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A GLOBAL CGE MODEL AT THE NUTS 1 LEVEL FOR TRADE POLICY EVALUATION

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Abstract

This paper aims at building a global CGE trade model at NUTS 1 level (sub-national level) for the EU15 regions. The focus is on the production side. The model is used to assess production reallocation across sectors in each NUTS 1 regions after an agricultural tariff liberalization. Nevertheless, it can also be used to simulate other trade policy reform according to the special objective of the researcher. The model is parsimonious in terms of data at the NUTS 1 level. The unskilled and skilled labour are the source of the heterogeneity across the NUT 1 regions. A stylised model is built in order to interpret the results. A sensitivity analysis on trade policy results according to two different degrees of skilled/unskilled labour mobility (perfect immobility and high mobility within the EU15) is conducted. Moreover, an integrated unskilled/skilled labour market within EU27 is tested.

JEL Classification: F12, F13, D58, Q17

Keywords: computable general equilibrium models, international trade

1. Introduction

In recent years the development of the *World Trade Organization* (WTO) has generated a great demand for estimates of potential consequences of trade policy. The Uruguay round and Doha round negotiations are typical examples. *Policy maker* could be interested in having information about the effects of trade liberalization on income, production and other relevant macroeconomic variables. It could also be useful for her/him to know the distribution of these effects across families, countries or sectors to evaluate who are the winners and who are the losers. *Computable General Equilibrium* (CGE) models are an important tool for meeting this need because they allow a lot of trade information to be elaborated in a coherent economic structure where agents maximise their utility and firms maximise their profits. Today many governments and international institutions, e.g. the WTO, the *European Commission* (EC) and the *World Bank* (WB), use CGE models to assess the impact of global trade reform.

While these models are widely used in policy analysis in different areas (international trade, tax policy, income distribution), they were funded and developed in the context of academic research. 'The central ideal is to convert the Walrasian general equilibrium structure (formalized in the 1950s by Kenneth Arrow, Gerard Debreu, and others) from an abstract representation of an economy into realistic models of actual economies.' (Shoven and Walley, 1992, p. 1) The models are solved numerically. In 1967 Scarf found the first algorithm that guaranteed a convergence toward an equilibrium solution. Today specific software, such as GAMS or GEMPACK, makes the computation easy and allows thousands of equations and variables to be solved.

Over the years, the CGE models have evolved by incorporating elements that do not belong to Walrasian framework. The so-called Structuralist CGE models incorporate elements of short-run macro models, including "demand driven" Keynesian equilibria where money is not neutral.

In this work my attention is directed toward large-scale global CGE trade models, such as GTAP, MEGABARE and MIRAGE, used by international organizations (e.g. the WB, the WTO, the EC) for their analysis of trade liberalization.[1] I have chosen this kind of model because I had the opportunity to work with MIRAGE at CEPII.

This type of models maintains a strong Walrasian spirit. Factors are fully employed, money does not explicitly figure into the model and a solution is made possible through relative prices. Nevertheless, some important non-Walrasian assumptions, such as imperfect competition and others, are introduced or can be introduced.

A global approach has the unquestionable advantage of taking into account within the same theoretical structure the trade relationships of all countries or groups of countries in the world, such as the EU, the USA, China, India and Africa. With respect to this, it is very important to have a consistent economic global database that covers all parts of the world. GTAP, based in the Agricultural Economics Department at Purdue University (West Lafayette, Indiana), has been created to satisfy this need; It is a global network of researchers who conduct quantitative analysis of international economic policy issues, especially trade policy. The latest version of the GTAP database, GTAP 7.0 (Narayanan and Walmsley, 2008), is a large *social account matrix* (SAM). It contains complete bilateral trade information as well as transport and protection linkages among 113 countries or groups of countries and 57 sectors for the base year 2004. GTAP is the most widely used dataset for global CGE trade models. It is very rich and practical, however it only allows analysis at the national level.

CGE trade models exist at a sub-national level but they only consider a single region or a handful of regions. The CAPRI-GTAP (Jansson, Kuiper and Adenäuer, 2009), MONASH-MRF (Peter *et al*., 1996) and MIRAGE-DREAM (Jean and Laborde, 2004) models are examples of large-scale global CGE trade models which

[1] GTAP is the acronyms for *Global Trade Analysis Project*. The MEGABARE model has been developed by ABARE (*Australian Bureau of Agricultural and Resources Economics*). MIRAGE stands for *Modelling International Relationships in Applied General Equilibrium*, it has been developed by CEPII (*Centre d'Etudes Prospectives et d'Informations Internationales*).

also include many regions.[2] MONASH-MRF refers to the Australian regions, CAPRI-GTAP is specific to the agriculture sector of the EU and MIRAGE-DREAM considers the NUTS (*Nomenclature d'Unités Statistiques*) regions of the 25 members of the EU (Romania and Bulgaria did not belong to the EU in 2004).[3]

There are so few models because there is a lack of well-suited regional data concerning foreign trade. For instance, in the EU there is no complete dataset on foreign trade that is available for the NUTS regions. Concerning foreign trade, some information is available for some countries at the regional level, but this is not systematically the case. Thus, simplifying assumptions must be made to make the models manageable. In addition, this kind of model is very demanding both in terms of data and computational resources. Research teams, supported by public institutions, work on these models which are highly disaggregated at the geographical level.

The objective of this work is to build a global CGE trade model at the NUTS 1 level for the 68 regions within the first 15 member states of the European Union. The aim is not to exactly reproduce the models mentioned above but, taking advantage of my work experience at CEPII, the aim is to build a simple parsimonious CGE model. Data on value added, skilled labour and unskilled labour are available at the NUTS 1 level while simplifying assumptions arise for the remaining variables. Therefore a CGE trade model is built in which only the production is specified at the NUTS 1 level.

This type of model should allow the consequences of trade policy in Europe to be investigated at a disaggregated geographical level while maintaining a global approach. This is of interest at both the theoretical and empirical levels.

[2] CAPRI is an acronym for *Common Agricultural Policy Regional Impact Analysis*. MONASH-MRF model has been developed at Monash university, MRF stands for *Multi-Regional Forecasting*. DREAM stands for *Deep Regional Economic Analysis Model*.

[3] The *Nomenclature d'Unités Statistiques* is a sub-national geocode standard developed by the European Union for referencing the subdivisions of European countries for statistical purposes. There are 3 level of aggregation: level 1 (more aggregated), level 2 (medium aggregated) and level 3 (less aggregated).

It is of theoretical interest because it helps one to understand how this kind of model works from an economic point of view. Its relative simplicity allows the results to be interpreted.

It is of empirical interest because the knowledge gained about the geographical disaggregated effects could be useful information for the *policy maker*. In fact, trade liberalization implies strong distributional effects not only across people but also across the regions of a given country. Just as there can be winner and loser countries, there can also be winner and loser regions and the *policy maker* could be interested in compensating loser regions for equity.

The model is used to analyse the output reallocation across sectors in each region after a trade shock and this source of information could be useful for a *policy maker* in order to implement, for example, the right outplacement policy.

The EU economy is very diversified and world trade agreements do not take into account the disparities existing at regional level. This geographical heterogeneity in the EU should be considered in WTO negotiations. In addition, it is of interest to assess how European workers respond to trade shock. Will they migrate to another European region?

The model has been built starting from the updated version of the MIRAGE model (Decreux and Valin, 2007) but several important changes have been introduced. As a result, the model must be considered apart from MIRAGE, as my original contribution.

My approach is also different from that used by Jean and Laborde (2004) in the MIRAGE-DREAM model, where a NUTS 1 representative regional household, as well as a NUTS 1 representative regional firm appear. Their model is very demanding both in terms of data and computational resources. However, the lack of well-suited data concerning trade across NUTS 1 regions and between NUTS 1 regions and countries outside of Europe makes it necessary to resort to simplifying assumptions.

In contrast, I have built a parsimonious CGE model which uses relatively little information at the NUTS 1 level, i.e. the value added, skilled and unskilled labour. Only the production side is considered at the NUTS 1 level. In each NUTS 1 region, a representative firm maximises profits. Simplifying assumptions are made for all the variables of production other than value added, skilled and unskilled labour.

The demand side continues to be specified at the EU15 level. This means that imports, exports, domestic demand, as well as the associated prices, are at the EU15 level. This implies, for example, that the price of goods, paid by the EU15 representative household, is the same in all the NUTS 1 regions. Thus, the focus is on production.

The CGE models usually give a poor economic interpretation of trade policy effects. For this reason, I have built a stylised model, which reproduces the main features of my big model, in order to better understand the underlying economic functioning.

In addition, I conduct a sensitivity analysis on trade policy results according to two different degrees of skilled/unskilled labour mobility (perfect immobility and high mobility within EU15). Moreover, an integrated unskilled/skilled labour market within EU27 is tested.

I assume perfect competition and constant returns to scale to hold in all the sectors. The paper is organized as follows. In section 2 the two dataset are described, the regional one and national one, as well as the procedure used to match them. In section 3 the chosen sectoral and geographical aggregations are presented. In section 4 the theoretical structure is set out. In section 5 the calibration strategy is described. In section 6 the trade policy shock is illustrated. In section 7 the results of trade policy on production reallocation across sectors in each region are presented as well as the results of the sensitivity analysis which is conducted to test the relevance of the assumption about skilled/unskilled labour mobility. Further interesting results are shown in this section, such as welfare analysis at the macro-area level, the change in the trade pattern and the unskilled/skilled labour migration. In section 8 a stylised model is proposed for interpreting the results. Section 9 concludes.

2 Database

Two different databases are used: a national database and a sub-national database. The national database is GTAP 6 (Dimaranan and Mac Dougall, 2005). It is a large SAM for 87 countries or groups of countries and 57 sectors. It contains information on bilateral trade flows and transports linkages among countries. It also incorporates the Macmap database for tariff barriers. Macmap is a highly esteemed dataset on trade protection. It includes *ad valorem* equivalent measure of specific tariff, *ad valorem* tariff and tariff quotas. In addition, preferential agreements are taken into account in a quasi-exhaustive way. As a result, the description of trade barriers preserves the bilateral dimension of the information. A special procedure is designed to limit the extension of the bias that occurs when data are aggregated according to the nomenclature chosen for trade policy experiments (Bouët *et al.*, 2004). The base year for the GTAP 6 version is 2001.

The sub-national database is derived from EUROSTAT. I draw on the methodology used by Laborde and Valin (2007) to obtain value added, skilled and unskilled labour at the NUTS 1 level. Laborde and Valin use *e2vabp95*, *sbs_r_NUTS_03* and *lf2eedu* EUROSTAT tables, which consider 247 NUTS 2 regions in the EU25.[4] The *e2vabp95* table contains the NUTS 2 value added for 16 NACE sectors. The *sbs_r_NUTS_03* table contains data on employment at NUTS 2 level for 63 NACE sectors. The *lf2eedu* table contains NUTS 2 data on employment listed by the highest level of education attained.

The *sbs_r_NUTS_03* table does not contain any precise data for employment in the agricultural sector. Thus, it is supplemented by the *a2acc797* EUROSTAT table, which provides data on the production of 39 agricultural products. The agricultural employment is divided among the NUTS 2 regions according to the production share of each NUTS 2 region.

The *e2vabp95* table provides data on value added in only 16 NACE sectors. In order to have more detailed information, value added in each country is distributed at

[4] Data are not available for Bulgaria, Romania and French Overseas Territories.

a more detailed sector level by using the GTAP 6 database. This new value is then distributed among the NUTS 2 regions according to employment share computed in the *sbs_r_NUTS_03* table.

To determine skilled and unskilled labour, Laborde and Valin refer to the *lf2eedu* table of EUROSTAT. The table provides the number of low skilled, medium skilled and high skilled labour for each NUTS 2 region. The EUROSTAT database defines skilled and unskilled labour based on the ISCED (*International Standard Classification of Education*) classification, i.e. according to the highest level of education attained. In contrast, GTAP uses the ILO (*International Labour Organisation*) classification. In GTAP, the skilled labour (professional workers) category is made up of managers and administrators, professionals and para-professionals. Trades-persons, clerks, salespersons and personal service workers, plant and machine operators and drivers, labourers and related workers, and farm workers comprise the unskilled labour (production workers) category. Considering that the medium-level in EUROSTAT corresponds to the ISCED levels 3 and 4 and that the analysis is conducted over developed countries, Laborde and Valin match low and medium-levels of education with unskilled labour and the high level of education with skilled labour.

Unfortunately no data are available to date from EUROSTAT concerning the distribution of skilled and unskilled workers across sectors in the NUTS regions. Thus the authors adopt the following methodology to divide skilled and unskilled workers across sectors:

1) At the national level, a mean wage $\overline{W}_{l,c}$ is computed for each labour type l (unskilled and skilled) and for each European country c by dividing remuneration (GTAP data) by the number of employees in 2001 for each labour type l (unskilled or skilled) and for each European country c computed by using *lf2eedu* table.

2) For each labour type l, each European country c and each sector i, GTAP data are then used to calculate the share $\alpha_{l,c,i}$ of skilled and unskilled labour in the total remuneration on a national basis.

