A Global Assessment of the Trade Facilitation Effects: the Case of MIRAGE Model

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Abstract

Using a multi-regional and multi-sectoral model (MIRAGE), this paper attempts to model explicitly trade facilitation in a dynamic computable general equilibrium (CGE) model of the world economy. We use ad valorem equivalents (AVEs) of such barriers 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 widespread, corruption and geographical barriers on time to trade. My main findings show that, on the regional level, developing countries in Africa and Asia, especially the Middle East and North Africa gain much more from trade facilitation than developed ones. On the sectoral level, food, textiles, electronics and metal products witness a more important expansion than other products.

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1 Introduction

The World Trade Organization (WTO) negotiations aim at boosting international trade through trade liberalization. Recently, a new aspect has been added to those negotiations aiming at "*facilitating trade*". The intuition behind is simple. Once formal trade (tariffs and non-tariffs) barriers have come down, other issues have become more important. Among those issues, administrative barriers to trade are nowadays one of the most serious impediments hindering trade. Many efforts have been deployed in order to liberalize trade but less attention has been given to such impediments. Hoekman and Konan (1999) define the deep integration as the explicit government actions 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. Such definition shows to what extent trade facilitation encompasses different aspects and deals with a large range of issues. This is why concluding negotiations on trade facilitation in the WTO are quite complicated.

The empirical literature of trade facilitation assessment in multinational models is not very abundant. Hertel et al. (2001) modified the GTAP[1] 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. Fox et al. (2003) followed them by inducing an import-augmenting technical change also in the GTAP model (iceberg tariffs). This allowed them to simulate the removal of an iceberg tariff by applying a positive shock to the technical efficiency of the trade flow. APEC (1999) modeled, using also GTAP model, 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 trade liberalization and trade facilitation increase GDP real income by 0.16% and 0.25% respectively for APEC countries and by 0.1% and 0.15% for the world. Moreover, Dennis (2006), using GTAP model, argued that welfare gains induced by an integration with the European Union (E.U.) are observed to triple when the implementations of the agreement

[1]Global Trade Analysis Project.

are complemented with trade facilitation improvements. Francois et al. (2003 and 2005) showed that one of the most important issue of the Doha Development Round is trade facilitation as it explains one third of the gains taking into account that such barriers are "pure deadweight loss", especially for Asia-Pacific developing countries. Finally, Fontagné et al. (2009) introduced an iceberg cost in the Mirage model to determine the impact of trade facilitation and found that trade facilitation would add each year some US$99 billion gains to the world GDP in the long run.

This paper contributes to the empirical literature on trade facilitation in two ways. First, it tries to take into account the complexity of the trade facilitation issues by using ad valorem equivalents of time to export and to import estimated from a gravity model (Zaki, 2009). Those AVEs take into account the effect of bureaucracy, corruption, customs computerization and geographical impediments. Therefore they are more precise and more exhaustive than other AVEs of time to trade (Hummels, 2001 and Minor and Tsigas, 2008). Zaki (2010) has used those AVEs to determine the impact of trade facilitation on the Egyptian economy. Second, this paper attempts to model explicitly trade facilitation in a dynamic computable general equilibrium (CGE) model using a multi-regional and multi-sectoral model (Mirage). The latter is very adequate to study the impact of trade facilitation for two reasons. First, being a multi-regional model, it should determine who are the most important winners from such a process as the spectrum of administrative barriers is quite different between developed and emerging economies. Second, being a multi-sectoral model, MIRAGE allows to take into account the specificities of various sectors and their response to more facilitated trade.

Our main findings show that, on the regional level, developing countries in Africa and Asia, especially the Middle East and North Africa gain much more from trade facilitation than developed ones. Moreover, they witness an important exports diversification thanks to such a process. On the sectoral level, food, textiles and electronics witness a more important expansion than other products.

The remainder of the paper is organized as follows. Section 2 analyzes the trade facilitation landscape in the world. Section 3 displays the theoretical framework. Section 4 presents the data. Section 5 discusses the results. Section 6 concludes.

2 Trade Facilitation Overview

Table 1 displays some of the trade facilitation aspects from the "Logistics Performance Index" database. Observing the aspects of trade facilitation reveals two things. First, it shows to what extent the trade facilitation encompasses different features: infrastructure, logistics, time, etc. Second it presents to what extent developed and developing countries are quite divergent. It is obvious that high-income countries are more performing than low income ones as the LPI index for the former is 3.67 and for the latter 2.29. A detailed analysis shows that developed countries have better infrastructure, logistics and timeliness (3.45, 3.52, 4.05 respectively) than developing ones (2.06, 2.48, 2.71 respectively).

[Table 1 about here]

The huge divergence between different sectors and countries is confirmed by my 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 includes mainly 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 highly benefit from the elimination of such barriers.

[Figures 1 and 2 about here]

Having a more detailed look on the sectoral characteristics of the AVEs, it is worth mentioning that the least sensitive products figure on the lower bound of the AVEs values. Regarding time to export, the lowest values of AVEs (almost 0%) are the one associated with tobacco, footwear and wood products for Japan, USA and Canada. On the other extreme, African and Asian countries (Chad, Kazakhstan, Kirghizistan and Rwanda) have the highest AVEs for chemicals, transports and electrical machines are quite sensitive with an average AVE equivalent to 112%. As to time to import, those figures are quite higher as Chad and Rwanda have an AVE equal to 200% for textiles, garments and non-ferrous metals.

Recall that such AVEs of time to export and to import take into account many aspects of trade facilitation: bureaucracy, corruption, the Internet widespread as a proxy for customs computerization and the geographical impediments that may increase time to

trade. Despite the coverage of many indicators in our AVEs, other aspects are not taken taken account, especially the harmonization of trade and customs standard. This feature is very important because it increases the time as well as the cost of transactions. In case that the Government do not trust foreign certification systems or consider foreign standards to be unacceptable, products will be subjected 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 then be reduced further. An interesting example of such a harmonization is the one of Switzerland. The latter adopted the EU regime on technical regulations and industrial standards (*the acquis communautaire*). According to Hoekman and Konan (1999), this ensured that Swiss goods can enter in the EU on the same basis as EU produced goods. Despite its importance, such an aspect is difficult to measure and to introduce in a CGE model but it is still on our research agenda.

Bearing in mind the importance and the complexity of the trade facilitation process, it is worth 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 model is based on a series of assumptions as follows[2]. It is a multi-region, multi-sector CGE model. This model has some major characteristics: 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. Regarding the first element, 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 distinguishing two ranges of qualities: goods produced in a developing country are assumed to belong to a different quality range than those

[2]For more details, interested readers should refer to Bchir et al (2002)

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 MIRAGE presented in Figure 3, in the first level, production in each sector is represented through a Leontieff 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 between unskilled labor, land, natural resources and a composite bundle. In the third level, the latter is modeled as a CES function between capital and skilled labor.

[Figure 3 about here]

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 of the same region with an elasticity of substitution σ_{GEO}. Thus, this tier captures the vertical differentiation which is gaining more importance in international trade theory (Fontagné et al., 1997). In the fourth level, local and foreign goods are differentiated through the Armington assumption (Armington, 1979). Imported goods coming 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.

[Figure 4 about here]

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.

[3]As mentioned in Decreux and Valin (2006), 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 $\sigma_{VAR} - 1 = \sqrt{2}(\sigma_{IMP} - 1)$.

The closure of the model is based on the following assumptions. First, the share of the current account is considered as exogenous. Therefore, the real effective exchange rate adjusts in order to harmonize variation of exports, imports and FDI. Second, natural resources are fixed, savings rate are fixed and the GDP deflator is the numéraire[4]. Production factors are assumed to be fully employed and immobile internationally. 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

For the sake of simplicity, we explicit here the equations related to trade facilitation. Other equations are detailed in appendix 4.

To take into account the trade facilitation process in the CGE models, we have adopted the methodology that have been developed by Decreux and Fontagné (2009). Differently from what I have done in Zaki (2010), they model the cost associated with administrative barriers as an iceberg cost (Samuelson, 1954) as it is one the most tractable ways of modeling transport costs since it impacts no other market[5].

