Climate Policies and Competitiveness: Options for Border Adjustment Measures[1]

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Abstract

The introduction of unilateral climate policies, and the absence of a climate constraint in many parts of the world raise questions about the distortions in competitiveness and CO_2 leakage that may result. Therefore, proposed climate policies are often accompanied by corrective measures intended to limit competitiveness losses. These corrective measures are called Border Carbon Adjustment Measures (BAMs). The objective of this paper is to analyze carbon-related BAMs as potential instruments to reduce emissions leakage and loss of competitiveness. To attain this objective we use a Computable General Equilibrium Model and simulate different climate policies regimes with and without BAMs. We analyse the environmental and welfare effects of these scenarios.

We use a multi-regional computable general equilibrium model, the GEMINI-E3 model, in order to investigate the issues of BAMs. First, we describe the main features of GEMINI-E3 that we use on our analysis. Second, we describe our reference scenario. Third, we present the scenarios that we tested and the main results stemming out from them. Finally, we present how we introduce carbon-related BAMs in our model and the main effects that this have on leakage and welfare.

We simulate four scenarios that suppose different degrees of participation in a climate agreement. In each of them we compute the loss of competiveness and the carbon leakage. The introduction of border adjustment measures will be done within the second scenario that assumes that only industrialized countries (OECD countries) undertake GHG emission reductions. We simulate 4 different BAMs:

- the introduction of tariffs to imports;
- the inclusion of imports into a domestic permit trading schemes;
- the introduction of tax rebate on exports done by OECD countries;
- the introduction of a tax on exports done by non OECD countries.

We use two different definitions of CO_2 content based on (i) direct CO_2 content and (ii) direct & indirect CO_2 content. The direct CO_2 content is based on the fossil energy consumed by firms in non-OECD countries. In the second definition, we take into account not only direct emissions but also indirect emissions representing the carbon content of goods used as intermediate inputs.

We find that the level of leakage is rather limited concerning GHG emissions (12%) and output losses of Energy Intensive Industries. This does not mean that, at the industry level, the problem is not serious. We find that although leakage may be reduced after the introduction of a BAM, this reduction is not really important. Moreover, we find that the welfare effects are not always unambiguous. However, the concrete implementation is not obvious at an economic point of view (e.g. measures of CO_2 content, definition of instrument, administrative cost). The integration of main emerging countries into the climate agreement seems more efficient and BAMs could be used as a stick to force the participation of these countries. However a crucial assumption is linked to Armington elasticities which represent the substitution between domestic good and imported goods.

1. Introduction

There is a strong link between international environmental policy making and trade. In particular, this link is apparent whenever trade measures are invoked as instruments to cope with the international environmental regulation involved - e.g. the Montreal Protocol. We find that border adjustment measures (BAMs) are nowadays one of the most discussed instruments in this respect.[2] For instance, in the last few decades, a number of environment-related border adjustment practices have been introduced. BAMs can be applied both by applying internal taxes to imports and by giving tax rebates to exports. However, taxes and other fiscal measures are not the only domestic policy measures used for border adjustment. There are also non-fiscal internal measures, such as standards, regulations and requirements, which countries may apply to imported products at the border.

For instance, in 1986 the US adopted a Superfund Amendments and Reauthorization Act, which, inter alia, introduced export and import border adjustment for an excise tax on certain chemicals used as inputs for producing chemical derivative products (Biermann and Brohm, 2005). Another example of adjustment measures for environmental taxes is export and import border adjustment of an excise tax on certain ozone-depleting chemicals, introduced by the US in 1989 to meet its obligations under the Montreal Protocol. The taxed chemicals were either present in the final product or were themselves a finished product.

In the context of climate policy, BAMs are currently viewed as a way to address competitiveness and carbon leakage concerns associated with a cap-and-trade or any other emission reduction system which imposes additional costs on domestic producers. Furthermore, BAMs may be used to address one of the prominent issues related to climate policy namely, emissions leakage. The IPCC defines leakage as the increase in CO2 emissions outside the countries taking domestic mitigation action divided by the reduction in the emissions of these countries (IPCC, 2007). Several studies have estimated the size of this leakage. The range in estimations is large and uncertainties seem to be high. But most analyses conclude that the efforts of Annex B countries, which have committed themselves to reduce GHG emissions in the Kyoto Protocol, cause a leakage between 5% and 20% in Non-Annex B countries (IPCC, 2007).

As it was noted in Paltsev (2001) there are several sources of leakage, but two are of particular relevance for our study, the first one is linked to the decrease of energy consumption coming from the regions which are taking commitment in CO2 abatement, this decrease of fossil energy consumption lead to a lower world energy prices which induces, in regions which are not taking into account any commitment, an increase of energy consumption and therefore an increase in CO2 emissions. The second source is due to trade effects. The higher cost of fossil energy leads to an increase of production prices in energy-intensive industries in countries, which are implementing a climate policy, this loss of competitiveness induces an increase of imports from other countries and higher emissions level. BAMs may be applied to either imports, exports or both. Import-BAMs for carbon taxes or carbon-related requirements level the playing field between domestic and foreign firms in the home market by imposing the same costs on imports, as the costs imposed by climate legislation on domestic products. Export-BAMs eliminate competitive disadvantages of domestic firms in the world markets by reimbursing carbon costs when they export their products. Putting domestic and foreign producers on an equal footing prevents relocation of

[2] See Altamirano et al. (2010) for legal aspects of BAMs.

emission-intensive production to countries without emissions restrictions and supports the efficiency of climate change mitigation actions.