The following formula is used:

$$\sum_{l} \alpha_{l,c,i} = 1 \tag{1}$$

3) It is assumed that the remuneration of each NUTS 2 region *nut* within a country has the same sectoral skilled/unskilled distribution as the country to which it belongs. Thus, it is possible to determine the remuneration *REM* for each labour type *l*, each sector *i* and each NUTS 2 region *nut* by multiplying the share $\alpha_{l,c,i}$ (GTAP data) by total NUTS 2 remuneration in each sector *i* obtained from the *sbs_r_NUTS_03* and *a2acc797* EUROSTAT tables according to the following formula:

$$REM_{l,nut,i} = \alpha_{l,c,i} \cdot REM_{nut,i} \tag{2}$$

4) Finally, assuming the mean wage $\overline{W}_{l,c}$ to be homogeneous across sectors in each NUTS 2 region within a country, the value of employment *EMP* in each NUTS 2 region *nut*, sector *i* and type *l* is determined as follows:

$$EMP_{l,nut,i} = \frac{REM_{l,nut,i}}{\overline{W}_{l,c}} \tag{3}$$

It should be noted that EUROSTAT tables have some missing values. Filling methodologies have been applied by the authors by using other complementary tables from EUROSTAT and GTAP information (see Laborde and Valin, 2007). Most of the EUROSTAT data are from 2003 which is the most recent year that has the smallest number of missing values. However, when no data is available in 2003, data from 2001 and 2002 are used. To summarize, I can use a national database (GTAP 6) with 87 countries or groups of countries and 57 sectors, and a sub-national database (EUROSTAT) with 247 NUTS 2 regions and 39 NACE sectors.[5]

[5] 39 is a compromise based on different EUROSTAT tables which have been used in addition to the GTAP information incorporated into the NUTS 2 dataset.

3 Sectoral and geographical aggregations

In this section I set out the sectoral and geographical aggregations chosen for the model and trade policy simulations.

Two levels define geographical aggregation: one level is for three macro-areas and the other one is for the 68 NUTS 1 regions in the EU15. The first level is used to define demand side variables. There are three macro-areas: the EU15, the rest of Europe (REU) and the rest of the world (ROW). I distinguish between the EU15 and the REU because EUROSTAT database is more precise for the first fifteen member states of the European Union. In addition, Bulgaria and Romania do not figure in the NUTS database. Finally, it is reasonable to think EU15 and REU as more homogenous economic macro-areas. The second geographical level is used to define production side variables. There are 68 NUTS 1 regions within EU15. ROW and REU production variables continue to be defined at the first geographical level.

Concerning sectoral aggregation there are four sectors. A small number of sectors is preferable because the aim is not to assess trade policy effects with respect to a special sector but rather to understand general equilibrium effects of production reallocation across the NUTS 1 regions. Table 1, Table 2 and Table 3 display chosen aggregations.

Table 1: first geographical level of aggregation (3 Macro-areas)

Macro-areas	
EU15	Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal, Spain, Sweden, United Kingdom
REU	Bulgaria, Cyprus, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Romania, Slovakia, Slovenia
ROW	Rest of the world

Table 2: second geographical level of aggregation (68 NUTS 1 regions)

	NUTS 1 regions
Austria	**East Austria, South Austria, West Austria**
Belgium	**Brussels Capital Region, Flemish Region, Walloon Region**
Denmark	**Denmark**
Finland	**Mainland Finland, Åland**
France	**Île-de-France, Parisian basin, Nord-Pas-de-Calais, East, West, South West, Centre East, Mediterranean**
Germany	**Baden-Wüttenberg, Bavaria, Berlin, Brandenburg, Bremen, Hamburg, Hessen, Mecklenburg-Vorpommern, Lower-Saxony, North Rhine-Westphalia, Rhineland-Palatinate, Saarland, Saxony, Saxony-Anhalt, Schleswig-Holstein, Thuringia**
Greece	**Voreia Ellada, Kentriki Ellada, Attica, Nisia Aigaiou-Kriti**
Ireland	**Ireland**
Italy	**North West, North East, Centre, South, Islands**
Luxembourg	**Luxembourg**
Netherlands	**North Netherlands, East Netherlands, West Netherlands, South Netherlands**
Portugal	**Portugal**
Spain	**North West, North East, Community of Madrid, Centre, East, South**
Sweden	**Sweden**
United Kingdom	**North East England, North West England, Yorkshire and the Humber, East Midlands, West Midlands, East of England, Greater London, South East England, South West England, Wales, Scotland, Northern Ireland**

Table 3: sectoral aggregation (4 sectors)

Sectors	
AGM	Agriculture and minerals
PRM	Primary energy sources
IND	Manufactures
SERV	Services

4 The theoretical structure of the model

In this section I explain the theoretical structure of the model. I identify four main parts: demand side, supply side, factor markets and macroeconomic closure.

4.1 Demand

As stated above, all demand variables are defined at macro-areas level mainly because of the lack of well-suited trade data among NUTS 1 regions and between NUTS 1 regions and foreign countries. This implies that the price of each demand variable is equal for all the NUTS 1 regions. Unlike the DREAM-MIRAGE approach and for the sake of simplicity, trade-relationships are specified for the EU15 as whole and not by each single European country.

As in MIRAGE total demand is made up of final consumption, intermediate inputs and capital goods. In each macro-area a representative household chooses the optimal sectoral composition of its final consumption by maximising a LES-CES utility function subject to household budget constraint.

The demand for capital goods in each sector is specified through a CES function. Intermediate inputs enter in the production side, therefore in the next sub-section I will lay out assumption about this variable.

Standard Armington assumption is introduced. Product differentiation according to the first geographical level of aggregation is modelled by a CES function.

As in MIRAGE, in each macro-area representative household includes the government. Household pays and earns taxes so that public budget constraint is implicit to meet its budget constraint. Any decrease in tax revenues (for example as a consequence of trade liberalization) is assumed to be exactly compensated by a non-distorting replacement tax. Representative household owns factor endowments.

Figure 1 illustrates demand structure in each sector and in each one of the 3 macro-areas. In the rectangle I put the variable, in the rhomb the functional form used; *i* represents sectoral general index while σ^{ARM} and σ^{IMP} are, respectively, elasticity of substitution between domestic and foreign aggregate good and elasticity across foreign goods.

4.2 Supply

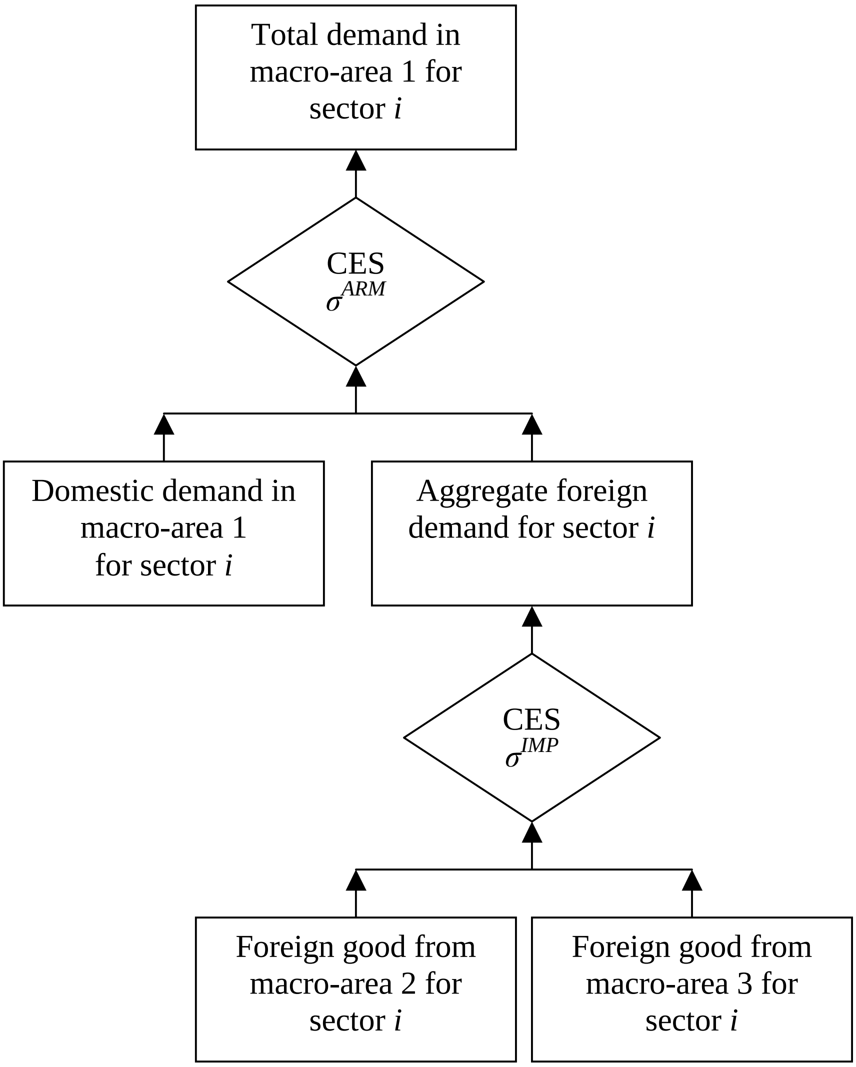
The supply side is specified at NUTS 1 level. Its structure is close to one used in MIRAGE model, but the latter doesn't specify the production at sub-national level.

In each one of the 68 NUTS 1 regions a representative firm maximises profit. It uses primary factors to obtain value added and intermediate inputs to obtain aggregate intermediate input. Value added and aggregate intermediate input are linked by a Leontief technology to produce output. Thus, it is assumed perfect complementarity between value added and aggregate intermediate input.

In every sector of each NUTS 1 region aggregate intermediate input is defined by a CES function among intermediate goods of all other sectors. Therefore, intermediate goods are used as intermediate inputs in the production side but also they enter in the demand side together with the final consumption and capital goods.

Concerning value added as in GTAP and MIRAGE model there are 5 primary factors: skilled labour, unskilled labour, capital, land and natural resources. The value added follows a two stage structure. At the first stage value added is given by a CES combination of land, unskilled labour, natural resources and a fictive factor.

Figure 1: demand structure



The latter is defined at the second stage. It is a bundle between capital and skilled labour; this modelling draws on MIRAGE and allows for the complementarity among the 2 primary factors which has been described in the empirical literature (Duffy, Papageorgiou and Perez-Sebastian, 2004). Therefore, as in MIRAGE, this implies that the elasticity of substitution between skilled labour and capital (σ^{Q}) is smaller than the elasticity of substitution between fictive factor and the other primary factors (σ^{VA}).

Perfect competition and constant returns to scale hold in all the sectors.

Figure 2 illustrates supply structure for each one of the 68 NUTS 1 regions and each one of the 4 sectors; *nut* represents general index for NUTS 1 region while σ^{VA}, σ^{INI} and σ^{Q} are, respectively, elasticity of substitution across primary factors, among intermediate inputs and between capital and skilled labour. Sector 1 represents anyone of the 4 sectors.

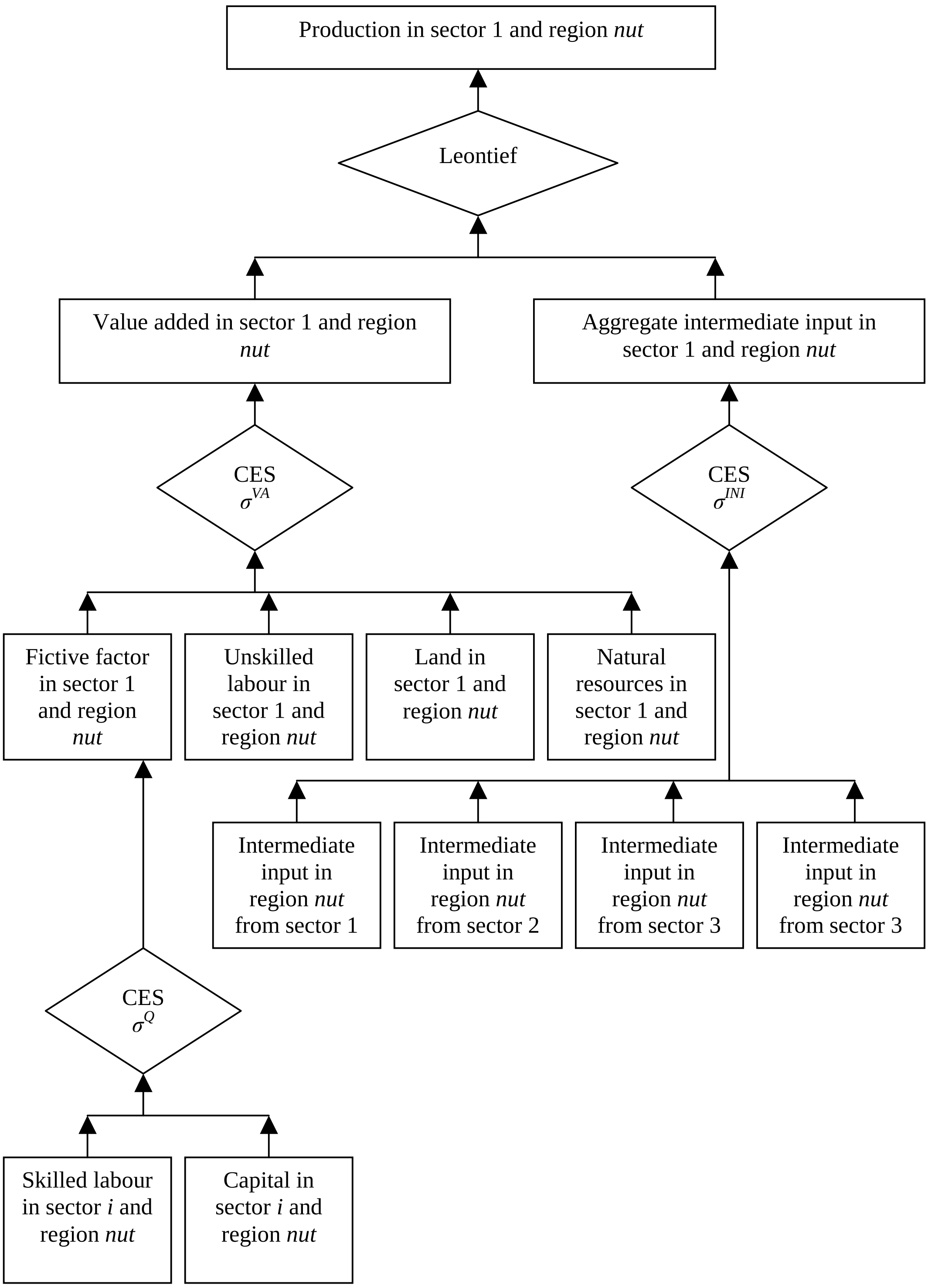
4.3 Factor markets

Factor endowments are assumed to be fully employed.

