Value-added in a Computable General Equilibrium model with oligopolistic competition: drivers and implications of sourcing by agent in the MIRAGE-VA model

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Abstract

The dramatic increase in merchandise world trade since the early 90s has been partially driven by the development of global value chains. Production processes have been fragmented and each stage localized according to comparative advantages. These global value chains are now more and more analysed and the localisation of value added is taken into account by policymakers to determine trade policies.

Different initiatives have been launched in order to improve the available statistics. TiVA (Trade in Value-Added), WIOD (World Input-Output Database) and the forthcoming GTAP module (MRIO, Multi-Regional Input-Output) share the same objectives of providing trade data in value added terms and better identify the differences between final and intermediate consumption in terms of origin and destination. All these endeavors basically combine input-output information with trade data at the HS6 level and product categorization using the UN Broad Economic Classification (BEC).

To be fully consistent with this literature, and to take full advantage of the refinement of Input Output (IO) databases in policy analysis, general equilibrium models should adapt their modelling assumptions, in particular on trade behaviours, and their outputs. For instance, demand for imports can be differentiated by agent (final consumer or firms), allowing to account for the differentiated tariffs they face due to the aggregation of different tariff lines. We therefore develop a new version of the multi-country, multi-sector global computable general equilibrium model MIRAGE that integrates these features. More precisely, firms jointly form their sourcing decision for intermediate inputs according to the same structure (Armington CES and choice of variety) as the consumer does for final consumption. At this stage, sourcing decisions for intermediate goods are assumed to be symmetric across sectors, in line with the most recent developments in

global value chain analysis mentioned above, since available data needed to relax this assumption are not available for a large number of countries and sectors. They allow to trace foreihn value added both in trade flows, domestic consumption and domestic production.

Using the MAcMap HS-6 database on tariff protection, the Looi Kee et al. (2009) database on *ad valorem* equivalents of non-tariff measures and the ImpactEcon MRIO version of the GTAP database developed by ImpactEcon, we run a simple policy simulation (uniform reduction in worldwide tariffs) in presence of oligopolistic competition and then provide a detailed analysis of the results, comparing them with the output of the standard version of the model, and identifying the drivers of the differences. We also apply the decompositions developed by Koopman et al. (2014) and Wang et al. (2013) to better take advantage of the new features of the model.

Introduction

To be completed.

Key contributions:

- An extension of the MRIO modelling framework by Walmsley et al. (2014) to oligopolistic competition.
- Introduction of the differentiated impacts of NTMs by agents at the bilateral level.
- Indicators measuring value-added content of international trade adapted to the CGE framework, in line with the most recent advances in the litterature, and extension to greenhouse gas emissions embedded in international trade.

1 Integration of sourcing by agent in global CGE databases

1.1 Review of the litterature

Different initiatives have been launched in order to improve the trade statistics used with respect to sectoral and regional interlinkages. TiVA (Trade in Value-Added), WIOD (World Input-Output Database) and the forthcoming GTAP module (MRIO, Multi-Regional Input-Output) share the same objective of providing trade data in value added terms and better identify the differences between final and intermediate consumption in terms of origin and destination. All these endeavors basically combine input-output information with trade data at the HS6 level and product categorization using the UN Broad Economic Classification (BEC).

Johnson and Noguera (2012) provided one of the first attempts to trace value added in trade flows, while the latest decomposition has been proposed by Koopman et al. (2014). WIOD is well documented and publicly available, but offers limited geographic coverage (43 countries) and no guarantee of future update (although an update has been done last autumn). TiVA is less documented and also has a limited geographic coverage (61 countries, of which 34 OECD countries). GTAP-MRIO (Carrico, 2017) is not available yet but Walmsley et al. (2014) and Koopman et al. (2014) already document two similar approaches to obtain a MRIO database from GTAP. GTAP-MRIO will be based on the last GTAP database release (GTAP 9, for the year 2011), will have an extensive geographic coverage (the same as the GTAP database, 140 regions), will be updated regularly and is consistent with all other data used otherwise by most CGE modelers. In addition, the ImpactEcon consultancy already proposes a code package to obtain a MRIO database from GTAP 9 and Koopman et al. (2014) made their code available to build trade in VA from the GTAP database (version 7) and BEC classification, for the sectoral and regional aggregation they used in their paper. In this paper, we will retain the Supply Chains database by ImpactEcon, which is the only one currently available.

To be completed.

1.2 Databases for value-added analysis in CGE model

1.2.1 The ImpactEcon database

To be added.

1.2.2 Tariff by agent using the MAcMap-HS6 database

To be added.

1.2.3 Non-tariff measures by type of agent

To be added.

2 Modelling strategy

2.1 The MIRAGE model framework

MIRAGE[1] (Modelling International Relationships in Applied General Equilibrium) is a multi-sector and multi-region computable general equilibrium model dedicated to impact assessment of trade policy and interactions between trade and climate change. The model is documented in Bchir et al. (2002); Decreux and Valin (2007); Fontagné et al. (2013).