The AVEs are introduced in the prices and the transport sector equations as follows. The free on board prices $PFOB_{i,r,s,t}$ depends on 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 tax$txp_{i,r,s,t}$, export tax rate $texp_{i,r,s,t}$ and the export tax equivalent to Multi-Fibre Agreement quotas $txamf_{i,r,s,t}$).

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

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

[5]As in MIRAGE, different agents are not modeled explicitly but all agents are modeled through the 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 lot of data in order to take into account corruption. This is why I stick to Decreux and Fontagné (2009) modeling.

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

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

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 by export

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

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

Therefore, introducing explicitly the AVEs in the model captures in a more direct way the effect of trade facilitation on the world economy.

4 Data

This study employs mainly the GTAP 7 Data Base 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 ones from COMTRADE. Tariffs are originating from MacMAP's[6] constructed by the CEPII. The business as usual 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.

Concerning trade facilitation data, ad valorem equivalents have been estimated using a gravity model (Zaki, 2009) to determine the ad valorem equivalent rates of exports and imports time which have been introduced in the CGE model. The novelty of those AVEs is that they take into account many trade facilitation aspects namely, number of documents to export and to import, corruption, the Internet widespread and some geographical impediments like the fact of being landlocked or an island. Therefore, we take into account only the part of time to export and to import that is explained by trade facilitation facets.

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

Those AVEs have been estimated for 138 countries and 25 manufacturing sectors. Among the 113 countries and 57 sectors available in GTAP, I have the AVE estimations for 98 countries and 28 sectors[7]. They have been aggregated to the Mirage level of regions and sectors. As to agriculture, services and countries for which I do not have estimations of AVEs, I have used Minor and Tsigas (2008) estimations as our AVEs are computed only for manufacturing sectors.

GTAP dataset has been aggregated to 19 regions and 21 sectors covering the whole world. Regional and sectoral aggregation are shown in Tables 2 and 3.

[Tables 2 and 3 about here]

A couple of remarks worth to be mentioned. First, Egypt has been considered explicitly in order to compare its benefits from trade facilitation using Mirage with respect to what I have obtained using a mono-country model. Second, such an aggregation allows us to take into account the most important developing regions which have a poor performance in trade facilitation so that their benefits can be assessed.

5 Empirical Results

Removing administrative barriers to trade yields positive gains for the whole world except Japan that witnesses a deterioration of its terms of trade. As displayed in Table 4, welfare gains are affected by gains and losses in terms of trade and capital accumulation. In the short run, while the U.S.A.'s welfare increases only by 0.24%, the European Union (E.U.) witness an increase by 1% in its welfare. Such a difference is explained by the fact that the U.S.A., in our sample, is the best practise. Therefore, facilitating its trade will not generate important gains. On the other hand, 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), its benefits are relatively important. Among developing countries, sub-saharan (3.44%), other Asian (4%) Middle East (2.39%) and North African countries (2.26%) benefits a lot from trade facilitation.

[7]Therefore, Minor and Tsigas estimations have been used for 29 sectors and 15 countries

Egypt gains are less than Middle East ones since it performs better than those countries in facilitation issues[8].

[Table 4 about here]

In the long run, welfare gains are amplified thanks to higher capital accumulation, in particular for developing countries. Unlike Asian countries, African countries terms of trade increases. However, in the groups of countries, capital accumulation and other gains are quite important that they yield positive welfare gains (on average 5%). Some developing economies are not highly affected by trade facilitation especially Brazil, China, India and Mexico as they have already a relatively efficient environment of goods clearance and delivery.

Developing countries are much more affected by trade facilitation then developed ones. Table 5 shows that Sub-Saharan African, Asian, other Latin American Countries (LACs) and Middle East exports increase by 16%, 12.7%, 12.4% and 10.3% 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 augment modestly (the USA exports increase only by 3%, Japan by 1.7% and Canada by 4%), the E.U. ones increase more (by 8%) since it includes some countries whose performance in trade facilitation is quite poor (Bulgaria, Poland and Czech Republic). It 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 5, in particular Egypt by 0.9%, Middle East by 1.9%, North Africa by 3% and Sub-Saharan Africa by 2.9%.

[Table 5 about here]

Clearly, trade facilitation does not affect inter-regional trade in the same way. The more a country and its partners facilitate, the higher they should trade. Table 6 proves this since trade is boosted first between different developing countries and second within each developing region. To begin with, the removal of red tape costs boot intra-regional

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

trade in Asia by 15.2%, in North Africa by 16.8%, in LACs by 25.5%, in the Middle East by 34.2% and in Sub Saharan African by 54.7%. Such a result points out to the fact that trade facilitation is very important to boost the South-South trade. As per trade with the triad, it is worth to be mentioned that the E.U. increases its imports from the Middle East by 11.3%, Sub-Saharan Africa by 20.9%, North Africa by 10.5%. Even with the rest of Europe and Turkey, intra-European trade is boosted by 10%. Second, the USA imports more from South Africa, the Middle East and Asian countries. Interestingly, the USA also imports more from Mexico (up by 8%) showing that, even between integrated countries like the USA and Mexico, behind-the-border procedures do matter. Finally, Japan's imports augment significantly with Asian countries (by 8.7%), with Sub-Saharan ones (by 7.6%) and with India (by 4%) to the detriment of other countries (such as Brazil, Egypt, North Africa and LACs).

[Table 6 about here]

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 is trade is facilitated, each country will produce more the good where it has a comparative advantage. Regarding the first result, as displayed in Table 7, Australia and New Zealand increase their production of agricultural products by 1.3%, Egypt, North Africa and Middle East increase their production of garments and textiles by 10%, 52.8% and 44% respectively. Another interesting result that was highlighted by the empirical literature on trade facilitation. Three main categories of commodities are highly boosted: seasonal (garments), perishable (agro-food) and products with a short lifetime (electronics). For instance, in the Middle East, those three sectors increase by 44%, 19% and 34.3% respectively. In Sub-Saharan African countries, the trade facilitation effect is even more important as administrative impediments are much more important. For these three sectors, such figures are 109.6%, 10.8% and 101.7% respectively.

[Table 7 about here]

Table 8 shows that developing countries witness a remarkable exports diversification. The majority of gains are reaped by Sub-Saharan Africa whose exports increase by 101% in

electronics, 200% in manufacturing and 110% in textiles and garments. Benefits are lower for the Middle East, in North Africa and in Rest of Asia. For instance, exports of food and fishing increase by 19%, chemicals by 31%, electronics by 34.3% and metals by 64% in the Middle East. For North Africa, same trends are observed but with higher figures for chemicals (48%) and machines (61%). Finally, LACs gains are diversified among five main sectors, namely chemicals (24%), textiles (37%), metal products (43.5%), electronics (47.5%) and transport equipment (76%).

[Table 8 about here]

As trade facilitation affects sectors in different ways, employment in each one is impacted also differently as displayed in Table 9. Since the manufacturing sector expands in developing countries, industrial (and services) employment increases in Sub-Saharan Africa (by 1.87%), in the Middle East and North Africa (by 25%). By contrast, Australia and New-Zealand, Brazil, Egypt, India and South Africa experience an increase in the agricultural employment thanks to the expansion of production of primary goods that become more competitive once trade is facilitated.

[Table 9 about here]

When trade is facilitated and in turn countries specialization changes, employment and factor incomes change. Table 10 presents the changes in returns to capital, land, natural resources, skilled and unskilled labor in different region. In the same line as the trade liberalization effects, skilled wages are positively affected by trade facilitation pointing out to 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 intensive in unskilled labor expand, their demand is boosted and therefore their wages. Developed countries experience a modest change in their returns since the shock effect is rather weak. Land returns increase the most in countries where agriculture expands especially in Australia and New-Zealand, Brazil, Egypt, South Africa and USA. Finally, return to capital decrease almost everywhere except in Sub-Saharan African countries and the Rest of Asia where they increase moderately.