Land and natural resources are immobile in each NUTS 1 region and in each sector. However, land is used only in agricultural sector and natural resources are used only in agricultural and primary energy sources sectors.

Skilled and unskilled labour are perfectly mobile across the sectors. Concerning geographical labour mobility, in each macro-area skilled and unskilled workers maximise wage income subject to a CET (*Constant Elasticity of Transformation*) constraint. This implies imperfect mobility within the EU15 and different wages across the NUTS 1 regions.

Figure 2: supply structure



Sensitivity analysis is conducted to test the relevance of the assumption about skilled/unskilled labour mobility; 2 different values of the elasticity of migration in the CET function are simulated to analyse how the results of trade policy shock change at the NUTS 1 level.

ROW (rest of the world) and REU (rest of Europe) macro-areas are not divided into regions, thus it doesn’t make sense to think about geographical unskilled/skilled labour mobility. Nevertheless, an integrated EU27 labour market can be considered. In this integrated labour market skilled and unskilled workers can move not only within EU15 NUTS 1 regions but also between EU15 NUTS 1 regions and the rest of Europe (REU).

Unlike MIRAGE capital supply is perfectly mobile across sectors and within each macro-areas. It is then distributed among sectors and NUTS 1 regions according to first order conditions for profit maximisation with respect to capital factor.

4.4 Macro-economic closure

Macro-economic closure is neoclassical. Investment is savings-driven. It is determined by the income and the exogenous saving rate for the representative household in the macro-area. In equilibrium the value of investment equals the value of total demand for capital goods.

External current account balance is fixed, therefore the net flow of foreign income doesn’t depend on a world interest rate. Unlike MIRAGE, the model doesn’t take into account the role of FDI, which is useful to analyse especially in a dynamic set-up.

My model is static. As a result, no transitional dynamic is considered. Comparative static must be interpreted as medium or long-run effects because capital is perfectly mobile across sectors and within each macro-area, which are very large.

It is worthwhile to recall that income is defined at macro-area level. Thus, the computation of welfare change by the standard equivalent variation measure cannot be carried out at NUTS 1 level. As stated above, the focus of this work is on the production side.

5 Calibration

Calibration represents a very important stage in the building of a CGE model. The calibration strategy results crucial because trade policy effects can be very sensitive to the value of the parameters.

I obtain value added (*VA*), unskilled labour (*L*) and skilled labour (*H*) from EUROSTAT database. Simplifying assumptions arise to determine the other variables of the production side. For this reason repartition key of value added at NUTS 1 level is used to regionalize the other production variables, according to the following:

$$KEYVA_{i,nut} = \frac{VA_{i,nut}}{VA_{i,EU15}} \tag{4}$$

$$TE_{i,nut} = KEYVA_{i,nut} \cdot TE_{i,EU15} \tag{5}$$

$$RN_{i,nut} = KEYVA_{i,nut} \cdot RN_{i,EU15} \tag{6}$$

$$K_{i,nut} = KEYVA_{i,nut} \cdot K_{i,EU15} \tag{7}$$

$$INI_{j,i,nut} = KEYVA_{i,nut} \cdot INI_{j,i,EU15} \tag{8}$$

where i and j are sector index and *KEYVA* is the repartition key of value added; *TE*, *RN*, *K* and *INI* are, respectively, land, natural resources, capital and intermediate inputs (sold by sector j to sector i). Eq. (8) implies an additional assumption for intermediate inputs, i.e. the distribution of intermediate inputs among NUTS 1 regions in sector *i* doesn't depend on sector that sells the intermediate good.

It is reasonable to think that a greater valued added in the NUTS 1 region means a greater use of primary factors and intermediate inputs. Obviously, this hypothesis neglects the fact that 2 equal NUTS 1 regions in terms of factor endowments can use primary factors and intermediate inputs through different intensities, i.e. they can have different technologies. Data constraints force me to do this choice.

Thus, skilled and unskilled labour are the only 2 factors which preserve their original heterogeneity at NUTS 1 level. In section 8 it will be shown that they result decisive to explain trade policy effects.

All parameters are calibrated to reproduce SAM in the base year (2001). Most of them can be directly determined through the available data. However, for some of them, as CES elasticities, this operation is not feasible and, therefore, I explicitly refer to the latest version of MIRAGE model (Decreux and Valin, 2007), which, in turn, draws elasticities from empirical literature or plausible assumptions.

Final consumption, capital goods and intermediate inputs have all the same elasticity of substitution across sectors. Its value is 0.6 for all the 3 variables.

The elasticity of substitution across unskilled labour, land, natural resources and fictive factor $\left(\sigma_{VA}\right)$ is equal to 1.1 for all four sectors. The fictive factor is a combination between capital and skilled labour. As noted above, the fictive factor allows for skill labour/capital complementarity. For this reason the elasticity of substitution between skilled labour and capital $\left(\sigma_{CAP}\right)$ is less than 1.1 and it is equal to 0.6.[6]

The elasticities of substitution between domestic and foreign aggregate good $\left(\sigma_{ARM_i}\right)$, i.e. Armington elasticities, are drawn from the GTAP 6 database. The

[6] According to many studies (see Cahuc and Zylberberg for a survey, 1996) the elasticity of substitution between skilled labour or capital and unskilled labour is close to unity. However, Decreux *et al*. (2003) show that the true value of the parameter also depends on the level of sectoral aggregation.

Armington elasticity and the elasticity of substitution across foreign goods $\left(\sigma_{IMP_i}\right)$ are linked by the following relation:

$$\sigma_{IMP_i} - 1 = \sqrt{2}\left(\sigma_{ARM_i} - 1\right) \qquad (9)$$

In the model the Armington elasticity is set exogenously and only depends on the sector; for agriculture it is equal to about 3.4, for primary energy sources 10.9, for manufactures 4.6 and for services 2.9. The elasticity of substitution across foreign goods is then calibrated residually using Eq. (9).

An other important parameter is the elasticity of migration in the CET function, which determines skilled and unskilled labour supplies in each NUTS 1 region. Putting this parameter equal to zero means perfect immobility at NUTS 1 level. In contrast, rising its value increases labour mobility within EU15.

In MIRAGE-DREAM the value of elasticity of migration is chosen mainly on the basis of Eichengreen's work (1993). Using a panel data analysis, Eichengreen finds that the elasticity of inter-regional migration with respect to unemployment and wage differentials is smaller in the United Kingdom and Italy than that observed in the United States. This suggests that migration is less responsive to demand shocks in these European countries than in the United States.

A *Policy maker* is likely to be interested in labour reallocation across the NUTS 1 regions after a trade policy reform. Therefore, the elasticity of migration is a very interesting parameter. For this reason and unlike to MIRAGE-DREAM model, a sensitivity analysis has been conducted to test the relevance of this parameter for the determination of trade policy results. As a result, the parameter can assume two different values (zero and ten) according to the simulated scenario.

The numeraire is the utility price of the representative household in the ROW macro-area.

6 Trade policy simulation

CGE models are widely used to simulate scenarios of trade policy liberalization, for example in the Uruguay round and Doha rounds. The latter is the current trade negotiations of the WTO. Its objective is to lower trade barriers around the world to help the development of the international trade. The Doha round started in 2001 and it has not still been accomplished.

Doha negotiations can be very complex. Indeed, the agreement must be accepted by all the 153 WTO members (unanimity principle) and tariff cuts are harmonised in order to reduce trade distortions among countries.[7] In addition, the WTO fully recognizes the heterogeneity among its members; therefore no commitment is required from least developed countries and less commitment is expected from middle income countries. This means smaller rate cuts for tariffs and subsidies and longer implementation period.

This model does not aim at exactly simulating scenarios of trade policy liberalization in the current Doha round. The main objective is to shed light on possible outcomes of global trade liberalization at the NUTS 1 level. As noted above, the focus in on the production side.

I start from MIRAGE to model trade barriers. The picture of trade barriers is rich in the latest version of MIRAGE (Decreux and Valin, 2007).

The market access measure stems form MACMAP database and includes specific tariff, *ad valorem* tariff and tariff quotas. In addition, preferential agreements are taken into account. Domestic supports on land and output are also introduced; they are assumed to be proportional to the volume of output or factor. Production quotas are considered; they generate rents.

MIRAGE introduces also a price intervention mechanism to give more realism to European agricultural trade policy and to make exportation subsidies endogenous. Basically three options are possible. When internal prices are higher than the intervention price (first option), no export support is given. When internal prices are

[7] For example, the so-called Swiss formula tends to cut higher tariff rates more than lower ones, since the latter are supposed to be less trade-distorting.

lower than the intervention price (second option), producers receive subsides to sustain production prices at the intervention level. Finally, an equation in the model forces subsides exports to stay below the WTO ceiling (third option). For countries other than European Union the export subsidy rate is set exogenous.

In my model I put this rich picture of trade barriers aside to concentrate my attention on market access measure. I do this choice for two reasons. First I want to preserve the simplicity of my model in order to be able to better interpreting its outcomes at the NUTS 1 level. Second, I want to make the most of MACMAP database.

MACMAP (Bouet *et al.*, 2004) is the most comprehensive tariff database currently available. It was expressly created for CGE trade models. As stated above, MACMAP provides a very good measure of market access. This measure is a consistent *ad valorem* equivalent of specific tariffs, *ad valorem* tariffs and tariff quotas. Moreover and considerably this dataset allows for preferential agreements preserving the information at bilateral level. A very good point for CGE modellers and researchers is the special procedure, which is designed to limit the extension of the bias occurring when data are aggregated according the nomenclature chosen for trade policy experiment. Before the creation of MACMAP database assessment of multilateral trade policy liberalization was carried out without taking into account specific tariff nor preferential agreements.

The 2004 version of MACMAP is used in GTAP 6 database; the base year is 2001. The most recent version of MACMAP (see Boumelassa, Laborde and Mitaritonna, 2009) is used in GTAP 7; the base year is 2004. In my model I use GTAP 6, thus the older version of MACMAP database. However, global market access has not changed substantially from 2001 to 2004 mainly because Doha round is still ongoing. Overall average tariff protection has decreased by 0.5 % point from 5.6 % in 2004 to 5.1% in 2001. This reduction is primarily due to middle income countries, which had to achieve their Uruguay round commitments within 2004 and to unilateral liberalizations.[8]

[8] China and India, for example, unilaterally cut tariffs for their industrial products to complete their WTO accession.

According to MACMAP database and its *ad valorem* equivalent measure, the market access is the following in 2001. The agriculture is the most protected sector. The world average is 19.1%. Average agricultural protection ranges from 2.7% in Australia to 59.6% in India. Manufacturing products outside textile and apparel are less protected sector in average (4.2%). However tariffs are low in developed countries but remain high in developing country. Tariff in textile and apparel sectors are also high both in developed and developing countries. Services market access is a problematic concept, since explicit tariffs do not exist. Sometimes equivalent tariffs for services are estimated using gravity equations.

Table 4 shows *ad valorem* equivalent rate for the geographical and sectoral nomenclature chosen in my model. Basically, the parameter enters in the demand side by the following equation:

$$PDEM_{i,mac,mac*} = PY_{i,mac} \cdot \left(1 + DD_{i,mac,mac*}\right) \tag{10}$$

where *PDEM* is the price for the good *i* produced in the macro-area *mac* and paid by the macro-area *mac**, *PY* is the price (marginal cost) for the good *i* produced in macro-area *mac* and the parameter *ATR* is the *ad valorem* tariff rate applied by the macro-area *mac** and paid by the macro-area *mac* for the good *i*. Table 4 confirms the previous facts about trade barriers.[9] Since the agricultural sector is the most protected one, I decide to implement a multilateral tariff liberalization in agriculture. Therefore, all the *ad valorem* tariff rates are set to zero in the agricultural sector for all the macro-areas (values in bold in Table 4).