In MIRAGE, firms interact in an oligopolistic competition framework *à la* Krugman (1980) or in a perfect competition framework. In the former, a number of identical firms in each sector and region compete one with another and

[1]The actual version used in this paper has been developed from MIRAGE-e version 1.1

charge a markup over marginal cost or a perfect competition framework (a representative firm by sector and region charges the marginal cost). Whatever the competition framework, production combines value-added plus energy and intermediate consumption in fixed shares, while demanding five primary factors (labor with two different skill levels, capital, land, natural resources) which are fully employed.

In each region, a representative consumer represents both households and the government and maximizes its intra-temporal utility function under its budget constraint. This representative agent saves a part of his income and the rest is spent on commodities according to a LES-CES function.

Trade is usually represented with a standard Armington specification – though more complex product differentiation by quality zones can also be considered – and encompasses a wide range of trade-impacting measures: bilateral protection stems from the MAcMap databas,e which allows for a fine definition of trade policy scenarios at the HS6 level (5000+ products); trade restrictiveness of non-tariff measures, whether generating rents or not, is also taken into account.

Every agent in the model emits greenhouse gas emissions by her consumption of fossil energy goods (coal, crude oil, gas, refined petroleum) as well as by the production process of firms. These emissions can be mitigated through the implementation of a carbon tax or cap & trade mechanism, and can also be subject to a border carbon adjustment when traded.

Finally, MIRAGE is a recursive dynamic model, where the baseline is calibrated in close relationship with the MaGE model (Fouré et al., 2013) to deal with world structural change from medium (2030) to very long-run horizon (2100), as presented in Figure 1. Adjustment inertial comes from the reallocation of capital via depreciation of capital stock and investment.

2.2 Sourcing by agent

2.2.1 Implementation in MIRAGE-VA

First of all, we start by implementing in the MIRAGE model a structure that is similar to that of Walmsley et al. (2014); Walmsley (2016). The implementation is summarized in Figure 2.

2.2.2 An extension to oligopolistic competition

The MIRAGE framework is then extended to account for oligopolistic competition *à la* Krugman (1980), following the implementation proposed by Bekkers and Francois (2017). In a nutshell, we define after these authors the generalized marginal cost $GnMC_{i,r}$ as:

$$GnMC_{i,r} = \begin{cases} 1 & \text{in perfect competition} \\ N_{i,r}^{\frac{1}{1-\sigma_{VAR}}} \frac{\sigma_{VAR}}{\sigma_{VAR}-1} & \text{in imperfect competition} \end{cases} \tag{1}$$

Figure 1: 2-step workflow in MIRAGE-VA

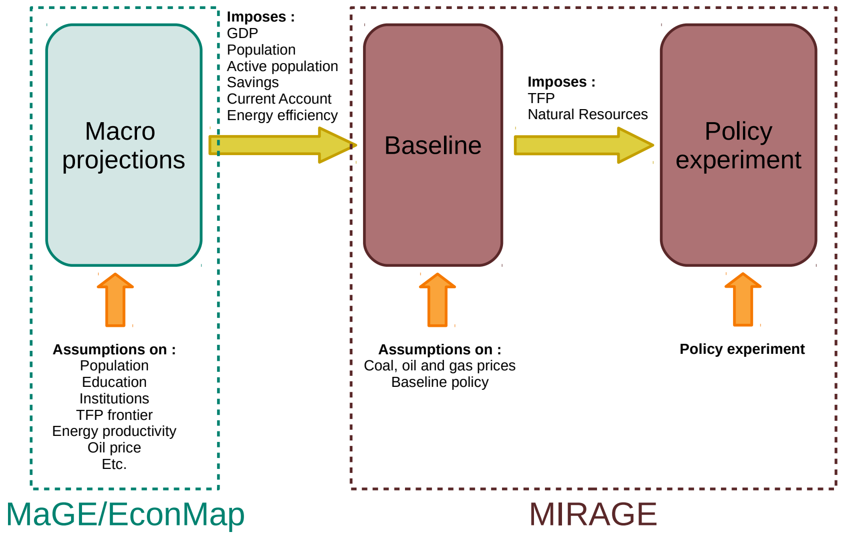
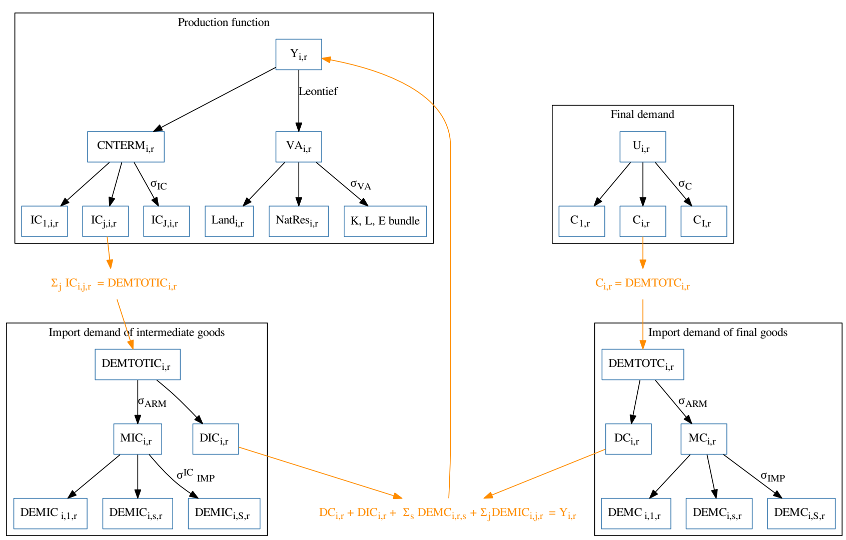