[Table 10 about here]

6 Conclusion

This paper attempts to model explicitly trade facilitation in a dynamic computable general equilibrium (CGE) model of the world economy. Using a multi-regional and multi-sectoral model (MIRAGE), this paper assesses the effect of removal administrative barriers on different countries. We use ad valorem equivalents of such barriers 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 widespread, corruption and geographical barriers on time to trade. Our main findings show that, on the regional level, developing countries in Africa and Asia, especially the Middle East and North Africa gain much more from trade facilitation than developed ones. Moreover, they witness an important exports diversification thanks to such a process. On the sectoral level, food, textiles and electronics witness a more important expansion than other products.

From a policymaking point of view, this study points out to some important implications of the current WTO negotiations. First, as the trade facilitation process is beneficiary for all involved parties, we can perceive trade facilitation as one of the factors that could work in favor of concluding the Doha Round in 2010. Since there are no concessions as in agriculture or sensitive products, agreement may be easily reached in trade facilitation and put some flesh onto the bones of the Doha Development negotiations. Second, not only trade will be boosted, but the economic efficiency of different countries will increase as infrastructure, customs and the business environment will be improved. This is why trade facilitation reforms can be promoted as a necessary tool of growth and development rather than as a concession paid to others. Third, this issue of trade facilitation is crucial for developing countries that would be amongst the principal losers if reforms are undertook only by developed ones. Heydon (2006) argues that that the resulting trade diversion would cause a 3% income drop in developing countries if trade facilitation is just carried by industrialized countries. Last but not least, the most important issue in trade facilitation is the one associated with technical assistance and capacity building to implementing trade facilitation measures. Yet, it can be resolved via two mechanisms: first, through aid for trade and second through the government revenues increase used to fund new projects. The government revenues increase is explained by the fact that

efficiency in revenue collection and customs effectiveness must be improved once trade is facilitated.

My future research includes two potential areas to improve trade facilitation modeling. First, it will more appropriate to take into account the different costs of implementing the trade facilitation measures. In addition, it would more suitable to consider the corruption aspects which can reduce the gains coming from of trade facilitation.

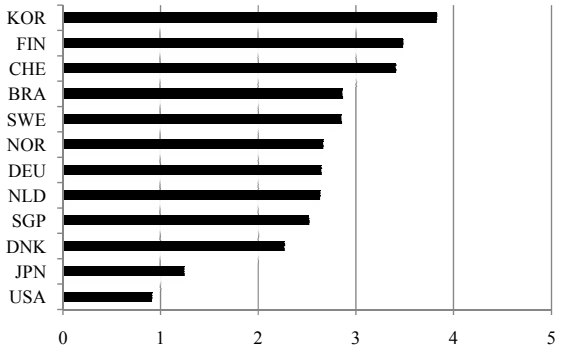
Tables and Figures

Table 1: Logistics Performance Indicators and Development Level

Aspect	LPI	Customs	Infra-structure	International shipments	Logistics competence	Tracking & tracing	Domestic logis-tics costs	Time-liness
High income: all	3.67	3.45	3.66	3.52	3.64	3.71	2.58	4.05
Upper-middle income	2.85	2.64	2.7	2.84	2.8	2.83	2.94	3.31
Lower-middle income	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

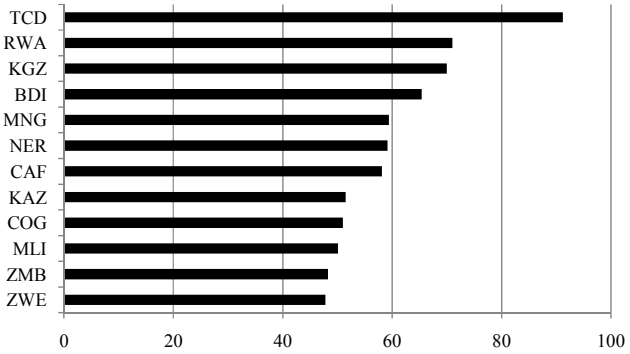
Source: Constructed by the author from "Logistics Performance Indicators", the World Bank, 2007.
Note: The LPI index is ranked from 1 to 4. The higher the index, the better the country's performance.

Figure 1:
Administrative Barriers to Trade: Best Ten Countries (%)



Source: Constructed by the author.

Figure 2:
Administrative Barriers to Trade: Worst Ten Countries (%)



Source: Constructed by the author.

