Trade under the Paris agreement: Do global value chains hinder climate change mitigation?

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Abstract

Climate change policies, and in particular the Paris Agreement, are ment to reduce emissions, setting emission targets for the coming decade. It is well known that the impacts of trade on climate change are ambiguous. On the one hand, increased production leads ceteris paribus to increased emissions (scale effect). On the other hand, trade induces a change in the production specialization (composition effect) that can result either in positive or in negative impacts, depending on the emission intensity of the newly produced goods. In this context, emissions targets promote positive composition and technical trade effects, helping to compensate for the negative scale effect that trade has on the environment. They also ensure that, whatever the trade policy in place, GHG emissions respect the cap that has been imposed, thanks to the adjustement of carbon prices. However, this could streghten the constraint on emissions, inducing higher carbon costs and a higher social cost of climate mitigation. Another downside of the Paris Agreement is that it does not cover the transportation activities, while increased trade raises transport activities and, as a consequence, the related emissions.

To propose a quantitative answer, we tailored the applied general equilibrium model MIRAGE-e to (i) account for global value chains by separating trade in goods for final consumption and trade in intermediates, including their respective tariffs and non-tariff trade costs, (ii) encompass the emissions of five different greenhouse gas and (iii) represent international transportation by mode. Using this framework, we simulate several trade agreements, all taking into account the constraints imposed by the Nationally Determined Contributions of the Paris Agreement. The unlikely scenario of a global trade liberalization has the advantage to produce large impacts, to illustrate the different effects linking international trade and climate change and ease their decomposition, while scenarios based on existing or potential trade policies or agreements illustrate the diversity in the issues related to the specificities of each trade policy.

Introduction

To be completed.

Key contributions:

- An emcompassing framework on trade and climate change mitigation analysis
- 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 and greenhouse gas 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.
- An application to interactions between climate change policy and free trade agreement.

1 Global value chains and climate change mitigation : existing approaches and data

1.1 Sourcing by agents

1.1.1 Review of the litterature

Different initiatives have been launched in order to improve the statistics used. 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.

1.1.2 The ImpactEcon database

To be added.

1.1.3 Tariff by agent using the MAcMap-HS6 database

To be added.

1.1.4 Non-tariff measures by type of agent

To be added.

1.2 Greenhouse gases and greenhouse gas mitigation in CGE models

1.2.1 Review of the litterature

To be added.

1.2.2 The GTAP Non-CO2 Emissions Data Base

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 whether in an oligopolistic competition framework *à la* Krugman (1980), where a number of identical firms in each sector and region compete one with another and charge a markup over marginal cost

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

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

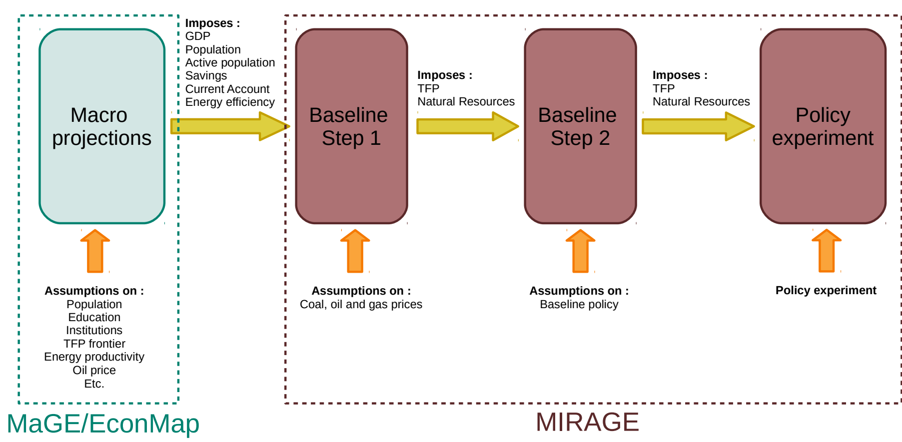
In each region, a representative consumer represents both households and the government and maximizes its intra-temporal utility function under its budget constraint. This representative agent saves a part of his income and the rest is spent on commodities according to a LES-CES function.