Figure 2: Simplified diagram of MIRAGE-VA final and intermediate demand



where $N_{i,r}$ is the number of operating firms in sector i of country r and σ_{VAR} the elasticity of substitution between varieties.

With such a definition, introducing oligopolistic *à la* Krugman (1980) is as simple as writing price for domestic good $PD_{i,s}$ and foreign good $PDEM_{i,r,s}$ as:

$$\left\{ \begin{array}{lcl} PD_{i,s} & = & GnMC_{i,s} PY_{i,s} \left(1 + tax^P_{i,s}\right) \\ PDEM_{i,r,s} & = & GnMC_{i,r} \left(1 + GnTariff_{i,r,s}\right) \left(1 + tCost_{i,r,s}\right) \\ & & \left[\left(1 + tax^P_{i,r}\right) \left(1 + GnTax^{EXP}_{i,r,s}\right) PY_{i,r} + \mu_{i,r,s} P^{Tr}_{i,r,s}\right] \end{array} \right. \quad (2)$$

where $PY_{i,s}$ is the marginal cost of production, $tax^P_{i,r}$ production tax, $tCost_{i,r,s}$ an iceberg trade cost, $GnTariff_{i,r,s}$ a generalized tariff that comprises both tariffs and NTM ad-valorem equivalent modelled as an import duty, $GnTax^{EXP}_{i,r,s}$ a generalized export tax that comprises export taxes and NTM ad-valorem equivalent modelled as an export tax, $\mu_{i,r,s}$ the average demand for transportation and $P^{Tr}_{i,r,s}$ the price of transportation.

2.3 Indicators for global value chains in CGE models

In addition to the modelling of sourcing by type of agents, we implement a serie of indicators to take advantage of the most recent advances in the literature on trade in value added (in particular Koopman et al., 2014; Wang et al., 2013) in the presentation of CGE results.

2.3.1 Trade in value-added indicators

Methodology:

- Recovering Leontief coefficients from model results
- Inversion of the Leontief matrix
- Decomposition of trade flows, domestic production and domestic consumption to identify value-added flows and double-counted terms.

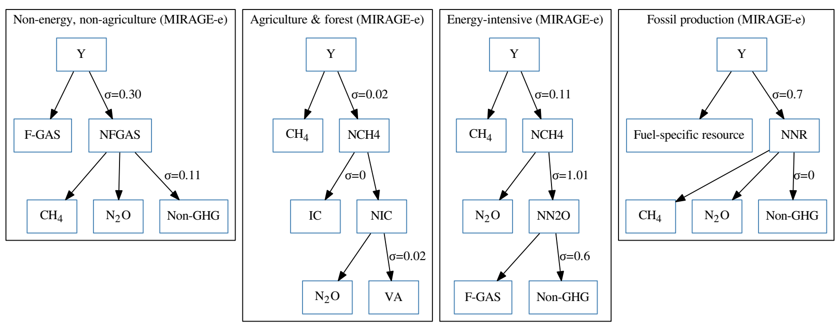
Indicators:

- The content of VA from country c that is included in the trade of good i between regions r and s.
- The content of VA from country c that is included in the final consumption of good j in country r.
- The content of VA from country c that is included in the domestic production of good j in country r.
- More to be added.

2.3.2 An extension to GHG emissions embedded in international trade

Greenhouse gas emissions are integrated in the modelling framework at two different stages. First, the model integrates GHG emissions in the production function of firms, in order to account for Marginal Adjustment Cost (MAC) curves specific to each sector and greenhouse gas (CO_2, CH_4, N_2O and fluorinated gas). In this order, we build on the modelling initially proposed by Hyman et al. (2003) for the EPPA model (Paltsev et al., 2005). The production structure, differentiated by type of sector (agricultural, energy-intensive manufacturing, fossil energy and other) is detailed in Figure 3.

Figure 3: Simplified diagram of MAC modelling in MIRAGE-VA



Second, the decomposition *à la* Koopman et al. (2014) is adapted to identify the amount of GHG emissions originating from country c embeded in the trade of good i between regions r and s.

3 Value Added displacement following a worldwide full trade liberalization

In this section, we illustrate the benefits from the accounting of trade in value-added in CGE model by proposing an application to a full worldwide trade liberalization.

3.1 Baseline and scenarios

To be added.

3.2 Value-added content of trade

To be added.

Concluding remarks

To be added.

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