Figure 3:
Structure of the Model: Production Side

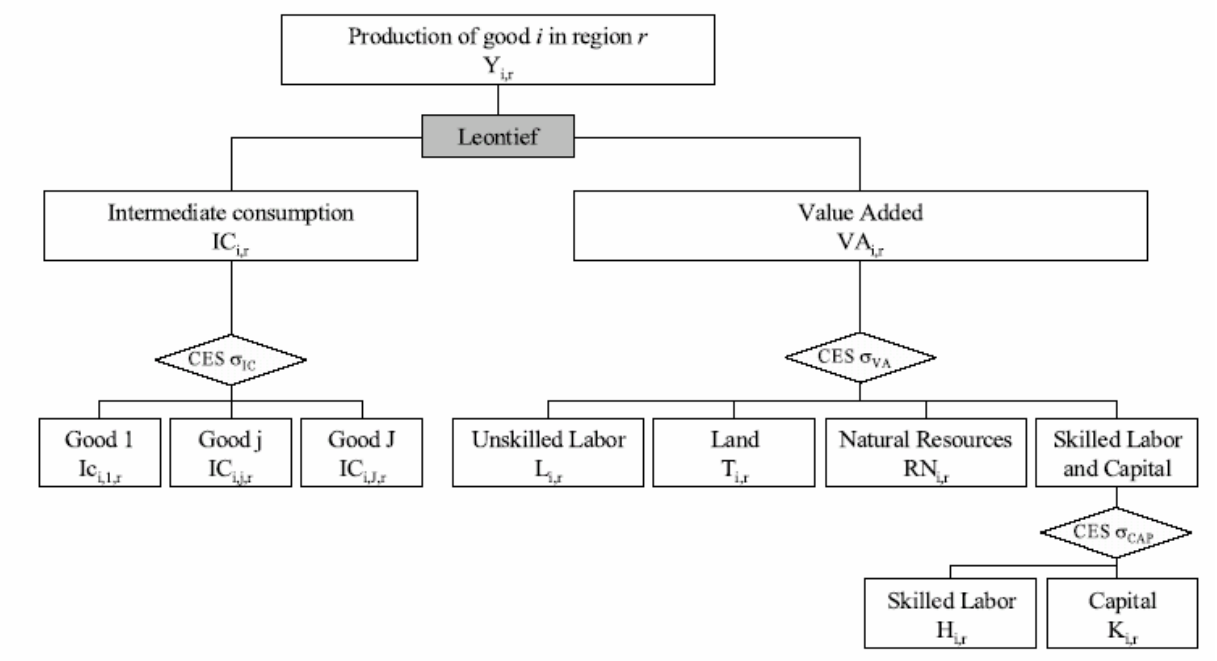


Figure 4:
Structure of the Model: Demand Side

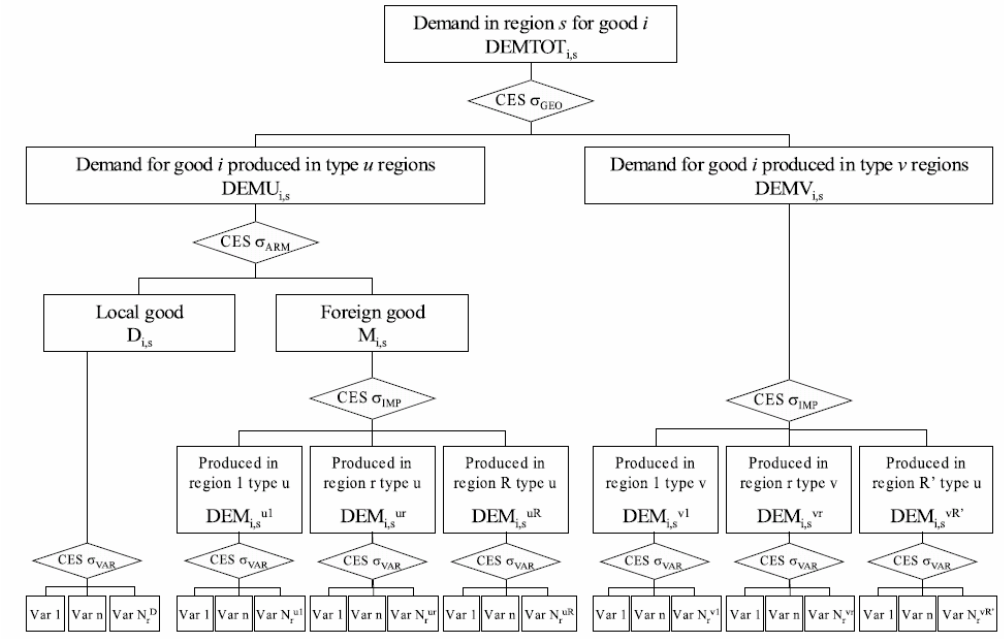


Table 2: Regional Aggregation

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 Regional Welfare Gains

	Short Run				Long Run			
	Capital accumulation gains	Terms of trade gains	Other gains	Welfare	Capital accumulation gains	Terms of trade gains	Other gains	Welfare
Australia and NZ	0.05	0.29	0.25	0.59	0.37	0.35	0.28	1.01
Brazil	0.02	0.00	0.16	0.19	0.20	0.03	0.06	0.29
Canada	0.04	0.03	0.64	0.72	0.35	0.12	0.63	1.10
China	0.09	-0.49	1.31	0.91	0.42	-0.69	1.40	1.15
Egypt	0.07	0.42	0.65	1.14	0.63	0.43	0.67	1.74
European Union	0.05	0.03	1.02	1.09	0.49	0.04	1.08	1.60
India	0.07	-0.11	0.51	0.48	0.37	-0.35	0.65	0.72
Japan	0.01	-0.07	-0.04	-0.11	0.06	-0.08	-0.06	-0.09
Korea and Taiwan	0.09	-0.76	1.85	1.18	0.70	-0.99	2.04	1.75
Mexico	0.04	-0.39	1.36	1.01	0.44	-0.33	1.81	1.92
Middle East	0.27	0.32	1.80	2.39	1.91	0.87	1.54	4.33
North Africa	0.16	0.69	1.42	2.26	1.23	1.28	0.91	3.42
Other LAC	0.09	-0.03	1.53	1.61	0.75	-0.00	1.57	2.36
Ro Africa	0.26	0.86	2.35	3.44	2.06	1.02	2.29	5.36
Ro Asia	0.30	0.15	3.64	4.08	2.50	-0.30	4.02	6.22
Ro Europe and Turkey	0.12	0.20	1.73	2.04	0.96	0.27	1.68	2.90
Russia	0.16	0.26	1.04	1.45	0.75	0.90	0.52	2.17
South Africa	0.10	-0.24	1.66	1.52	1.09	-0.26	1.71	2.56
USA	0.02	0.16	0.07	0.24	0.12	0.18	0.12	0.43

Source: Author's calculations using MIRAGE

Table 5: Long Run Change in Regional Exports and Imports

	Exports	Imports	Terms of Trade
Australia and NZ	6.24	5.85	0.91
Brazil	3.44	4.27	0.09
Canada	3.97	4.20	-0.02
China	6.98	7.51	-1.80
Egypt	6.47	6.54	0.93
European Union	8.38	8.33	-0.56
India	7.46	6.88	-2.40
Japan	1.69	2.37	-0.86
Korea and Taiwan	6.53	7.50	-1.70
Mexico	9.19	9.31	-1.58
Middle East	10.34	11.45	1.89
North Africa	8.54	9.25	3.05
Other LAC	12.46	13.29	-0.21
Ro Africa	15.96	16.09	2.07
Ro Asia	12.65	13.35	-1.05
Ro Europe and Turkey	11.41	11.68	0.08
Russia	6.07	7.79	2.90
South Africa	13.55	14.56	-0.87
USA	3.12	2.72	0.45

Source: Author's calculations using MIRAGE

Table 6: Regional Trade Matrix (Long Run)

	Aust NZ	Brazil	Canada	China	Egypt	EU	India	Japan	Kor Twn	Mex	Mid East	Nor Afr	Oth LAC	Ro Africa	Ro Asia	Ro Eur Tur	Russia	So Afr	USA
Aust NZ	13.81	2.24	6.71	4.70	3.53	7.06	5.82	1.25	2.27	11.75	7.33	9.38	10.26	8.40	5.67	5.37	12.06	24.51	1.18
Brazil	0.31	0.00	1.31	8.35	6.07	4.02	7.41	-0.64	4.75	16.71	1.35	2.12	7.76	-0.77	7.86	12.43	24.54	12.59	-2.82
Canada	9.07	-0.56	0.00	5.38	6.37	7.18	3.89	1.86	4.34	11.33	6.49	2.97	18.45	14.86	5.53	2.52	5.16	6.92	2.66
China	2.46	2.29	4.99	11.16	2.71	6.54	6.98	-0.70	7.67	11.62	7.53	3.27	9.47	2.43	16.26	4.02	4.61	6.08	0.51
Egypt	1.24	6.81	2.04	8.88	0.00	5.03	8.81	-1.23	1.08	6.54	25.71	4.97	2.95	59.12	8.64	6.79	7.56	17.37	1.10
EU	9.23	1.96	6.07	6.61	6.62	9.23	4.99	1.17	5.71	10.66	11.29	10.41	12.23	20.89	8.52	9.86	3.87	10.42	3.13
India	2.82	6.52	3.34	13.86	5.21	6.45	0.00	1.52	4.89	5.11	6.33	35.32	3.84	4.06	11.14	2.59	13.07	15.97	0.67
Japan	-0.27	-1.71	-0.35	2.68	-2.05	0.66	3.98	0.00	2.90	4.27	2.07	-0.27	-1.41	7.57	8.77	-0.77	4.50	8.05	-1.84
Kor Twn	4.89	1.29	9.18	9.34	3.23	10.11	7.04	5.94	11.89	8.43	3.82	6.74	5.20	16.89	13.18	7.63	5.29	4.79	4.89
Mex	8.83	8.66	7.63	22.58	5.88	9.67	12.56	4.08	13.77	0.00	20.03	11.63	22.13	21.96	26.12	9.49	25.18	14.60	4.91
Mid East	6.84	7.35	6.47	7.06	13.46	9.42	10.27	1.71	1.84	11.03	34.22	21.30	12.49	63.88	6.07	13.37	13.11	15.18	4.15
Nor Afr	10.70	7.14	4.64	10.26	20.54	8.69	6.19	1.67	-1.27	7.17	22.66	16.81	9.10	24.19	11.59	9.55	8.76	11.58	3.53
Oth LAC	9.18	9.39	9.89	16.29	10.98	11.80	14.70	5.20	6.28	22.43	17.61	11.47	25.46	12.79	13.45	14.05	10.09	22.92	3.76
Ro Africa	11.44	4.31	11.18	10.60	11.02	13.72	7.54	7.54	4.13	7.77	27.37	21.85	18.04	54.72	8.22	18.22	17.07	22.31	7.29
Ro Asia	11.70	8.61	11.94	16.51	12.19	12.00	13.40	4.20	13.83	18.95	6.37	16.04	21.16	25.45	15.15	11.34	12.91	18.55	6.73
Ro Eur Tur	11.60	3.79	8.47	7.91	11.06	11.57	6.52	4.24	7.86	11.80	20.12	9.10	20.78	64.99	9.73	26.43	7.70	4.80	6.10
Russia	1.49	1.41	-0.35	1.26	3.52	-0.11	3.29	-5.67	-5.72	8.45	29.22	2.93	13.67	21.36	2.30	36.04	0.00	8.88	0.52
So Afr	8.94	8.05	7.07	12.87	14.08	12.84	11.11	5.04	6.80	21.69	3.79	11.47	13.00	53.13	12.33	8.71	12.70	0.00	2.99
USA	2.81	-2.65	3.08	0.70	-1.57	1.22	0.59	-1.87	0.50	8.00	7.09	-1.81	6.79	5.29	7.21	2.59	4.07	11.74	0.00