As noted at the beginning of this section, the trade policy simulation does not try to reproduce the current Doha round. Especially for the market access in the agricultural sector the definition of the tariff reduction involves very technical issues, such as the formula adopted for the cuts, the definition of the "sensitive products",

[9] Not surprisingly, tariff barriers appear between EU15 and the rest of Europe, as 12 countries were not European members in 2001.

which are partly excluded from the general tariff reduction, and the commitments for the developing countries (Anania and Bureau, 2005).

Table 4: % *ad valorem* equivalent tariff

		ROW	EU15	REU
AGM	ROW	**14.73**	**5.27**	**5.65**
AGM	EU15	**10.70**		**10.37**
AGM	REU	**12.69**	**4.95**	**6.11**
PRM	ROW	1.64		0.20
PRM	EU15	0.01		0.00
PRM	REU	0.30		0.88
IND	ROW	5.10	2.83	6.85
IND	EU15	6.10		3.38
IND	REU	6.97	0.76	3.97

Notes: the second column shows macro-area paying tariff, the first row macro-area applying tariff.
Source: GTAP 6 database.

Consequently, the trade policy simulation in this model has to be interpreted as an illustrative exercise on the possible effects at the NUTS 1 level of a multilateral tariff liberalization in agriculture.

The role of export subsidies and domestic supports in agricultural trade liberalization is not assessed. However, it can be useful to recall a study of Hertel and Keeney (2005). The authors use the GTAP model to simulate a full liberalization of the agricultural sector by high-income countries. According to this work, full liberalization of agricultural sector determines an overall $47.6 billion gain. More than 90% of the benefits come from improved market access, i.e. the removal of the *ad valorem* equivalent tariffs, while the impact of supports and export subsidies is limited.[10] Even if this model is used to assess tariff liberalization in agriculture, it can be applied to other sectors according to the special interest of the researcher.

[10] Hertel and Keeney use MACMAP database for tariff barriers and OECD estimates for producer support in agriculture. The authors use data assembled by Aziz Elbehri of the U.S. Department of

7 Simulation results

In this section the results of trade policy simulation (world agriculture liberalization) are presented. GAMS software and the CONOPT 3 algorithm are used; there are 5197 equations and 5197 variables.

In subsection 7.1 the production reallocation in volume across sectors in the NUTS 1 regions is shown. In subsection 7.2 the impact of unskilled/skilled labour mobility on the results of previous subsection is assessed. Finally, in subsection 7.3 further interesting results such as unskilled/skilled labour migration within Europe and the change in total value added at the NUTS 1 level are illustrated; the changes in the trade patterns and welfare are also displayed at the macro-area level.

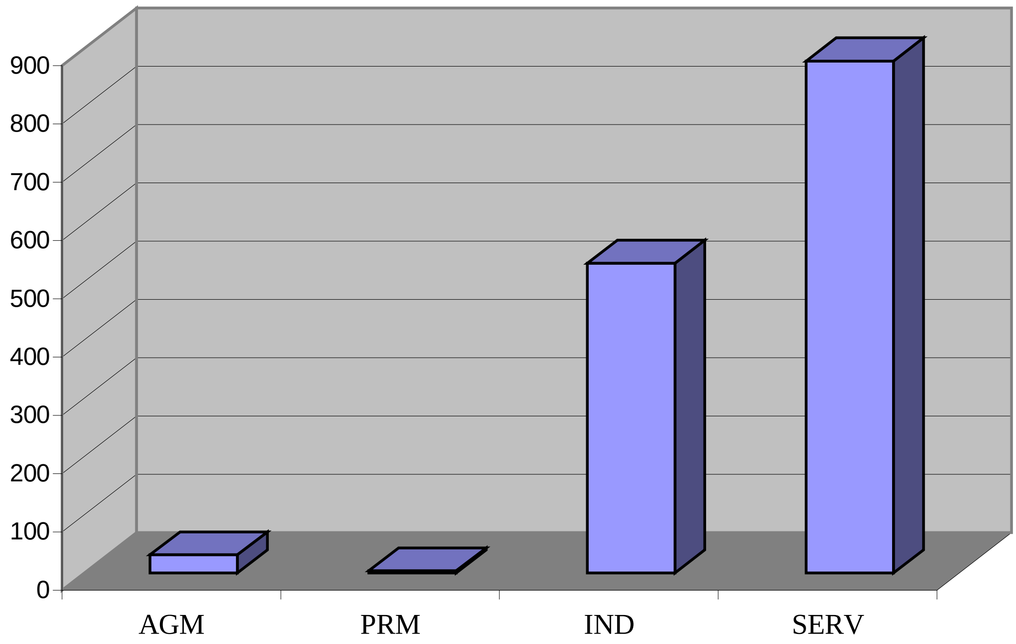
7.1 Production reallocation across sectors in the NUTS 1 regions after a world trade liberalization in the agricultural sector

In this section the results are shown regarding the production reallocation in volume across the four sectors in each of the 68 NUTS 1 region within the EU15 after a world trade liberalization in agricultural sector. In order to have an overview of the sectoral weight in the EU15 the value of each sector in 2001 (the base year in GTAP 6) is reported in *Figure 3*. Not surprisingly, services (SERV) is the most important sector (more than 2001 $8000 billion), followed by manufactures (IND) and the agricultural sector (AGM). The weight of primary energy sources is very small.

The results of this subsection are obtained under the assumption of unskilled/skilled labour immobility at the NUTS 1 level, i.e. workers have to stay in the NUTS 1 region to which they belong. This hypothesis is formalized by assuming that the elasticity of migration in the CET functions (see Appendix 4) is equal to zero, and denoting with the σ_L and σ_H, respectively, the elasticity of migration for the unskilled factor and skilled factor.

Agriculture's Economic Research Service for export subsidies. All the datasets are incorporated in GTAP 6 having 2001 as the reference year.

Figure 3: production by sector in the EU15 macro-area



Source: GTAP 6 database.
Notes: tens of $ billion in 2001.

Before showing results at the NUTS 1 level, simulated effects of liberalization at the macro-area level are reported in Table 5. In the EU15 the AGM sector is affected the most, the production decreases in volume by about 1%. Variations are small in the other sectors and macro-areas. Thus, it is interesting to assess if reallocation effects are more important at the NUTS 1 level.

Table 5: % production change in volume at the macro-area level

	ROW	EU15	REU
AGM	0.32	-0.93	-0.58
PRM	-0.10	0.07	0.01
IND	0.01	0.00	0.05
SERV	-0.02	0.05	0.04

Notes: unskilled/skilled labour immobility at the NUTS 1 level within the EU15 ($\sigma_L = \sigma_H = 0$).

Table 6 reports these effects for each one of the 68 NUTS regions. At first glance, it appears that positive and negative magnitudes are higher than the ones observed at the macro-area level. In addition, the changes are negative for all the NUTS 1 regions in the agricultural sector and both negative and positive in manufactures and services.

Table 6: % production change in volume at the NUTS 1 level

	AGM	PRM	IND	SERV
North Netherlands (Netherlands)	-0.81	0.05	0.60	-0.18
East Netherlands (Netherlands)	-0.86	0.05	0.36	-0.11
West Netherlands (Netherlands)	-0.77	0.05	0.56	-0.11
South Netherlands (Netherlands)	-0.91	0.06	0.61	-0.26
Sweden	-0.86	0.07	0.15	-0.06
Denmark	-0.83	0.05	0.10	-0.02
Mainland Finland (Finland)	-0.86	0.08	0.08	-0.03
Åland (Finland)	-0.84	0.05	-0.36	0.07
Ireland	-2.15	0.06	7.02	-2.31
North East England (United Kingdom)	-0.76	0.07	-0.23	0.06
North West England (United Kingdom)	-0.72	0.10	-0.51	0.14
Yorkshire and the Humber (United Kingdom)	-0.71	0.08	-0.35	0.10
East Midlands (United Kingdom)	-0.74	0.07	-0.24	0.09
West Midlands (United Kingdom)	-0.76	0.07	-0.29	0.10
East of England (United Kingdom)	-0.74	0.13	-0.55	0.13
Greater London (United Kingdom)	-0.76	0.06	-0.73	0.06
South East England (United Kingdom)	-1.00	0.11	-0.28	0.05
South West England (United Kingdom)	-0.80	0.07	-0.29	0.07
Wales (United Kingdom)	-0.94	0.07	-0.04	0.02
Scotland (United Kingdom)	-0.82	0.08	-0.24	0.05
Northern Ireland (United Kingdom)	-1.10	0.08	0.89	-0.18

Notes: unskilled/skilled labour immobility at the NUTS 1 level within the EU15 ($\sigma_L = \sigma_H = 0$).

cont Table 6: % production change in volume at the NUTS 1 level

	AGM	PRM	IND	SERV
East Austria (Austria)	-1.74	0.06	2.40	-0.59
South Austria (Austria)	-2.47	0.06	2.99	-1.15
West Austria (Austria)	-1.95	0.06	1.55	-0.63
Baden-Württemberg (Germany)	-0.83	0.09	-0.30	0.23
Bavaria (Germany)	-0.90	0.10	-0.14	0.09
Berlin (Germany)	-0.76	0.08	-0.60	0.11
Brandenburg (Germany)	-0.92	0.11	-0.48	0.14
Bremen (Germany)	-0.73	0.00	-0.37	0.14
Hamburg (Germany)	-0.76	0.08	-0.50	0.11
Hessen (Germany)	-0.78	0.10	-0.47	0.20
Mecklenburg-Vorpommern (Germany)	-1.19	0.09	2.10	-0.50
Lower Saxony (Germany)	-0.79	0.10	-0.29	0.13
North Rhine-Westphalia (Germany)	-0.78	0.10	-0.35	0.16
Rhineland-Palatinate (Germany)	-0.83	0.10	-0.21	0.11
Saarland (Germany)	-0.76	0.10	-0.37	0.19
Saxony (Germany)	-0.87	0.11	-0.33	0.14
Saxony-Anhalt (Germany)	-0.79	0.11	-0.46	0.15
Schleswig-Holstein (Germany)	-0.81	0.09	-0.45	0.15
Thuringia (Germany)	-0.83	0.11	-0.38	0.19
Luxembourg	-1.10	0.05	1.06	-0.27
Brussels-Capital Region (Belgium)	-1.06	0.06	1.94	-0.27
Flemish Region (Belgium)	-0.94	0.06	0.29	-0.11
Walloon Region (Belgium)	-0.96	0.07	0.32	-0.08

Notes: unskilled/skilled labour immobility at the NUTS 1 level within the EU15 ($\sigma_L = \sigma_H = 0$).

cont Table 6: % production change in volume at the NUTS 1 level

	AGM	PRM	IND	SERV
Portugal	-1.47	0.10	-0.69	0.47
North West (Spain)	-0.89	0.09	-0.46	0.21
North East (Spain)	-0.78	0.07	-0.59	0.39
Community of Madrid (Spain)	-0.79	0.09	-1.15	0.27
Centre (Spain)	-0.85	0.09	-0.10	0.11
East (Spain)	-0.77	0.08	-0.84	0.43
South (Spain)	-0.85	0.08	-0.45	0.15
Voreia Ellada (Greece)	-1.10	0.08	0.17	0.10
Kentriki Ellada (Greece)	-0.93	0.07	-0.35	0.30
Attica (Greece)	-1.44	0.07	-1.38	0.47
Nisia Aigaiou-Kriti (Greece)	-0.55	0.07	-7.62	1.62
North West (Italy)	-0.78	0.05	-0.29	0.20
North East (Italy)	-0.81	0.07	-0.30	0.23
Centre (Italy)	-0.88	0.07	-0.25	0.10
South (Italy)	-1.08	0.07	0.04	0.04
Islands (Italy)	-0.97	0.08	0.02	0.03
Île-de-France (France)	-0.92	0.07	0.01	-0.02
Parisian basin (France)	-0.73	0.09	-0.20	0.10
Nord-Pas-de-Calais (France)	-0.82	0.17	-0.13	0.05
East (France)	-0.78	0.07	-0.17	0.09
West (France)	-0.81	0.06	0.01	0.03
South West (France)	-0.84	0.06	-0.10	0.05
Centre East (France)	-0.91	0.09	-0.23	0.11
Mediterranean (France)	-0.78	0.07	-0.60	0.11

Notes: unskilled/skilled labour immobility at the NUTS 1 level within the EU15 ($\sigma_L = \sigma_H = 0$).

In Tables 7, 8 and 9 attention is focused on the ten greatest (positive and negative) changes in the AGM, IND and SERV sectors. PRM is neglected because the variations are generally small and the overall weight is not relevant in the EU15 economy.

Summarizing, South Austria and Ireland display, at the same time, the greatest decrease in agriculture, 2.47% and 2.15%, respectively, the highest increase in manufactures, 2.99% and 7.02%, respectively and the greatest decrease in services, 1.15% and 2.31%, respectively. In contrast, Nisia Aigaiou-Kriti (Greece) and Attica (Greece) have the greatest decrease in the IND sector (7.62% and 1.38%) but the greatest increase in the SERV sector (1.62% and 0.47%).