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 database 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, are also implemented.

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 the stock of capital via depreciation and investment.

Figure 1: 3-step workflow in MIRAGE-e 2

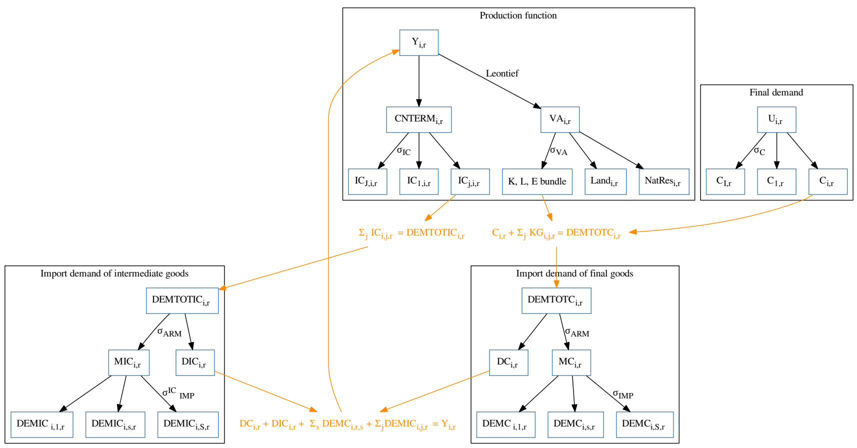


2.2 Sourcing by agent

2.2.1 Implementation in MIRAGE-e 2

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.

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



2.2.2 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:

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

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:

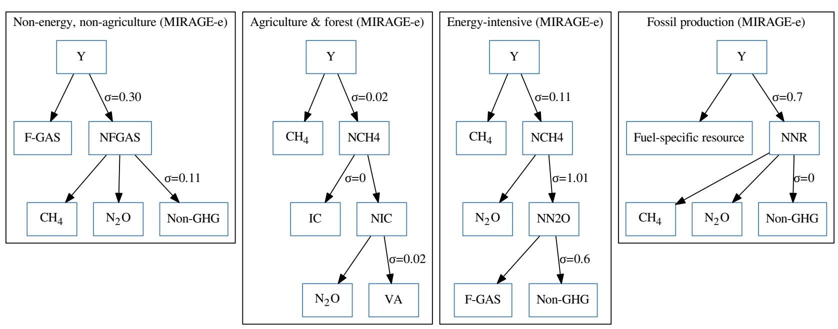
$$\begin{cases} PD_{i,s} & = & GnMC_{i,s} PY_{i,s} \left(1 + tax^P_{i,s}\right) \\ PDEM_{i,r,s} & = & GnMC_{i,r} \left(1 + GnTariff_{i,r,s}\right) \left(1 + tCost_{i,r,s}\right) \\ & & \left[\left(1 + tax^P_{i,r}\right) \left(1 + GnTax^{EXP}_{i,r,s}\right) PY_{i,r} + \mu_{i,r,s} P^{Tr}_{i,r,s}\right]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

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 Non-CO_2 greenhouse gases

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). To do so, 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-e 2



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.

2.4 Indicators for global value chains in CGE models

In addition to the modelling of sourcing by type of agents, we propose a series of indicators to take advantage of the most recent advances in the literature on trade in value added in the presentation of CGE results.

2.4.1 Trade in value-added indicators

Methodology:

- Recovering Leontief coefficients from model results
- Inversion of the Leontief matrix
- Decomposition in value-added and identification of double counting.

Indicators:

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

2.4.2 An extension to GHG emissions embedded in international trade

To be added.

3 Trade liberalization and the Paris Agreement

In this section, we apply the methodological framework described above to analyze interactions between free trade agreements and climate change mitigation.

3.1 Baseline and scenarios

To be added.

3.2 Value-added content of trade

To be added.

3.3 Trade liberalization and carbon prices

To be added.

Concluding remarks

To be added.

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