Source: Author's calculations using MIRAGE

Table 7: Long Run Change in Volume of Production by Region and by Sector

	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	1.17	1.64	-0.93	0.45	1.91	0.49	0.63	0.60	-0.65	0.20	1.36	2.21	0.21	0.29	1.14	0.63	1.42	1.91	0.72
Business	0.23	0.87	-0.03	1.55	-0.21	0.76	1.93	0.37	0.04	-2.74	2.16	1.42	-0.06	-0.75	-1.61	-0.45	2.46	1.38	0.54
Cars trucks	0.23	3.46	1.99	0.43	3.35	2.86	0.47	2.63	-0.98	4.96	6.42	1.82	1.96	40.77	5.22	14.82	3.49	7.66	0.58
Construct	1.38	0.80	1.43	1.56	2.47	1.74	0.99	0.23	2.16	1.81	5.41	4.23	2.71	6.15	6.36	2.99	3.28	3.23	0.56
Electronic	-11.92	-8.01	4.13	4.16	-10.76	-3.73	-10.99	-7.46	8.13	-0.92	6.21	-5.97	3.20	-9.81	34.83	-8.37	-15.88	-4.82	-8.15
Food fish	1.13	2.03	-1.26	0.66	1.89	1.14	1.08	0.50	-0.50	0.68	1.92	1.48	0.41	0.01	-0.66	0.52	2.13	1.48	0.58
Machi other	-1.84	-0.80	8.69	-0.65	25.12	3.04	0.73	1.25	4.13	16.11	13.34	9.39	0.04	21.95	10.72	13.30	-9.14	5.60	-3.05
Metal prod	-1.77	-0.79	-0.25	2.66	0.77	0.40	1.72	0.03	1.94	2.57	6.65	-2.81	-0.47	1.79	2.53	4.64	-5.15	0.59	-1.68
Metals	1.44	-2.96	-0.06	-1.64	-0.62	-2.43	-2.05	-0.18	-1.55	1.20	29.63	1.69	6.88	86.72	1.95	5.91	2.59	-0.01	-2.39
Oil gas	0.17	0.19	0.17	0.07	0.12	0.18	0.13	0.38	0.05	0.07	0.07	0.21	0.02	-0.05	-0.08	0.03	0.11	0.02	0.31
Oth manuf	-2.20	-1.80	-1.48	5.96	-12.47	-1.56	9.57	-2.10	-1.46	0.17	23.58	-3.69	-2.79	-2.12	1.61	1.89	-7.66	3.56	-6.41
Oth prim	-0.00	0.21	-0.52	-0.07	-0.03	0.73	0.05	0.67	-0.50	-0.67	0.91	0.36	-0.12	0.47	-0.49	-0.50	0.24	-0.30	0.14
Oth serv	0.67	0.22	0.43	0.55	1.02	0.52	0.42	0.04	0.54	0.79	1.94	1.29	0.74	2.24	1.48	0.33	0.84	1.19	0.55
Oth transp	4.42	-0.44	-1.21	-0.42	5.30	1.24	-1.95	2.08	-3.88	3.92	18.13	-5.20	16.03	103.08	-5.80	22.56	4.82	26.80	0.97
Paper Chem	-0.12	-2.32	2.27	-0.48	-2.17	2.70	-1.61	0.11	-0.60	3.20	1.81	-0.90	-1.46	-7.46	-0.64	2.19	4.49	3.48	-1.20
Petrol prod	-0.34	-1.95	2.35	-1.21	-0.01	0.44	-0.73	-1.60	-0.95	0.52	6.97	-1.58	6.28	2.12	-0.74	7.02	0.87	-0.57	-2.01
Tex Lea Clo	-2.87	1.03	-6.35	2.34	2.00	-2.43	1.39	0.28	-0.16	-1.35	15.01	17.90	4.64	14.76	-0.81	5.76	-1.83	-4.87	-2.15
Trade	0.57	0.27	0.41	0.71	0.71	0.15	0.63	0.13	0.48	2.03	3.87	1.97	1.22	4.39	1.74	1.02	2.65	1.04	0.05
Transport	0.29	-0.16	-0.11	0.50	0.45	0.68	0.07	0.74	-0.44	2.55	2.24	0.39	0.97	4.33	0.23	-0.00	1.71	0.54	0.34
Veg agr	1.91	1.88	-0.28	0.11	1.07	-0.51	0.76	0.69	-0.89	-0.71	0.18	0.48	4.56	-1.30	0.08	-1.09	-0.61	3.42	1.25
Wood prod	-0.33	2.39	-1.18	1.53	2.00	0.11	-1.06	-0.32	-4.54	-2.90	1.48	1.44	2.81	24.52	-0.64	-0.90	-4.82	3.07	-0.12

Table 8: Long Run Change in Value of Exports by Region and by Sector

	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	4.24	5.07	1.29	2.14	13.19	2.60	7.69	8.79	3.23	-3.74	3.04	6.53	1.38	-1.04	4.23	12.14	11.41	8.55	6.14
Business	1.20	7.68	0.06	5.89	1.49	2.00	4.04	8.87	-1.67	-3.39	-0.47	0.18	-1.94	-5.34	-5.70	-4.83	6.37	-0.80	7.92
Cars trucks	8.55	5.63	1.60	1.19	13.15	6.24	-1.48	2.76	-2.30	4.15	25.55	31.41	21.29	128.74	7.97	35.49	27.58	29.83	3.17
Construct	1.29	9.45	0.23	4.00	4.47	2.27	3.14	8.53	-0.85	-0.59	1.14	0.87	-1.07	0.77	-2.65	-2.40	6.80	0.87	6.30
Electronic	11.67	-1.67	11.20	10.48	20.28	6.67	-8.35	-9.31	8.07	6.79	34.30	34.94	47.45	101.73	29.08	15.61	34.69	45.45	-3.45
Food fish	3.83	7.13	-2.38	1.92	14.13	9.83	7.18	6.68	-3.68	-2.06	19.03	11.34	4.07	10.80	0.37	9.36	13.92	7.70	3.65
Machi other	22.64	5.03	17.43	5.48	39.71	13.00	6.87	2.50	11.81	28.97	49.40	61.39	46.15	131.42	17.92	20.79	41.41	49.62	0.10
Metal prod	14.23	5.07	7.86	13.55	38.77	14.43	10.62	5.98	8.07	4.48	63.96	74.75	43.56	208.39	15.74	32.42	32.20	17.95	3.89
Metals	6.51	-4.45	2.59	6.52	8.92	1.98	4.58	2.99	4.34	-4.08	64.29	16.49	12.21	120.24	6.76	11.32	5.59	2.79	3.11
Oil gas	2.88	8.85	0.81	5.14	7.13	2.30	4.46	3.57	2.80	1.94	-0.16	3.04	-1.47	1.88	2.74	1.42	1.72	1.55	5.97
Oth manuf	52.95	-6.88	30.51	11.40	25.36	16.32	19.89	8.36	8.90	-2.38	72.92	103.89	75.35	200.25	16.45	26.77	35.49	91.44	9.17
Oth prim	0.08	1.06	0.51	0.62	1.64	4.36	-0.21	1.14	-0.07	-0.71	0.99	-1.48	-0.63	-1.96	0.20	-0.22	0.39	0.39	2.72
Oth serv	2.66	10.56	0.61	6.90	5.06	1.38	6.93	10.12	-1.88	1.17	-2.10	0.42	-0.39	-5.32	-5.80	-5.19	7.36	0.93	10.00
Oth transp	41.96	-4.36	-0.64	-1.23	11.21	7.71	-3.85	3.60	-3.12	14.21	49.30	17.38	76.65	208.47	1.08	55.89	39.91	61.17	3.58
Paper Chem	22.23	5.05	8.74	12.43	9.47	14.78	12.83	3.19	7.44	18.77	31.09	48.05	23.84	29.51	6.16	17.83	44.08	35.92	0.60
Petrol prod	8.03	-4.18	12.02	-1.98	1.26	7.09	11.38	4.30	2.81	-5.58	19.02	-1.84	24.64	66.64	1.51	31.53	-0.51	-2.53	0.77
Tex Lea Clo	10.49	6.42	-3.37	4.34	9.87	9.24	3.86	6.90	4.51	1.81	43.98	52.88	36.88	109.62	4.33	16.98	19.09	17.41	4.41
Trade	1.78	7.26	-0.62	2.80	0.76	2.10	4.56	10.06	-2.42	1.05	-1.06	-0.09	-1.94	-4.59	-6.89	-4.80	7.99	-1.15	8.09
Transport	1.27	4.87	0.36	3.07	0.92	1.79	3.30	8.34	-1.53	3.51	-0.49	-0.72	0.43	-0.30	-2.96	-2.05	4.14	-0.25	6.18
Veg agr	5.61	3.75	1.81	3.30	10.17	4.91	6.20	9.62	0.28	-3.46	8.83	7.10	18.00	-4.45	8.75	2.42	9.02	7.83	4.81
Wood prod	8.63	3.27	-0.80	1.99	16.51	8.98	-1.58	6.59	-1.36	-2.70	34.92	36.48	19.29	99.08	1.37	24.20	17.27	17.76	3.09

