s,t}}{\sum_{rr} PDEM_{i,rr,s,t}DEM_{i,rr,s,t}} \tag{63}$$

$$NB_{i,r,t}(EP_{i,r,r,t} + \frac{1}{\sigma_{VAR,i}}) = [\frac{1}{\sigma_{VAR,i}} - \frac{1}{\sigma_{ARM,i}}] + [\frac{1}{\sigma_{ARM,i}} - \frac{1}{\sigma_{GEO,i}}]SU_{i,r,r,t} + [\frac{1}{\sigma_{GEO,i}} - \frac{1}{\sigma_{C,i}}]SH_{i,r,r,t} \tag{64}$$

$$NB_{i,r,t}(EP_{i,r,s,t}+\frac{1}{\sigma_{VAR,i}})=[\frac{1}{\sigma_{VAR,i}}-\frac{1}{\sigma_{IMP,i}}]+[\frac{1}{\sigma_{IMP,i}}-\frac{1}{\sigma_{ARM,i}}]SE_{i,r,s,t}+[\frac{1}{\sigma_{ARM,i}}-\frac{1}{\sigma_{GEO,i}}]SU_{i,r,s,t}+[\frac{1}{\sigma_{GEO,i}}-\frac{1}{\sigma_{C,i}}]SH_{i,r,s,t} \quad (65)$$

$$NB_{i,r,t}(EP_{i,r,s,t}+\frac{1}{\sigma_{VAR,i}})=[\frac{1}{\sigma_{VAR,i}}-\frac{1}{\sigma_{IMP,i}}]+\frac{1}{\sigma_{IMP,i}}-\frac{1}{\sigma_{GEO,i}}]SV_{i,r,r,t}+[\frac{1}{\sigma_{GEO,i}}-\frac{1}{\sigma_{C,i}}]SH_{i,r,r,t} \quad (66)$$

8- Investment

$$INV_{i,r,s,t}=a_{i,r,s}B_{r,t}KTOT_{i,s,t}e^{\alpha WKi,s,t} \quad (67)$$

$$WK_{i,s,t}=PK_{i,s,t}+\frac{Profit_{i,s,t}}{KTOT_{i,s,t}} \quad (68)$$

$$INVTOT_{s,t}=\sum_{i,r}INV_{i,r,s,t} \quad (69)$$

10- Regional Equilibrium

$$Lbar_{r,t}=\sum_{j}L_{j,r,t} \quad (70)$$

$$TEbar_{r,t}=\sum_{j}TE_{j,r,t} \quad (71)$$

$$Hbar_{r,t}=\sum_{j}H_{j,r,t} \quad (72)$$

$$REV_{r,t}+SOLD_{r,t}=\sum_{i,s}PK_{i,s,t}K_{i,r,s,t}+\sum_{i,s}Profit_{i,r,t}\frac{K_{i,r,s,t}}{KTOT_{i,s,t}}+\sum_{s}(RQUOTA_{r,s,t}-RQUOTA_{s,r,t})+RECTAX_{r,t}\sum_{i}PRN_{i,r,t}RN_{i,r,t}+Lbar_{r,t}PLbar_{r,t}+TEbar_{r,t}PTEbar_{r,t}+Hbar_{r,t}PHbar_{r,t} \quad (73)$$

$$GDP_{t}=\sum_{i,r}PVA_{i,r,t}VA_{i,r,t} \quad (74)$$

$$epa_{r}REV_{r,t}=\sum_{i,s}PINVTOT_{s,t}INV_{i,r,s,t} \quad (75)$$

11- Factor Mobility

$$PL_{j,r,t}=PLbar_{r,t} \quad (76)$$

$$PTE_{j,r,t}=PTEbar_{r,t} \quad (77)$$

$$PH_{j,r,t} = PHbar_{r,t} \tag{78}$$

12- Dynamics

$$K_{i,r,s,t} = K_{i,r,s,t-1}(1-\delta) + INV_{i,r,s,t} \tag{79}$$

$$Lbar_{r,t} = d_r Lbar_{r,t-1} \tag{80}$$

$$Hbar_{r,t} = d_r Hbar_{r,t-1} \tag{81}$$