Using the MIRAGE-DREAM model and simulating a full agricultural liberalization (domestic support and export subsidies included), Jean and Laborde (2004) find that Ireland, Portugal, the NUTS 1 regions of Greece except Athens area, Central and Southern Spain and Southern Italy experience the greatest decreases of agricultural value added in volume.

Consistent with the previous results, in this model the ten strongest production decreases in the AGM sector include Voreia Ellada (Greece), Portugal and Ireland but also Austrian NUTS 1 regions are affected by the shock.

However, in the Jean and Laborde approach (2004) unskilled and skilled labour is imperfectly mobile within each European country of the EU25 and no alternative scenario is given. For this reason in the next subsection the role carried out by the labour mobility is looked at in-depth.

Table 7: the 10 greatest % production decreases in volume at the NUTS 1 level

	AGM
South Austria (Austria)	-2.47
Ireland	-2.15
West Austria (Austria)	-1.95
East Austria (Austria)	-1.74
Portugal	-1.47
Attica (Greece)	-1.44
Mecklenburg-Vorpommern (Germany)	-1.19
Northern Ireland	-1.10
Luxembourg	-1.10
Voreia Ellada (Greece)	-1.10

Notes: unskilled/skilled labour immobility at the NUTS 1 level within the EU15 ($\sigma_L = \sigma_H = 0$).

Table 8: the 10 greatest % production increases or decreases in volume at the NUTS 1 level

	IND
Nisia Aigaiou-Kriti (Greece)	-7.62
Attica (Greece)	-1.38
Community of Madrid (Spain)	-1.15
Luxembourg	1.06
West Austria (Austria)	1.55
Brussels-Capital Region (Belgium)	1.94
Mecklenburg-Vorpommern (Germany)	2.10
East Austria (Austria)	2.40
South Austria (Austria)	2.99
Ireland	7.02

Notes: unskilled/skilled labour immobility at the NUTS 1 level within the EU15 ($\sigma_L = \sigma_H = 0$).

Table 9: the ten greatest % production increases or decreases in volume at the NUTS 1 level

	SERV
Ireland	-2.31
South Austria (Austria)	-1.15
West Austria (Austria)	-0.63
East Austria (Austria)	-0.59
Mecklenburg-Vorpommern (Germany)	-0.50
North East (Spain)	0.39
East (Spain)	0.43
Portugal	0.47
Attica (Greece)	0.47
Nisia Aigaiou-Kriti (Greece)	1.62

Notes: unskilled/skilled labour immobility at the NUTS 1 level within the EU15 ($\sigma_L = \sigma_H = 0$).

7.2 Sensitivity analysis on production reallocation with the introduction of unskilled/skilled labour mobility

In this scenario it is supposed that skilled and unskilled workers can respond to trade policy shock by moving from the NUTS 1 region, to which they belong. There are two possible options. In the first one EU15 workers can move only towards other NUTS 1 region within the EU15. In the second option, EU15 workers and REU workers can move within the EU27. As explained in the section 2.4.3, the unskilled/skilled labour mobility is modelled through a CET function in which σ_L and σ_H represent the elasticity of migration for unskilled factor and skilled factor, respectively. In the first option these parameters refer to the EU15 labour market while in the second option they refer to the EU27 labour market.

Jean and Laborde (2004) use elasticity of migration based on Eichengreen work (1993). As stated above, Eichengreen draws the value of this parameter from data of the United Kingdom and Italy and no distinction is made between unskilled and skilled labour. To the best of my knowledge no specific econometric estimates exist to calibrate unskilled/skilled elasticity of migration for the EU15 and the EU27 in CGE models. Therefore, a sensitivity analysis was carried out to evaluate the impact of the labour mobility hypothesis on trade policy results. As a result, the elasticity values of migration (σ_L and σ_H) are set to 10. Thus, the scenario of previous subsection, characterised by unskilled/skilled labour immobility at the NUTS 1 level, can be compared with the present one, characterised by high mobility within the EU15 or the EU27.

Table 10 reports results for production change in volume at the macro-area level under the assumption of unskilled/skilled labour mobility across the NUTS 1 regions within the EU15. The results in Table 10 compared to those in Table 5 confirm that the AGM is the most affected sector in the EU15 macro-area even if the percent change (-0.76%) is less in magnitude than in the case of labour immobility. The economic responses in services and manufactures remain about the same except for the EU15 manufactures, which are characterised by an increase of 0.13%.

Table 10: % production change in volume at the macro-area level

	ROW	EU15	REU
AGM	0.32	-0.76	-0.57
PRM	-0.07	0.16	0.05
IND	0.01	0.13	0.05
SERV	-0.02	0.08	0.04

Notes: unskilled/skilled labour mobility across the NUTS 1 regions within the EU15 ($\sigma_L = \sigma_H = 10$).

Table 11, Table 12 and Table 13 display the results of the ten greatest (positive and negative) changes in the AGM, IND and SERV sectors at the NUTS 1 level.

According to Table 11, the Austrian agricultural sector is the most stricken because all three of its NUTS 1 regions (South Austria, West Austria and East Austria) are in the first three position of the ranking, however the changes are not great (between 1% and 2%).

In contrast, Table 12 and Table 13 show a very strong reallocation of production in manufactures and services with inverse patterns for some NUTS 1 regions. Indeed, two Greek NUTS 1 regions, Nisia Aigaiou-Kriti and Kentriki Ellada, have the highest positive values for production change in services, 18.64% and 7.53%, respectively, and the greatest negative values for production change in manufactures, -90.00% and -21.04%, respectively. Conversely, Luxembourg and Ireland have the highest positive values for production change in manufactures, 23.33% and 31.40%, respectively, and the greatest negative values for production change in services, -6.06%and -11.09%, respectively. These results do not intend to be realistic because the labour mobility is likely to be too high, but they are a guide to the relevance of the assumption about labour mobility.

Table 11: the 10 greatest % production decreases in volume at the NUTS 1 level

	AGM
South Austria (Austria)	-1.72
West Austria (Austria)	-1.43
East Austria (Austria)	-1.28
Ireland	-1.28
Portugal	-1.27
Attica (Greece)	-1.22
Voreia Ellada (Greece)	-0.95
Luxembourg	-0.94
South (Italy)	-0.91
Islands (Italy)	-0.82

Notes: unskilled/skilled labour mobility across the NUTS 1 regions within the EU15 ($\sigma_L = \sigma_H = 10$).

Table 12: the 10 greatest % production increases or decreases in volume at the NUTS 1 level

	IND
Nisia Aigaiou-Kriti (Greece)	-90.00
Kentriki Ellada (Greece)	-21.04
Attica (Greece)	-10.24
Portugal	-9.51
Île-de-France (France)	10.93
East Austria (Austria)	11.19
West Netherlands (Netherlands)	11.23
Brussels Capital Region (Belgium)	17.87
Luxembourg	23.33
Ireland	31.40

Notes: unskilled/skilled labour mobility across the NUTS 1 regions within the EU15 ($\sigma_L = \sigma_H = 10$).

Table 13: the 10 greatest % production increases or decreases in volume at the NUTS 1 level

	SERV
Ireland	-11.09
Luxembourg	-6.06
East Austria (Austria)	-3.19
North East (Spain)	2.99
East (Spain)	3.25
Voreia Ellada (Greece)	3.41
Attica (Greece)	3.56
Portugal	5.61
Kentriki Ellada (Greece)	7.53
Nisia Aigaiou-Kriti (Greece)	18.64

Notes: unskilled/skilled labour mobility across the NUTS 1 regions within the EU15 ($\sigma_L = \sigma_H = 10$).

Table 14 reports the results for production change in volume at the macro-area level under the assumption of unskilled/skilled labour mobility between the NUTS 1 regions (EU15) and the Rest of Europe (REU) within the EU27 ($\sigma_L = \sigma_H = 10$). Table 14 confirms the results of Table 10 with the exception of the REU macro-area, which takes advantage of the integrated labour market within the EU27. Indeed, with respect to Table 10 the Rest of Europe shows a lesser AGM decrease (-0.46%) and a greater IND and SERV increase (0.17% and 0.14%).

Table 14: % production change in volume at the macro-area level

	ROW	EU15	REU
AGM	0.32	-0.76	-0.46
PRM	-0.06	0.16	0.15
IND	0.01	0.13	0.17
SERV	-0.02	0.08	0.14

Notes: unskilled/skilled labour mobility between the NUTS 1 regions (EU15) and the Rest of Europe (REU) within the EU27 ($\sigma_L = \sigma_H = 10$).

Table 15, Table 16 and Table 17 display the results of the ten greatest (positive and negative) changes in the AGM, IND and SERV sectors for the 68 NUTS 1 regions. The results of these three tables do not significantly change with respect to Tables 11, 12 and 13.

Table 15: the 10 greatest % production decreases in volume at the NUTS 1 level

	AGM
South Austria (Austria)	-1.74
West Austria (Austria)	-1.44
Ireland	-1.30
East Austria (Austria)	-1.29
Portugal	-1.27
Attica (Greece)	-1.22
Voreia Ellada (Greece)	-0.94
Luxembourg	-0.94
South (Italy)	-0.91
Islands (Italy)	-0.81

Notes: unskilled/skilled labour mobility between the NUTS 1 regions (EU15) and the Rest of Europe (REU) within the EU27 ($\sigma_L = \sigma_H = 10$).

Table 16: the 10 greatest % production increases or decreases in volume at the NUTS 1 level

	IND
Nisia Aigaiou-Kriti (Greece)	-95.00
Kentriki Ellada (Greece)	-21.28
Attica (Greece)	-10.46
Portugal	-9.65
Île-de-France (France)	10.79
West Netherlands (Netherlands)	11.24
East Austria (Austria)	11.67
Brussels Capital Region (Belgium)	18.23
Luxembourg	23.34
Ireland	32.84

Notes: unskilled/skilled labour mobility between the NUTS 1 regions (EU15) and the Rest of Europe (REU) within the EU27 ($\sigma_L = \sigma_H = 10$).

Table 17: the 10 greatest % production increases or decreases in volume at the NUTS 1 level

	SERV
Ireland	-11.60
Luxembourg	-6.08
East Austria (Austria)	-3.34
South Netherlands (Netherlands)	-3.05
East (Spain)	3.29
Voreia Ellada (Greece)	3.48
Attica (Greece)	3.61
Portugal	5.65
Kentriki Ellada (Greece)	7.60
Nisia Aigaiou-Kriti (Greece)	19.64

Notes: unskilled/skilled labour mobility between the NUTS 1 regions (EU15) and the Rest of Europe (REU) within the EU27 ($\sigma_L = \sigma_H = 10$).

3 Further interesting results

In this subsection further interesting results of trade policy simulation are presented. The *policy maker* is likely to be interested in labour reallocation across the NUTS 1 region after the agricultural liberalization. For this reason in Tables 18 and 19 migration results are reported for unskilled and skilled labour levels, respectively, under the assumption of unskilled/skilled labour mobility across the NUTS 1 regions within the EU15.

Table 18: unskilled labour migration within the EU15

	% Change in *L* supply
Ireland	1.29
Luxembourg	0.67
Brussels Capital Region (Belgium)	0.55
Île-de-France (France)	0.41
South Netherlands (Netherlands)	0.36
West Netherlands (Netherlands)	0.35
East Austria (Austria)	0.31
North Netherlands (Netherlands)	0.28
East Netherlands (Netherlands)	0.24
Brandenburg (Germany)	-0.27
Community of Madrid (Spain)	-0.28
Voreia Ellada (Greece)	-0.32
South (Spain)	-0.32
Centre (Spain)	-0.33
North West (Spain)	-0.33
Attica (Greece)	-0.37
North East (Spain)	-0.37
East (Spain)	-0.39
Kentriki Ellada (Greece)	-0.55
Nisia Aigaiou-Kriti (Greece)	-0.96

Notes: the 20 greatest % increases or decreases in unskilled labour supply (σ_L = 10).

Table 19: Skilled labour migration within the EU15

	% Change in *H* supply
Portugal	2.00
Nisia Aigaiou-Kriti (Greece)	1.90
Kentriki Ellada (Greece)	1.11
Attica (Greece)	0.77
Voreia Ellada (Greece)	0.67
East (Spain)	0.49
Centre (Spain)	0.44
North West (Spain)	0.44
South (Spain)	0.41
North East (Spain)	0.40
Brandenburg (Germany)	0.39
East Netherlands (Netherlands)	-0.41
North Netherlands (Netherlands)	-0.44
East Austria (Austria)	-0.51
South Netherlands (Netherlands)	-0.57
West Netherlands (Netherlands)	-0.59
Brussels Capital Region (Belgium)	-0.67
Île-de-France (France)	-0.74
Ireland	-1.55
Luxembourg	-1.73

Notes: the 20 greatest % increases or decreases in skilled labour supply ($\sigma_H = 10$).