Table 9: Long Run Percent Change in Employment

	Agriculture	Industry and Services
Australia and NZ	0.89	-0.04
Brazil	1.53	-0.06
Canada	-1.62	0.02
China	-0.11	0.02
Egypt	0.29	-0.07
European Union	-0.81	0.02
India	0.18	-0.04
Japan	0.63	-0.01
Korea and Taiwan	-1.65	0.04
Mexico	-1.33	0.19
Middle East	-1.87	0.25
North Africa	-1.13	0.25
Other LAC	1.59	-0.17
Rest of Africa	-2.62	1.87
Rest of Asia	-1.32	0.16
Rest of Europe and Turkey	-2.22	0.14
Russia	-0.49	0.06
South Africa	0.63	-0.01
USA	1.00	-0.01

Source: Author's calculations using MIRAGE

Table 10: Long Run Percent Change in Real Returns to Factors of Production

	Capital Return	Land Return	Skilled Wages	Unskilled Wages	Natural Resources
Australia and NZ	-0.61	1.26	1.47	0.96	1.12
Brazil	-0.52	4.03	0.49	0.08	3.96
Canada	-0.64	-1.08	1.71	1.10	1.82
China	-0.58	0.81	1.88	1.10	0.57
Egypt	-0.16	2.44	2.31	1.53	1.97
European Union	-0.28	-0.13	2.38	1.66	2.75
India	-1.02	0.62	1.12	0.60	1.34
Japan	-0.30	1.44	0.07	-0.02	2.54
Korea and Taiwan	-0.55	-1.67	2.51	1.68	-2.40
Mexico	-0.17	-0.76	2.94	1.75	2.59
Middle East	-0.63	2.61	7.94	5.72	1.42
North Africa	-1.31	0.97	5.73	3.73	2.43
Other LAC	-0.20	2.34	3.28	2.48	0.39
Rest of Africa	0.14	-0.46	9.91	5.71	-0.05
Rest of Asia	0.23	1.44	8.39	5.81	-1.37
Rest of Europe and Turkey	-0.64	-0.23	4.37	3.12	-0.05
Russia	-1.56	0.35	2.45	1.05	3.47
South Africa	-0.58	2.15	3.87	2.38	-1.61
USA	-0.51	2.61	0.45	0.17	4.09

Source: Author's calculations using MIRAGE

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Appendix 1: List of Countries in GTAP Database

Table 11: 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 12: 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, Education, 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
$share_r$	Share of minimal consumption in the total final consumption 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

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
$mmoy_{i,r}$	Mark up average

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
$VAQL_{j,r,t}$	Value added from skilled labor and capital in sector j in region r
$Y_{j,r,t}$	Production of sector j in region r
$CCI_{j,r,t}$	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
$TFP_{r,t}$	Total factor productivity of region r
$TFPI_{i,r,t}$	Sectoral total factor productivity of region r

2- Factor

$Lbar_{r,t}$	Total Supply of unskilled labor
$TEbar_{r,t}$	Total Supply of land
$Hbar_{r,t}$	Total Supply of skilled labor
$WLbar_{r,t}$	Shadow price of unskilled labor
$WTEbar_{r,t}$	Shadow price of land
$WKbar_{r,t}$	Shadow price of capital
$Kbar_{r,t}$	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
$UT_{r,t}$	Utility of 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
$D_{i,s,t}$	Demand for domestic good i
$DVAR_{i,s,t}$	Demand for a domestic variety of good i
$M_{i,s,t}$	Imports by s from its quality zone
$DEMTOT_{i,r,t}$	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
$DEM_{i,r,s,t}$	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
$WorldTR_{j,t}$	World supply of international transportation j
$TRSupply_{j,r,t}$	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
$EPD_{i,r,t}$	Perceived price elasticity of demand for domestic good i
$NB_{i,r,t}$	Number of varieties (=1 in perfect competition)
$SDU_{i,r,s,t}$	Share of domestic demand for the same good coming from the same quality region
$SDT_{i,r,s,t}$	Share of domestic demand in total demand for the same good
$SM_{i,r,s,t}$	Share of imports from r to s in total imports of i by s r and s in the same quality region)
$ST_{i,r,s,t}$	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[9]

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

$RECPROD_{i,r,t}$	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

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
$PVAQL_{j,r,t}$	Price of value added from skilled labor and capital in sector j in region r
$PCNTER_{i,r,t}$	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
$PQUOTA_{i,r,t}$	Quota price
$PM_{i,s,t}$	Shadow price of imports by s from its quality zone
$PD_{i,s,t}$	Shadow price of demand for domestic good i
$PDVAR_{i,s,t}$	Shadow price of demand for a domestic variety of good i
$PDEMTOT_{i,r,t}$	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 dvpment 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 dvpment 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
$WLt_{l,r,t}$	Rate of return to unskilled labor type l in region r
$WTE_{j,r,t}$	Rate of return to land in region r
$WH_{r,t}$	Rate of return to skilled labor in region r
$WK_{i,r,t}$	Rate of return to capital in region r
$PWORLD_{j,t}$	World price of commodity j

10- Closure

$SOLD_{r,t}$	Current account balance of region r
$GDP_{r,t}$	Gross domestic product of region r
$GROWTH_{r,t}$	GDP growth (volume)
$GDPVAL_t$	World GDP value
$GDPDEF_t$	World GDP deflator

The Model Equations

1- Production Bloc

First tier: Leontieff between VA and IC

-Sectors with imperfect competition and IRS

$$NB_{i,r,t}(Y_{i,r,t} + cf_{i,r,t}) = a_{VA,i,r}VA_{i,r,t} \tag{A1}$$

$$NB_{i,r,t}(Y_{i,r,t} + cf_{i,r,t}) = a_{CNTER,i,r}CNTER_{i,r,t} \tag{A2}$$

$$NB_{i,r,t}PY_{i,r,t}(Y_{i,r,t} + cf_{i,r,t}) = PVA_{i,r,t}VA_{i,r,t} + PCNTER_{i,r,t}CNTER_{i,r,t} \tag{A3}$$

- Sectors with perfect competition and CRS

$$Y_{i,r,t} = a_{VA,i,r}VA_{i,r,t} \tag{A4}$$

$$Y_{i,r,t} = a_{CNTER,i,r}CNTER_{i,r,t} \tag{A5}$$

$$PY_{i,r,t}Y_{i,r,t} = PVA_{i,r,t}VA_{i,r,t} + PCNTER_{i,r,t}CNTER_{i,r,t}+ \tag{A6}$$

Second tier: CES between endowments

$$L_{i,r,t} = a_{L,i,r}VA_{i,r,t}[\frac{PVA_{i,r,t}}{PL_{i,r,t}}]^{\sigma_{VA,i}} \tag{A7}$$

$$TE_{i,r,t} = a_{TE,i,r}VA_{i,r,t}[\frac{PVA_{i,r,t}}{PTE_{i,r,t}}]^{\sigma_{VA,i}} \tag{A8}$$

$$RN_{i,r,t} = a_{RN,i,r}VA_{i,r,t}[\frac{PVA_{i,r,t}}{PRN_{i,r,t}}]^{\sigma_{VA,i}} \tag{A9}$$

$$Q_{i,r,t} = a_{Q,i,r}VA_{i,r,t}[\frac{PVA_{i,r,t}}{PQ_{i,r,t}}]^{\sigma_{VA,i}} \tag{A10}$$

Third tier: CES between capital and skilled labor

$$KTOT_{i,r,t} = a_{K,i,r}Q_{i,r,t}[\frac{PQ_{i,r,t}}{PK_{i,r,t}}]^{\sigma_{CAP,i}} \tag{A11}$$

$$H_{i,r,t} = a_{H,i,r} Q_{i,r,t} [\frac{PQ_{i,r,t}}{PH_{i,r,t}}]^{\sigma_{CAP,i}} \tag{A12}$$

Equilibrium

$$PVA_{i,r,t} VA_{i,r,t} = PL_{i,r,t} L_{i,r,t} + PTE_{i,r,t} TE_{i,r,t} + PRN_{i,r,t} RN_{i,r,t} + PQ_{i,r,t} Q_{i,r,t} \tag{A13}$$

$$PQ_{i,r,t} Q_{i,r,t} = PK_{i,r,t} KTOT_{i,r,t} + PH_{i,r,t} H_{i,r,t} \tag{A14}$$

$$KTOT_{i,s,t} = \sum_{r} K_{i,r,s,t} \tag{A15}$$

2- Demand Bloc

First tier: LES - CES

$$C_{i,r,t} - cmin_{i,r} = a_{C,i,r} [\frac{P_{r,t}}{PC_{i,r,t}}]^{\sigma^C} \tag{A16}$$

$$BUDC_{r,t} = \sum_{i} PC_{i,r,t} C_{i,r,t} \tag{A17}$$

$$IC_{i,j,r,t} = a_{IC,i,j,r} CNTER_{j,r,t} [\frac{PCNTER_{j,r,t}}{PIC_{i,j,r,t}}]^{\sigma^{IC}} \tag{A18}$$

$$PCNTER_{j,r,t} CNTER_{j,r,t} = \sum_{i} PIC_{i,j,r,t} IC_{i,j,r,t} \tag{A19}$$

$$KG_{i,r,t} = a_{KG,i,r} INVTOT_{r,t} [\frac{PINVTOT_{r,t}}{PKG_{i,r,t}}]^{\sigma^{KG}} \tag{A20}$$

$$PINVTOT_{r,t} INVTOT_{r,t} = \sum_{i} PKG_{i,r,t} KG_{i,r,t} \tag{A21}$$

Second tier: Regions Groups

$$DEMU_{i,r,t} = a_{U,i,r} DEMTOT_{i,r,t} [\frac{PDEMTOT_{i,r,t}}{PDEMU_{i,r,t}}]^{\sigma^{GEO}} \tag{A22}$$

$$DEMV_{i,r,t} = a_{V,i,r} DEMTOT_{i,r,t} [\frac{PDEMTOT_{i,r,t}}{PDEMV_{i,r,t}}]^{\sigma^{GEO}} \quad \text{(A23)}$$

$$DEMTOT_{i,r,t} PDEMTOT_{i,r,t} = DEMU_{i,r,t} PDEMU_{i,r,t} + DEMV_{i,r,t} PDEMV_{i,r,t} \quad \text{(A24)}$$

Third tier: Armington

$$DEM_{i,r,t} = a_{LOC,i,r} DEMU_{i,r,t} [\frac{PDEMU_{i,r,t}}{PDEM_{i,r,t}}]^{\sigma^{ARM,i}} \quad \text{(A25)}$$

$$DEMETR_{i,r,t} = a_{ETR,i,r} DEMU_{i,r,t} [\frac{PDEMU_{i,r,t}}{PDEMETR_{i,r,t}}]^{\sigma^{ARM,i}} \quad \text{(A26)}$$

$$PDEMU_{i,r,t} DEMU_{i,r,t} = PDEMETR_{i,r,t} DEMETR_{i,s,t} + PDEM_{i,r,t} DEM_{i,r,t} \quad \text{(A27)}$$

Fourth tier: Regions

$$DEM_{i,r,s,t} = a_{IMP,i,r,s} DEMETR_{i,s,t} [\frac{PDEMETR_{i,s,t}}{PDEM_{i,r,s,t}}]^{\sigma^{IMP,i}} \quad \text{(A28)}$$

$$PDEMETR_{i,s,t} DEMETR_{i,s,t} = \sum_{r \in Etra(s)} PDEM_{i,r,s,t} DEM_{i,r,s,t} \quad \text{(A29)}$$

$$DEM_{i,r,s,t} = a_{IMP,i,r,s} DEMV_{i,s,t} [\frac{PDEMV_{i,s,t}}{PDEM_{i,r,s,t}}]^{\sigma^{IMP,i}} \quad \text{(A30)}$$

$$PDEMV_{i,s,t} DEMV_{i,s,t} = \sum_{r \in V(s)} PDEM_{i,r,s,t} DEM_{i,r,s,t} \quad \text{(A31)}$$

Fifth tier: Varieties

$$DEMVAR_{i,r,s,t} = DEM_{i,r,s,t} NB_{i,r,t}^{1-\frac{1}{\sigma^{VAR,i}}} \quad \text{(A32)}$$

$$PDEM_{i,r,s,t} = PDEMVAR_{i,r,s,t} NB_{i,r,t}^{\frac{1}{1-\sigma^{VAR,i}}} \quad \text{(A33)}$$

Equilibrium

$$DEMTOT_{i,r,t} = C_{i,r,t} + \sum IC_{i,j,r,t} + KG_{i,r,t} \quad \text{(A34)}$$

$$Y_{i,r,t} = \sum_{s} DEMVAR_{i,r,s,t} \tag{A35}$$

3- Revenues

$$Profit_{i,r,t} = NB_{i,r,t} PY_{i,r,t} \sum_{s} \frac{DEMVAR_{i,r,s,t}}{1 + EP_{i,r,s,t}} - (PVA_{i,r,t} VA_{i,r,t} + PCNTER_{i,r,t} CNTER_{i,r,t}) \tag{A36}$$

$$RECPROD_{i,r,t} = tp_{i,r} PY_{i,r,t} NB_{i,r,t} \sum_{s} \frac{DEMVAR_{i,r,s,t}}{1 + EP_{i,r,s,t}} \tag{A37}$$

$$RECEXP_{i,r,t} = tp_{i,r} PY_{i,r,t} NB_{i,r,t} \sum_{s} te_{i,r,s} \frac{DEMVAR_{i,r,s,t}}{1 + EP_{i,r,s,t}} \tag{A38}$$

$$RECDD_{i,r,t} = \sum_{s} DD_{i,r,s,t} PCIF_{i,r,s,t} NB_{i,r,t} DEMVAR_{i,r,s,t} \tag{A39}$$

$$RQUOTA_{r,s,t} = \sum_{i \in TQUOTA_{i,r,s}} TQUOTA_{i,r,s,t} PCIF_{i,r,s,t} NB_{i,r,t} DEMVAR_{i,r,s,t} \tag{A40}$$

$$RECCONS_{i,s,t} = PDEMTOTi, s, t(tc_{i,s} C_{i,s,t} + tkg_{i,s} KG_{i,s,t} + \sum_{i,j,s} tic_{i,j,s} IC_{i,j,s,t}) \tag{A41}$$

$$\begin{aligned} RECTAX_{s,t} \;=\; & \sum_{i} RECPROD_{i,r,t} + \sum_{i} RECEXP_{i,r,t} \\ & + \sum_{i} RECDD_{i,r,t} + \sum_{i} RECCONS_{i,s,t} \end{aligned} \tag{A42}$$