It is interesting to note that the NUTS 1 regions displaying the highest sectoral production reallocation also show the highest levels of unskilled/skilled labour reallocation. The labour reallocation follows an inverse pattern in these NUTS 1 regions according to their sectoral specialisation. For example, Ireland and Luxembourg absorb unskilled labour because they increase production in the IND sector and decrease production in the SERV sector after the trade shock while Kentriki Ellada and Nisia Aigaiou-Kriti absorb skilled labour because they decrease production in the IND sector and increase production in the SERV sector. Basically, the results do not change with the integrated labour market within the EU27 for the NUTS 1 regions, as it is shown in Tables 20 and 21. However, it can be noted that the REU experiences an unskilled/skilled labour immigration.

Table 20: unskilled labour migration within the EU27

	% Change in *L* supply
REU (Rest of Europe)	0.24
Ireland	1.34
Luxembourg	0.66
Brussels Capital Region (Belgium)	0.56
Île-de-France (France)	0.40
South Netherlands (Netherlands)	0.35
West Netherlands (Netherlands)	0.34
East Austria (Austria)	0.31
North Netherlands (Netherlands)	0.27
Mecklenburg-Vorpommern (Germany)	0.24
Brandenburg (Germany)	-0.28
Community of Madrid (Spain)	-0.30
South (Spain)	-0.34
Centre (Spain)	-0.34
Voreia Ellada (Greece)	-0.34
North West (Spain)	-0.35
North East (Spain)	-0.39
Attica (Greece)	-0.39
East (Spain)	-0.41
Kentriki Ellada (Greece)	-0.57
Nisia Aigaiou-Kriti (Greece)	-1.03

Notes: the 20 greatest increases or decreases in unskilled labour supply (σ_L = 10). REU change in unskilled labour supply is also included.

Table 21: skilled labour migration within the EU27

	% Change in *H* supply
REU (Rest of Europe)	0.16
Portugal	2.00
Nisia Aigaiou-Kriti (Greece)	1.98
Kentriki Ellada (Greece)	1.11
Attica (Greece)	0.77
Voreia Ellada (Greece)	0.67
East (Spain)	0.49
Centre (Spain)	0.44
North West (Spain)	0.44
South (Spain)	0.41
North East (Spain)	0.41
Brandenburg (Germany)	0.37
East Netherlands (Netherlands)	-0.42
North Netherlands (Netherlands)	-0.45
East Austria (Austria)	-0.55
South Netherlands (Netherlands)	-0.58
West Netherlands (Netherlands)	-0.60
Brussels Capital Region (Belgium)	-0.68
Île-de-France (France)	-0.74
Ireland	-1.62
Luxembourg	-1.74

Notes: the 20 greatest % increases or decreases in skilled labour supply ($\sigma_H = 10$). REU change in skilled labour supply is also included.

Welfare analysis cannot be carried out at the macro-area level. Therefore, a Laspeyres index is used to evaluate the percent change in the overall value added at the NUTS 1 level. Tables 22, 23 and 24 display value added changes corresponding to the three different scenarios about labour mobility.

Table 22: the 20 greatest % value added increases or decreases within the EU15

	Change
Ireland	0.45%
Nisia Aigaiou-Kriti (Greece)	0.28
Attica (Greece)	0.06
Mecklenburg-Vorpommern (Germany)	0.06
Portugal	0.04
Kentriki Ellada (Greece)	0.04
East (Spain)	0.03
North East (Spain)	0.02
Community of Madrid (Spain)	0.02
North East (Italy)	0.02
Brussels Capital Region (Belgium)	-0.02
Île-de-France (France)	-0.02
North Netherlands (Netherlands)	-0.02
East Netherlands (Netherlands)	-0.03
South Austria (Austria)	-0.03
West Netherlands (Netherlands)	-0.03
South Netherlands (Netherlands)	-0.03
West Austria (Austria)	-0.04
East Austria (Austria)	-0.05
Luxembourg	-0.07

Notes: unskilled/skilled labour immobility at the NUTS 1 level within the EU15 ($\sigma_L = \sigma_H = 0$).

Table 23: the 20 greatest % value added increases or decreases within the EU15

	Change
Nisia Aigaiou-Kriti (Greece)	3.47
Ireland	1.75
Kentriki Ellada (Greece)	1.18
Portugal	0.90
Attica (Greece)	0.62
Voreia Ellada (Greece)	0.51
East (Spain)	0.34
North East (Spain)	0.27
North East (Spain)	0.18
Flemish Region (Belgium)	-0.19
North Netherlands (Netherlands)	-0.20
Greater London (United Kingdom)	-0.20
Denmark	-0.21
East Netherlands (Netherlands)	-0.28
Brussels Capital Region (Belgium)	-0.31
East Austria (Austria)	-0.32
South Netherlands (Netherlands)	-0.35
West Netherlands (Netherlands)	-0.47
Île-de-France (France)	-0.79
Luxembourg	-1.48

Notes: Unskilled/skilled labour mobility across the NUTS 1 region within the EU15 ($\sigma_L = \sigma_H = 10$).

Table 24: the 20 greatest % value added increases or decreases within the EU27

	Change
Nisia Aigaiou-Kriti (Greece)	3.64
Ireland	1.83
Kentriki Ellada (Greece)	1.18
Portugal	0.88
Attica (Greece)	0.62
Voreia Ellada (Greece)	0.51
East (Spain)	0.34
North East (Spain)	0.27
North East (Spain)	0.18
Flemish Region (Belgium)	-0.20
Greater London (United Kingdom)	-0.21
North Netherlands (Netherlands)	-0.21
Denmark	-0.22
East Netherlands (Netherlands)	-0.28
Brussels Capital Region (Belgium)	-0.31
East Austria (Austria)	-0.35
South Netherlands (Netherlands)	-0.36
West Netherlands (Netherlands)	-0.48
Île-de-France (France)	-0.79
Luxembourg	-1.50

Notes: Unskilled/skilled labour mobility between the NUTS 1 regions (EU15) and the Rest of Europe (REU) within the EU27 ($\sigma_L = \sigma_H = 10$).

The changes are small in the first scenario (labour immobility) but not negligible in the second and third ones (labour mobility within the EU15 and the EU27). The NUTS 1 regions, characterised by a stronger production reallocation, are the ones which experience the most important gains from trade policy reform in terms of increase of value added (Nisia Aigaiou-Kriti, Kentriki Ellada, Ireland, Portugal) and the most important losses from trade policy reform in terms of decrease of value added (West Netherlands and Luxembourg).

The changes in the trade patterns, i.e. the change in the sectoral imports and exports at the macro-area level, are set out in Tables 25, 26 and 27.

Table 25: % trade pattern change in volume at the macro-area level

		ROW	EU15	REU
AGM	ROW	53.80	18.80	15.00
AGM	EU15	31.59	-5.09	39.78
AGM	REU	43.68	18.48	18.49
PRM	ROW	-0.11	-0.08	-0.09
PRM	EU15	0.06	0.09	0.08
PRM	REU	0.01	0.04	0.02
IND	ROW	-0.01	0.02	-0.07
IND	EU15	-0.04	0.00	-0.11
IND	REU	0.09	0.12	0.02
SERV	ROW	-0.07	-0.28	-0.19
SERV	EU15	0.25	0.04	0.13
SERV	REU	0.09	-0.12	-0.03

Notes: the second column shows the exporting macro-area, the first row the importing macro-area. Unskilled/skilled labour immobility at the NUTS 1 level within the EU15 ($\sigma_L = \sigma_H = 0$).

Table 26: % trade pattern change in volume at the macro-area level

		ROW	EU15	REU
AGM	ROW	53.80	19.00	15.00
AGM	EU15	31.62	-4.91	39.81
AGM	REU	43.68	18.68	18.49
PRM	ROW	-0.11	0.25	-0.10
PRM	EU15	-0.16	0.19	-0.16
PRM	REU	0.04	0.40	0.05
IND	ROW	-0.02	0.06	-0.11
IND	EU15	0.04	0.14	-0.05
IND	REU	0.09	0.17	-0.01
SERV	ROW	-0.07	-0.29	-0.19
SERV	EU15	0.30	0.08	0.18
SERV	REU	0.08	-0.14	-0.04

Notes: the second column shows the exporting macro-area, the first row the importing macro-area. Unskilled/skilled labour mobility across the NUTS 1 regions within the EU15 ($\sigma_L = \sigma_H = 10$).

Table 27: % trade pattern change in volume at the macro-area level

		ROW	EU15	REU
AGM	ROW	53.80	19.00	15.07
AGM	EU15	31.62	-4.91	39.90
AGM	REU	43.76	18.75	18.64
PRM	ROW	-0.11	0.26	0.01
PRM	EU15	-0.17	0.19	-0.05
PRM	REU	0.04	0.41	0.17
IND	ROW	-0.02	0.06	-0.05
IND	EU15	0.04	0.14	0.01
IND	REU	0.18	0.26	0.14
SERV	ROW	-0.07	-0.30	-0.13
SERV	EU15	0.30	0.07	0.24
SERV	REU	0.13	-0.09	0.07

Notes: the second column shows the exporting macro-area, the first row the importing macro-area. Unskilled/skilled labour mobility between the NUTS 1 regions (EU15) and the Rest of Europe (REU) within the EU27 ($\sigma_L = \sigma_H = 10$).

Not surprisingly, the greatest variations strike the AGM sector. It should be noted that, even if export changes are small in the other sectors at the macro-area level, the NUTS 1 regions experience appreciable reallocation effects in production volume, which makes the NUTS model useful.

Finally, welfare analysis is carried out at the macro-area level. Table 28 lays out the welfare gains measured in equivalent variation (EV) $ million under the three different labour market scenarios.

Table 28: equivalent variation at the macro-area level

	ROW	EU15	REU
$\sigma_L = \sigma_H = 0$ within EU15	5462	157	75
$\sigma_L = \sigma_H = 10$ within EU15	5616	176	87
$\sigma_L = \sigma_H = 10$ within EU27	5618	-160	408

Notes: $ million.

Under the assumption of unskilled/skilled labour immobility at the NUTS 1 level within the EU15, ROW gains about $5462 million. The gain are limited for the EU15 and REU, $157 and $75 million, respectively.

Increasing labour mobility within the EU15 in the second scenario results in a slight improvement in welfare. Indeed, the ROW gains $5616 million and the EU15 and REU, $176 and $87 million, respectively. However the gain for Europe as a whole continues to be almost insignificant.

Finally, assuming an integrated labour market within the EU27, the welfare increase for the ROW macro-area is only $2 million. Interestingly, the EU15 loses and the REU wins in the third scenario. The liberalization of agriculture determines a gain of about $408 million for the REU and a loss by $160 million for the EU15. Nevertheless, gains and losses continue to be almost insignificant for Europe.

It is worth noting that other studies produce much higher estimates of equivalent variation. For example, using the GTAP model with perfect competition and constant returns to scale in all the sectors, Hertel and Keeney (2005) find that full liberalization of agriculture (market access, domestic support and export subsidies) produce a $55 billion gain for the world as a whole. Using MIRAGE model with imperfect competition in services and manufactures, Bouet *et al.* (2005) implement a likely Doha round agricultural liberalization. They find a $18 billion gain for the world as a whole.

In addition in both these two studies, the baseline equilibrium, in which trade liberalization is implemented, considers as achieved the European enlargement and other commitments that took place by the end of 2004 (e.g. China accession in the WTO). As a result, my model is likely to overestimate further the welfare gain of the tariff liberalization in agriculture because the world picture of tariff barriers refers to that of 2001. These different results could depend on the NUTS regional level adopted to define the production structure.

8 Interpretation of the results

CGE trade models are criticized because they do not allow the results to be interpreted adequately. As stated by Panagariya and Duttagupta (2001, p. 3), 'unearthing the features of CGE models that drive them is often a time-consuming exercise. This is because their sheer size, facilitated by recent advances in computer technology, make it difficult to pinpoint the precise source of a particular result. They often remain a black box. Indeed, frequently, authors are themselves unable to explain their results intuitively'.

For this reason I have built a stylised model in order to interpret the results and better understand the economic functioning of the big model.

The focus of this model is on the production side. Welfare analysis can be carried out only at the macro-area level. Therefore, the interpretation is given for the production reallocation across sectors in each NUTS 1 region after the tariff liberalization in agriculture under the hypothesis of perfect unskilled/skilled labour immobility at the NUTS 1 level. In fact, this kind of effect can be considered as the most important result in the model.

There are two main features concerning the results of trade policy simulation:

- ✓ different negative magnitudes of production change in the agricultural sector (AGM) across the NUTS 1 regions,
- ✓ different (positive and negative) magnitudes of production change across the NUTS 1 regions in the other sectors, manufactures (IND) and services (SERV).

The stylised model aims at explaining the reasons for such results.

Before the presentation of the stylised model, it is worth noting that skilled and unskilled labour are the only two primary factors for which data at the NUTS 1 level are available. As a results, they can be considered as the main source of heterogeneity across the NUTS 1 regions. It is possible to understand this by looking at the formula of the value added for the general NUTS 1 region at the calibration stage.