$$BUDC_{r,t} = (1 - epa_r) REV_{r,t} \tag{A43}$$

4- Trade

- Sectors with imperfect competition and IRS

$$TRADE_{i,r,s,t} = NB_{i,r,t} DEMVAR_{i,r,s,t} \tag{A44}$$

- Sectors with perfect competition and CRS

$$TRADE_{i,r,s,t} = DEM_{i,r,s,t} \tag{A45}$$

5-Transport

- Demand

$$TR_{i,r,s,t} = \mu_{i,r,s}(1 + tcost_{i,r,s,t})TRADE_{i,r,s,t} \tag{A46}$$

$$MONDTR_t = \sum_{i,r,s} TR_{i,r,s,t} \tag{A47}$$

- Supply

$$PY_{TRT,r,t}(1 + tp_{TRT,r})TRM_{r,t} = \theta_r PT_t MONDTR_t \tag{A48}$$

$$Y_{TRT,r,s,t} = \sum_s TRADE_{TRT,r,s,t} + TRM_{r,t} \tag{A49}$$

$$MONDTR_t = a_T \prod_r TRM_{r,t}^{\theta_r} \tag{A50}$$

6- Prices

$$P_{r,t} = \sum_i PC_{i,r,t}(C_{i,r,t} - cmin_{i,r}) \tag{A51}$$

$$PDEM_{i,r,s,t} = PCIF_{i,r,s,t}(1 + DD_{i,r,s,t} + ttf_{i,r,s,t}) \tag{A52}$$

$$PC_{i,r,t} = PDEMTOT_{i,r,t}(1 + tc_{i,r}) \tag{A53}$$

$$PKG_{i,r,t} = PDEMTOT_{i,r,t}(1 + tkg_{i,r}) \tag{A54}$$

$$PIC_{i,j,r,t} = PDEMTOT_{i,r,t}(1 + tic_{i,j,r}) \tag{A55}$$

$$PFOB_{i,r,s,t} = (1 + tcost_{i,r,s,t})(\frac{PY_{i,r,s,t}}{1 + EP_{i,r,s,t}})(1 + txp_{i,r,s,t})(1 + texp_{i,r,s,t} + txamf_{i,r,s,t}) \tag{A56}$$

$$PCIF_{i,r,s,t} = PFOB_{i,r,s,t} + (1 + tcost_{i,r,s,t})\mu_{i,r,s}PTr_{i,r,s,t} \tag{A57}$$

- Sectors with imperfect competition and IRS

$$PCIF_{i,r,s,t} = (1 + tp_{i,r})(1 + te_{i,r})\frac{PY_{i,r,t}}{(1 + EP_{i,r,s,t})} + \mu_{i,r,s}PT_t \tag{A58}$$

- Sectors with perfect competition and CRS

$$PCIF_{i,r,s,t} = (1 + tp_{i,r})(1 + te_{i,r} + ttfx_{i,r,s})PY_{i,r,t} + \mu_{i,r,s}PT_t \tag{A59}$$

7- Imperfect competition

$$SE_{i,r,s,t} = \frac{PDEM_{i,r,s,t}DEM_{i,r,s,t}}{\sum_{rr \in Etra(s)} PDEM_{i,rr,s,t}DEM_{i,rr,s,t}} \tag{A60}$$

$$SU_{i,r,s,t} = \frac{PDEM_{i,r,s,t}DEM_{i,r,s,t}}{\sum_{rr \ni V(s)} PDEM_{i,rr,s,t}DEM_{i,rr,s,t}} \tag{A61}$$

$$SV_{i,r,s,t} = \frac{PDEM_{i,r,s,t}DEM_{i,r,s,t}}{\sum_{rr \in V(s)} PDEM_{i,rr,s,t}DEM_{i,rr,s,t}} \tag{A62}$$

$$SH_{i,r,s,t} = \frac{PDEM_{i,r,s,t}DEM_{i,r,s,t}}{\sum_{rr} PDEM_{i,rr,s,t}DEM_{i,rr,s,t}} \tag{A63}$$

$$\begin{aligned} NB_{i,r,t}(EP_{i,r,r,t} + \frac{1}{\sigma_{VAR,i}}) &= [\frac{1}{\sigma_{VAR,i}} - \frac{1}{\sigma_{ARM,i}}] + [\frac{1}{\sigma_{ARM,i}} - \frac{1}{\sigma_{GEO,i}}]SU_{i,r,r,t} \\ &\quad + [\frac{1}{\sigma_{GEO,i}} - \frac{1}{\sigma_{C,i}}]SH_{i,r,r,t} \end{aligned} \tag{A64}$$

$$\begin{aligned} NB_{i,r,t}(EP_{i,r,s,t} + \frac{1}{\sigma_{VAR,i}}) &= [\frac{1}{\sigma_{VAR,i}} - \frac{1}{\sigma_{IMP,i}}] + [\frac{1}{\sigma_{IMP,i}} - \frac{1}{\sigma_{ARM,i}}]SE_{i,r,s,t} + [\frac{1}{\sigma_{ARM,i}} \\ &\quad - \frac{1}{\sigma_{GEO,i}}]SU_{i,r,s,t} + [\frac{1}{\sigma_{GEO,i}} - \frac{1}{\sigma_{C,i}}]SH_{i,r,s,t} \end{aligned} \tag{A65}$$

$$\begin{aligned} NB_{i,r,t}(EP_{i,r,s,t} + \frac{1}{\sigma_{VAR,i}}) &= [\frac{1}{\sigma_{VAR,i}} - \frac{1}{\sigma_{IMP,i}}] + \frac{1}{\sigma_{IMP,i}} - \frac{1}{\sigma_{GEO,i}}]SV_{i,r,r,t} \\ &\quad + [\frac{1}{\sigma_{GEO,i}} - \frac{1}{\sigma_{C,i}}]SH_{i,r,r,t} \end{aligned} \tag{A66}$$

8- Investment

$$INV_{i,r,s,t} = a_{i,r,s}B_{r,t}KTOT_{i,s,t}e^{\alpha WKi,s,t} \tag{A67}$$

$$WK_{i,s,t} = PK_{i,s,t} + \frac{Profit_{i,s,t}}{KTOT_{i,s,t}} \tag{A68}$$

$$INVTOT_{s,t} = \sum_{i,r} INV_{i,r,s,t} \tag{A69}$$

10- Regional Equilibrium

$$Lbar_{r,t} = \sum_{j} L_{j,r,t} \tag{A70}$$

$$TEbar_{r,t} = \sum_{j} TE_{j,r,t} \tag{A71}$$

$$Hbar_{r,t} = \sum_{j} H_{j,r,t} \tag{A72}$$

$$\begin{aligned} REV_{r,t} + SOLD_{r,t} \quad = \quad & \sum_{i,s} PK_{i,s,t} K_{i,r,s,t} + \sum_{i,s} Profit_{i,r,t} \frac{K_{i,r,s,t}}{KTOT_{i,s,t}} \\ & + \sum_{s} (RQUOTA_{r,s,t} - RQUOTA_{s,r,t}) + RECTAX_{r,t} \\ & \sum_{i} PRN_{i,r,t} RN_{i,r,t} + Lbar_{r,t} PLbar_{r,t} \\ & + TEbar_{r,t} PTEbar_{r,t} + Hbar_{r,t} PHbar_{r,t} \end{aligned} \tag{A73}$$

$$GDP_t = \sum_{i,r} PVA_{i,r,t} VA_{i,r,t} \tag{A74}$$

$$epa_r REV_{r,t} = \sum_{i,s} PINVTOT_{s,t} INV_{i,r,s,t} \tag{A75}$$

11- Factor Mobility

$$PL_{j,r,t} = PLbar_{r,t} \tag{A76}$$

$$PTE_{j,r,t} = PTEbar_{r,t} \tag{A77}$$

$$PH_{j,r,t} = PHbar_{r,t} \tag{A78}$$

12- Dynamics

$$K_{i,r,s,t} = K_{i,r,s,t-1}(1-\delta) + INV_{i,r,s,t} \tag{A79}$$

$$Lbar_{r,t} = d_r Lbar_{r,t-1} \tag{A80}$$

$$Hbar_{r,t} = d_r Hbar_{r,t-1} \tag{A81}$$

Parameters values

d_r =1 in developed countries
d_r =1.015 in developing countries