According to Eqs. (5), (6) and (7) value added (*VA*) can be written as:

$$VA_{i,nut} = KEYVA_{i,nut}\left(TE_{i,EU15} + RN_{i,EU15} + K_{i,EU15}\right) + L_{i,nut} + H_{i,nut} \qquad (11)$$

All the land (*TE*), natural resources (*RN*) and capital (*K*) variables use the repartition key of valued added (*KEYVA*) to determine their NUTS 1 level. It is assumed that all the prices associated with the above-mentioned variables are initialised to unity at the calibration stage. Using Eq. (4), the Eq. (11) can be rearranged as:

$$VA_{i,nut} = \left(L_{i,nut} + H_{i,nut}\right)\frac{VA_{i,EU15}}{VA_{i,EU15} - \left(TE_{i,EU15} + RN_{i,EU15} + K_{i,EU15}\right)} \qquad (12)$$

In the Eq. (12) it is clear that the source of the value added heterogeneity across the NUTS 1 regions stems from the skilled and unskilled labour at the NUTS 1 level.

Let us now move on to the description of the stylised model. The assumptions of the stylised model are the following:

1) two countries (home and foreign countries),
2) two regions (*A* and *B* regions) which both belong to the home country,
3) two factors, the unskilled labour (*L*) and skilled labour (*H*), which are assumed to be perfectly immobile at the regional level and perfectly mobile across sectors,
4) two sectors, sector 1 that is unskilled labour intensive, and sector 2 that is skilled labour intensive,
5) a CES function, which uses unskilled and skilled labour to produce value added, and a Leontief technology which uses value added and intermediate inputs to produce output,
6) constant returns to scale and perfect competition in both sectors,
7) a demand structure which reproduces that used in the big model (the Armington hypothesis is used to model the foreign trade). The elasticities of substitution in the CES functions are the same of those used in the big model.

Assumption 4, in turn, implies that:

$$\frac{\alpha L_{1,A}}{\alpha H_{1,A}} > \frac{\alpha L_{2,A}}{\alpha H_{2,A}} \tag{13}$$

$$\frac{\alpha L_{1,B}}{\alpha H_{1,B}} > \frac{\alpha L_{2,B}}{\alpha H_{2,B}} \tag{14}$$

where αL and αH are parameters of the CES value added function for the unskilled and skilled factors. These parameters can be considered as factor intensity indicators.

Given that in the big model a full tariff liberalization is implemented in the agricultural sector, I suppose that all the tariffs are removed in the unskilled intensive sector (sector 1) for both home and foreign countries in the stylised model.

Two cases are given for the stylised model. In the first case, *A* and *B* regions have the same technologies:

$$\frac{\alpha L_{1,A}}{\alpha H_{1,A}} = \frac{\alpha L_{1,B}}{\alpha H_{1,B}} \tag{15}$$

$$\frac{\alpha L_{2,A}}{\alpha H_{2,A}} = \frac{\alpha L_{2,B}}{\alpha H_{2,B}} \tag{16}$$

Eqs (15) and (16), in turn, imply that *A* and *B* have the same ratio of the unskilled/skilled labour endowments:

$$\frac{L_A}{H_A} = \frac{L_B}{H_B} \tag{17}$$

Trade liberalization in the unskilled labour intensive sector is simulated for the case 1. The results for the production relative change ($\Delta Y/Y$) are the following:

$$\frac{\Delta Y_{1,A}}{Y_{1,A}} = \frac{\Delta Y_{1,B}}{Y_{1,B}} < 0 \tag{18}$$

$$\frac{\Delta Y_{2,A}}{Y_{2,A}} = \frac{\Delta Y_{2,B}}{Y_{2,B}} > 0 \tag{19}$$

From Eqs. (18) and (19) it is clear that different technologies between *A* and *B* regions are crucial to explain different magnitudes of the production relative change between *A* and *B* regions. This result does not depend on the region size, i.e. the factor endowments of the regions.

The first case of the stylised model helps one to understand that different technologies are decisive in order to explain the different magnitudes of trade policy shock but does not help to understand which characteristics the technologies must have across sectors and regions in order to replicate the two main features of trade policy simulation in the big model. The second case of the stylised model meets this need. In the case 2 it is supposed that *A* and *B* regions have different technologies:

$$\frac{\alpha L_{1,A}}{\alpha H_{1,A}} \neq \frac{\alpha L_{1,B}}{\alpha H_{1,B}} \tag{0}$$

$$\frac{\alpha L_{2,A}}{\alpha H_{2,A}} \neq \frac{\alpha L_{2,B}}{\alpha H_{2,B}} \tag{21}$$

One condition is needed in the stylised model to replicate the results of the big model:

$$\frac{\alpha L_{1,A}}{\alpha H_{1,A}} - \frac{\alpha L_{2,A}}{\alpha H_{2,A}} < \frac{\alpha L_{1,B}}{\alpha H_{1,B}} - \frac{\alpha L_{2,B}}{\alpha H_{2,B}} \tag{22}$$

Eq. (22) is a technological condition on the sectoral difference between the ratios of the unskilled labour intensity to the skilled labour intensity. Both the left and right members of Eq. (22) have to be positive because they are the difference of the ratios between the unskilled and skilled labour intensive sector.

In case 2 Eq. (22) determines the following results:

$$\frac{\Delta Y_{1,B}}{Y_{1,B}} < \frac{\Delta Y_{1,A}}{Y_{1,A}} < 0 \tag{23}$$

$$\frac{\Delta Y_{2,B}}{Y_{2,B}} > \frac{\Delta Y_{2,A}}{Y_{2,A}} > 0 \tag{24}$$

In the big model there are four sectors while in the stylised model there are only two sectors. The result of this simplification is that the different (positive and negative) magnitudes in the IND and SERV sectors become different positive magnitudes in the skilled labour intensive sector. It can also be noted that a region (*B*) experiences the largest production reallocation across sectors.

In order to explain the production reallocation across sectors in each NUTS 1 region, I concentrate my attention on Eq. (22), the technological condition which gives the key parameter for interpreting the results, i.e. the sectoral difference between the ratios of the unskilled labour intensity to the skilled labour intensity. I use the following parameter in the big model as proxy of the key parameter in Eq. (22):

$$\frac{\alpha L_{i,nut}}{\alpha Q_{i,nut}} - \frac{\alpha L_{j,nut}}{\alpha Q_{j,nut}} \tag{25}$$

where *i* and *j* are sector indexes, *nut* is the index of the NUTS 1 regions and αL and αQ are parameters of the CES value added function for the unskilled and fictive factors. It is noteworthy to recall that the fictive factor (*Q*) is a CES bundle of capital and skilled labour (see the list of variables in Appendix 2). Indeed, in the big model the valued added is specified through a two-level nested technology (see *Figure 2*).

To show how the parameter determines the % production changes, in Table 29 and Table 30 I match the ten greatest % production decreases in volume at the NUTS 1 level for the AGM sector with the ten highest values of the *α(agm/ind)* and *α(agm/serv)* parameters. The latter is the difference between the ratios of the unskilled labour intensity to the fictive factor intensity in the AGM and SERV sectors, respectively. The former is the difference between the ratios of the unskilled labour intensity to the fictive factor intensity, respectively, in the AGM and IND sectors.

Table 29: the 10 greatest % production decreases in volume at the NUTS 1 level (AGM sector) and the ten highest values of the *α(agm/ind)* parameter

	$\Delta Y/Y$ (AGM)		*α(agm/ind)*
South Austria (Austria)	**-2.47**	**South Austria (Austria)**	**4.79**
Ireland	**-2.15**	**West Austria (Austria)**	**3.50**
West Austria (Austria)	**-1.95**	Kentriki Ellada (Greece)	3.15
East Austria (Austria)	**-1.74**	Nisia Aigaiou-Kriti (Greece)	2.96
Portugal	**-1.47**	**Portugal**	**2.91**
Attica (Greece)	**-1.44**	**East Austria (Austria)**	**2.73**
Mecklenburg-Vor. (Germany)	-1.19	**Voreia Ellada (Greece)**	**2.65**
Northern Ireland	-1.10	**Attica (Greece)**	**2.09**
Luxembourg	-1.10	**Ireland**	**1.58**
Voreia Ellada (Greece)	**-1.10**	South (Italy)	1.41

Notes: $\alpha(agm/ind) = \left(\alpha L_{agm,nut} / \alpha Q_{agm,nut}\right) - \left(\alpha L_{ind,nut} / \alpha Q_{ind,nut}\right)$

Table 30: the 10 greatest % production decreases in volume at the NUTS 1 level (AGM sector) and the ten highest values of the *α(agm/serv)* parameter

	$\Delta Y/Y$ (AGM)		*α(agm/serv)*
South Austria (Austria)	**-2.47**	**South Austria (Austria)**	**5.05**
Ireland	-2.15	**Portugal**	**4.41**
West Austria (Austria)	**-1.95**	**West Austria (Austria)**	**3.79**
East Austria (Austria)	**-1.74**	Kentriki Ellada (Greece)	3.67
Portugal	**-1.47**	Nisia Aigaiou-Kriti (Greece)	3.41
Attica (Greece)	**-1.44**	**Voreia Ellada (Greece)**	3.25
Mecklenburg-Vor. (Germany)	-1.19	**East Austria (Austria)**	2.98
Northern Ireland	-1.10	**Attica (Greece)**	2.72
Luxembourg	-1.10	South (Italy)	2.02
Voreia Ellada (Greece)	**-1.10**	Islands (Italy)	1.63

Notes: $\alpha(agm/serv) = \left(\alpha L_{agm,nut} / \alpha Q_{agm,nut}\right) - \left(\alpha L_{serv,nut} / \alpha Q_{serv,nut}\right)$

It is possible to see that seven % production changes match the corresponding key parameters for the NUTS 1 regions in Table 29 and six % production changes match the corresponding key parameter for the NUTS 1 regions in Table 30 (the % production changes and corresponding key parameters, which match each other, are reported in bold). Therefore, given the production decrease in the agriculture sector for all of the EU15 regions, the most affected regions will be those in which there is a stronger sectoral difference between AGM and the other sectors in the relative use of the unskilled and skilled factors. For example, South Austria experiences the greatest decrease in AGM and uses more intensively the unskilled labour in the AGM sector and the skilled labour in the IND and SERV sectors with respect to the other NUTS 1 regions.

An analogous argument can be made to explain the different (positive and negative) % production changes in the IND and SERV sectors, which are displayed respectively, in Table 31 and in Table 32.

Table 31: the 10 greatest % production increases or decreases in volume at the NUTS 1 level (IND sector) and the ten highest values of the *α(agm/ind)* parameter

	Δ*Y/Y* (IND)		*α(agm/ind)*
Nisia Aigaiou-Kriti (Greece)	**-7.62**	**South Austria (Austria)**	**4.79**
Attica (Greece)	**-1.38**	**West Austria (Austria)**	**3.50**
Community of Madrid (Spain)	-1.15	Kentriki Ellada (Greece)	3.15
Luxembourg	1.06	**Nisia Aigaiou-Kriti (Greece)**	**2.96**
West Austria (Austria)	**1.55**	Portugal	2.91
Brussels-Capital Region	1.94	**East Austria (Austria)**	**2.73**
Mecklenburg-Vor. (Germany)	2.10	Voreia Ellada (Greece)	2.65
East Austria (Austria)	**2.40**	**Attica (Greece)**	**2.09**
South Austria (Austria)	**2.99**	**Ireland**	**1.58**
Ireland	**7.02**	South (Italy)	1.41

Notes: $\alpha(agm/ind) = \left(\alpha L_{agm,nut} / \alpha Q_{agm,nut}\right) - \left(\alpha L_{ind,nut} / \alpha Q_{ind,nut}\right)$

Table 32: the 10 greatest % production increases or decreases in volume at the NUTS 1 level (SERV sector) and the ten highest values of the *α(agm/serv)* parameter

	Δ*Y/Y* (SERV)		*α(agm/serv)*
Ireland	-2.31	**South Austria (Austria)**	**5.05**
South Austria (Austria)	**-1.15**	**Portugal**	**4.41**
West Austria (Austria)	**-0.63**	**West Austria (Austria)**	**3.79**
East Austria (Austria)	-0.59	Kentriki Ellada (Greece)	3.67
Mecklenburg-Vor. (Germany)	-0.50	**Nisia Aigaiou-Kriti (Greece)**	**3.41**
North East (Spain)	0.39	Voreia Ellada (Greece)	3.25
East (Spain)	0.43	**East Austria (Austria)**	**2.98**
Portugal	**0.47**	**Attica (Greece)**	**2.72**
Attica (Greece)	**0.47**	South (Italy)	2.02
Nisia Aigaiou-Kriti (Greece)	**1.62**	Islands (Italy)	1.63

Notes: $\alpha(agm/serv) = \left(\alpha L_{agm,nut} / \alpha Q_{agm,nut}\right) - \left(\alpha L_{serv,nut} / \alpha Q_{serv,nut}\right)$

So far the reasons, which cause different magnitudes in the three sectors, have been explained but it is also important to understand the sign of the production change across the NUTS 1 regions. In the agricultural sector there is no doubt because the sign is the same for all the NUTS 1 regions and, thus, this can be interpreted as a result of the demand side at the macro-area level. In contrast, the sign changes according with the NUTS 1 region in manufactures and services. This can be interpreted as a result of the improved efficiency in the allocation of the inputs, i.e. as a result of the supply side at the NUTS 1 level.

Table 33 and Table 34 help us to understand the different signs in the IND sector.

Table 33: the 10 greatest % production increases or decreases in volume at the NUTS 1 level (IND sector) and the ten highest values of the *α(ind/serv)* parameter

	Δ*Y/Y* (IND)		*α(ind/serv)*
Nisia Aigaiou-Kriti (Greece)	**-7.62**	Portugal	1.50
Attica (Greece)	**-1.38**	North East (Italy)	0.75
Community of Madrid (Spain)	-1.15	North West (Italy)	0.66
Luxembourg	1.06	Centre (Italy)	0.63
West Austria (Austria)	1.55	**Attica (Greece)**	**0.63**
Brussels-Cap. Region (Belgium)	1.94	South (Italy)	0.61
Mecklenburg-Vor. (Germany)	2.10	Voreia Ellada (Greece)	0.60
East Austria (Austria)	2.40	Kentriki Ellada (Greece)	0.52
South Austria (Austria)	2.99	Islands (Italy)	0.51
Ireland	7.02	**Nisia Aigaiou-Kriti (Greece)**	**0.45**

Notes: $\alpha(ind/serv) = \left(\alpha L_{ind,nut} / \alpha Q_{ind,nut}\right) - \left(\alpha L_{serv,nut} / \alpha Q_{serv,nut}\right)$

Table 34: the 10 greatest % production increases or decreases in volume at the NUTS 1 level (IND sector) and the ten lowest values of the *α(ind/serv)* parameter

	Δ*Y/Y* (IND)		*α(ind/serv)*
Nisia Aigaiou-Kriti (Greece)	-7.62%	**Ireland**	**-0.02**
Attica (Greece)	-1.38%	**Mecklenburg-Vo (Germany)**	**0.05**
Community of Madrid (Spain)	-1.15%	Northern Ireland (U.K)	0.14
Luxembourg	1.06	**Brussels-Ca. Reg. (Belgium)**	**0.14**
West Austria (Austria)	1.55	Walloon Region (Belgium)	0.19
Brussels-Ca. Reg. (Belgium)	**1.94**	Scotland (United Kingdom)	0.20
Mecklenburg-Vor. (Germany)	**2.10**	North East England (U.K.)	0.21
East Austria (Austria)	2.40	Mainland Finland (Finlnad)	0.21
South Austria (Austria)	2.99	Greater London (U.K)	0.21
Ireland	**7.02**	Brandenburg (Germany)	0.22

Notes: $\alpha(ind/serv) = \left(\alpha L_{ind,nut} / \alpha Q_{ind,nut}\right) - \left(\alpha L_{serv,nut} / \alpha Q_{serv,nut}\right)$

For example, the Greek regions, Nisia Aigaiou-Kriti and Attica, experience the greatest decrease in the IND sector and have a *α(ind/serv)* value included within the ten highest values. This means that these regions use the unskilled labour in the IND sector and the skilled labour in the SERV sector more intensively with respect to the other NUTS 1 regions. In contrast, Ireland experiences the greatest increase in the IND sector and has the lowest *α(ind/serv)* value. This means that Ireland uses unskilled labour and skilled labour by similar intensities in both the IND and SERV sectors with respect to the other NUTS 1 regions.

A similar argument can be used for the SERV sector. Tables 35 and 36 indicate Nisia Aigaiou-Kriti, Attica and Portugal as the regions with the greatest increase in the SERV sector. These regions also have a *α(ind/serv)* value included within the ten highest values. In contrast, Ireland experiences the greatest decrease in the SERV sector and has the lowest *α(ind/serv)* value.

Thus, the increases and decreases of the production change in the IND and SERV sectors are characterised by inverse patterns at the NUTS 1 level.

Table 35: the 10 greatest % production increases or decreases in volume at the NUTS 1 level (SERV sector) and the ten highest values of the *α(ind/serv)* parameter

	Δ*Y/Y* (SERV)		*α(ind/serv)*
Ireland	-2.31	**Portugal**	**1.50**
South Austria (Austria)	-1.15	North East (Italy)	0.75
West Austria (Austria)	-0.63	North West (Italy)	0.66
East Austria (Austria)	-0.59	Centre (Italy)	0.63
Mecklenburg-Vor (Germany)	-0.50	**Attica (Greece)**	**0.63**
North East (Spain)	0.39	South (Italy)	0.61
East (Spain)	0.43	Voreia Ellada (Greece)	0.60
Portugal	**0.47**	Kentriki Ellada (Greece)	0.52
Attica (Greece)	**0.47**	Islands (Italy)	0.51
Nisia Aigaiou-Kriti (Greece)	**1.62**	**Nisia Aigaiou-Kriti (Greece)**	**0.45**

Notes: $\alpha(ind / serv) = \left(\alpha L_{ind,nut} / \alpha Q_{ind,nut}\right) - \left(\alpha L_{serv,nut} / \alpha Q_{serv,nut}\right)$

Table 36: the 10 greatest % production increases or decreases in volume at the NUTS 1 level (SERV sector) and the ten lowest values of the *α(ind/serv)* parameter

	Δ*Y/Y* (SERV)		*α(ind/serv)*
Ireland	**-2.31**	**Ireland**	**-0.02**
South Austria (Austria)	-1.15	**Mecklenburg-Vo. Germany)**	**0.05**
West Austria (Austria)	-0.63	Northern Ireland (UK)	0.14
East Austria (Austria)	-0.59	Brussels Ca. Reg. (Belgium)	0.14
Mecklenburg-Vor. (Germany)	**-0.50**	Walloon Region (Belgium)	0.19
North East (Spain)	0.39	Scotland (UK)	0.20
East (Spain)	0.43	North East England (UK)	0.21
Portugal	0.47	Mainland Finland (Finlnad)	0.21
Attica (Greece)	0.47	Greater London (UK)	0.21
Nisia Aigaiou-Kriti (Greece)	1.62	Brandenburg (Germany)	0.22

Notes: $\alpha(ind / serv) = \left(\alpha L_{ind,nut} / \alpha Q_{ind,nut}\right) - \left(\alpha L_{serv,nut} / \alpha Q_{serv,nut}\right)$

In Tables 33, 34, 35, 36 only two out of ten or three out of ten production changes match the corresponding key parameters. This means that further channels, in addition to the sectoral difference between the ratios of the unskilled labour intensity to the skilled labour intensity, could exist in the model that determine the sign in the IND and SERV sectors. However, the above-mentioned channel, based on the *α(ind/serv)* parameter value, is likely to be very important because it involves the NUTS 1 regions which shows the highest increases and decreases in the IND and SERV sectors, i.e. Ireland and Nisia Aigaiou-Kriti.

To summarize, trade policy strikes the AGM sector and causes a production decrease in the AGM sector for all of the NUTS 1 regions. The NUTS 1 regions, which use unskilled labour in the AGM sector and skilled labour in the IND and SERV sectors more intensively with respect to the other NUTS 1 regions, are the most affected regions in the AGM sector. The decrease in the AGM production, in turn, determines a production reallocation and reduces the labour demand for unskilled labour. As a result, in general the unskilled factor loses (the wage goes down) and the skilled factor wins (the wage goes up). However, in the NUTS 1 regions which use the unskilled labour in the IND sector and the skilled labour in the SERV sector more intensively, the IND production goes down and the SERV production goes up. In contrast, in the NUTS 1 regions, which use the unskilled and skilled factors in the IND and SERV sectors by similar intensities, the IND production goes up and the SERV production goes down.

The introduction of unskilled/skilled labour mobility within the EU15 and the EU27 determines smaller decreases in the AGM sector and, not surprisingly, a larger production reallocation between the IND and SERV sectors, as shown in Tables 10 through Table 17. Strong *amplification* effects are observed in these two sectors for the NUTS 1 regions, which experienced strong decreases or increases in the case of unskilled/skilled labour immobility. These *amplification* effects occur because workers can move toward the regions where they receive a higher wage. This is also the reason why the Greek regions and Portugal exhibit a stronger skilled immigration (Table 19 and Table 21) while Ireland and Luxembourg have a stronger unskilled immigration (Table 18 and Table 20).

Welfare analysis cannot be carried out at the macro-area level. Nevertheless, the % change in the overall value added can be evaluated at the NUTS 1 through a Laspeyres index. It is interesting to note in Tables 22, 23 and 24 that labour mobility increases the losses and gains in terms of value added, in particular for the NUTS 1 regions in which there is a stronger production reallocation.

9 Conclusions

The aim of this work was to build a global CGE model at the NUTS 1 level for trade policy evaluation. The model was applied to the 68 NUTS 1 regions in the EU15 mainly to assess the production reallocation across sectors in each NUTS 1 region after a world tariff liberalization in agriculture. Nevertheless, it can also be used to simulate other trade policy reforms according to the special interest of the researcher. Special attention is given to the economic interpretation of the trade policy effects. Indeed, a weak link of the CGE approach is the poor economic interpretation of the results.

The results at the NUTS 1 level are the following. The tariff liberalization in agriculture has a strong effect in the Austrian regions (East, West and South), Ireland and Portugal in the AGM sector. However, all the NUTS 1 regions decrease production in this sector. In the IND and SERV sectors it is possible to note inverse patterns of production at the NUTS 1 level. Indeed, Nisia Aigaiou-Kriti, Attica and Portugal show the greatest decreases in the IND sector while Ireland, East Austria and Luxembourg experience the greatest increase in this sector. In contrast, Nisia Aigaiou-Kriti, Attica and Portugal exhibit the greatest increases in the SERV sector while Ireland, East Austria and Luxembourg show the greatest decrease in this sector.

The stylised model allows the key parameter to be determined for interpreting the results. This parameter is the sectoral difference between the ratios of unskilled labour intensity to skilled labour intensity. Indeed, skilled labour and unskilled labour can be considered as the source of the heterogeneity across the NUTS 1 regions. To summarize, trade policy strikes the AGM sector and causes a production decrease in the AGM sector for all the NUTS 1 regions. The NUTS 1 regions, which use unskilled labour in the AGM sector and skilled labour in the IND and SERV sectors more intensively with respect to the other NUTS 1 regions, are the regions most affected in the AGM sector. The decrease in the AGM production, in turn, determines a production reallocation and reduces the labour demand for unskilled labour. As a result, in general the unskilled factor loses (the wage goes down) and the skilled factor wins (the wage goes up). However, in the NUTS 1 regions which use the unskilled labour in the IND sector and the skilled labour in the SERV sector more intensively, the IND production decreases and SERV production increases. In contrast, in the NUTS 1 regions, which use the unskilled and skilled factors in the IND and SERV sectors by similar intensities, the IND production goes up and the SERV production goes down.

The introduction of the labour mobility within the EU15 and the EU27 causes *amplification* effects for the NUTS 1 regions which experienced strong increases or decreases in the IND and SERV sectors under the assumption of perfect immobility at the NUTS 1 level. In general, this hypothesis has a strong impact on the outcomes and determines unrealistic variations of the production in the services and manufactures sectors after agricultural liberalization. These results are not intended to be realistic but are a guide regarding the relevance of the assumption about labour mobility.

Concerning the welfare analysis, very limited gains are obtained from trade liberalization. The welfare change is measured in terms of equivalent variation. The world gains are light under all three labour mobility scenarios, especially if compared to those observed in other studies (Hertel and Keeney, 2005; Bouet *et al*., 2005). In the third scenario, the integrated labour market within the EU27, the EU15 loses and the Rest of Europe (REU) wins.

Let us now move on to a description of the possible extensions for further research.

The focus of this model is on the production side. I concentrated my attention on the skilled and unskilled factors at the NUTS 1 level because of data constraints. Nevertheless other factors can be considered or added in order to make the analysis more complete.

Another issues is the welfare analysis. The policy maker is probably also interested in assessing the welfare change at the NUTS 1 level after a trade liberalization. This implies the introduction of a representative household in each NUTS 1 region, as in the approach of Jean and Laborde (2004). This, in turn, requires much more data, for example, on consumption, income and savings at the regional level. However, the lack of well suited data to model the trade flows across the NUTS regions and between the NUTS regions and the other parts of the world remains a serious constraint. Simplifying assumption must be made.

A more detailed regional level (NUTS 2 or NUTS 3) could be developed even if the computational tractability of the model should be verified.

In this model an agricultural tariff liberalization was implemented but only the agricultural market access at the world level was analysed. I made this choice to preserve the simplicity of the model in order to better understand its economic results and to make the most of the MAcMap database, which was expressly created for the *computable general equilibrium* analysis. However, the protection of agriculture is very tricky, especially in the European Union, where the *Common Agricultural Policy* (CAP) plays an important role. Therefore, it could be interesting to study the interactions between the market access liberalization with the other pillars of trade protection in agriculture: export subsidies, domestic support and quotas.

A more technical development of the model concerns the elasticity value of migration in the CET functions within Europe. As noted, a high labour mobility within Europe implies unrealistic production reallocation between the IND and SERV sectors. Common sense would suggest an elasticity value closer to zero than to ten. However, an econometric analysis would help to give a greater robustness to the model. In addition, the econometric analysis should distinguish between unskilled labour mobility and skilled labour mobility.

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