There are prominent examples of BAMs applied to climate policy in the European Union and the USA. One of the earlier drafts of amendments to the EU ETS Directive contained a more definitive proposal on allowance requirements for EU importers. The so-called FAIR (a future allowance import requirement) program would include imports in the EU ETS beginning from 31 December 2014. The US Waxman-Markey bill, which passed a vote in the House of Representatives in June 2009, provides for inclusion of imports to the US cap-and-trade starting from 2020. It was suggested that US importers would have to buy US "international reserve allowances" to offset lower energy and carbon costs of manufacturing covered goods. The design of these border adjustments is still in process of elaboration.

The objective of this paper is to analyze carbon-related BAMs as potential instruments to reduce emissions leakage. We show, by means of a computable general equilibrium (CGE) model, the environmental (emissions reduction and leakage) and welfare effects of an exogenous climate policy objective that resembles current the international climate policy regime.

The structure of the paper is as follows. Section 2 describes the model used to simulate different border adjustment measures. Section 3 present the reference scenario, and section 4 the climate policies scenarios considered in this paper. Section 4 presents our analysis of environmental and welfare effects of carbon related BAMs using our CGE model. Finally, section 5 concludes

2. The GEMINI-E3 model

GEMINI-E3[3] is a multi-country, multi-sector, recursive computable general equilibrium model comparable to the other CGE models (GREEN, EPPA, MERGE, Linkage, WorldScan) built and implemented by other modeling teams and institutions, and sharing the same long experience in the design of this class of economic models. The standard model is based on the assumption of total flexibility in all markets, both macroeconomic markets such as the capital and the exchange markets (with the associated prices being the real rate of interest and the real exchange rate, which are then endogenous), and microeconomic or sector markets (goods, factors of production).

The model is built on a comprehensive energy-economy dataset, the GTAP-6 database (Dimaranan, 2006), that incorporates a consistent representation of energy markets in physical units, social accounting matrices for each individualized country/region, and the whole set of bilateral trade flows. Additional statistical information accrues from OECD national accounts, IEA energy balances and energy prices and IMF. Carbon emissions are computed on the basis of fossil fuel energy consumption in physical units, carbon emissions that are not linked to energy combustion, like CO_2 emissions coming from chemical reaction in cement clinker production, are not taking into account. But non CO_2 greenhouses gases emissions are included in the model, for example the methane released during coal mining is taken into account. For the modeling of non- CO_2 greenhouse gases emissions (CH_4, N_2O and F-gases), we employ region- and sector-specific marginal abatement cost curves and emission projections provided by the Energy Modeling Forum within the Working Group 21.

[3] All information about the model can be found at http://gemini-e3.epfl.ch, including its complete description.

The nomenclatures - breakdowns by country/region and by sector/product - are framed according to the general context and the targets of each study. For the present exercise, it appeared convenient to disaggregate the main European Union into 6 entities (the 5 most important economies and the rest of the EU) and to retain a nomenclature of 18 products/sectors, with 3 sectors of fossil energy, 6 in the ETS or energy intensive sectors and 9 in the Non-ETS, according to table 1. We assume that the ETS sector encompasses all of the sectors listed in table 1. Due to data limitations and to the constraints coming from the initial sectors' classification of GEMINI-E3, we note that this formulation does not exactly fit the EU directive:

- some sectors are in both the ETS sector and in the non-ETS sector;
- within a given sector, some firms under the eligibility threshold should not be accounted in the ETS subgroup.

Table 1: Dimensions of the GEMINI-E3 Model

OECD Countries	***Sectors participating to the ETS***
Germany (DEU)	Petroleum Products
France (FRA)	Electricity
United Kingdom (GBR)	Mineral Products
Italy (ITA)	Chemical, rubber, Plastic
Poland (POL)	Metal and Metal products
Rest of European Union (EUR)	Paper products publishing
Japan (JAP)	***Other sectors***
USA (USA)	Coal
Canada, Australia, New Zealand (CAZ)	Oil
	Gas
non OECD Countries	Agriculture
Russia (RUS)	Forestry
India (IND)	Transport nec
Brazil (BRA)	Sea Transport
China (CHI)	Air Transport
Rest of the World (ROW)	Consuming goods
	Equipment goods
	Services
	Dwelings

3. The reference scenario

The reference scenario, also called business as usual (BAU), corresponds to a situation where no climate change policy is deemed necessary. Table 2 summarizes the projected annual GDP growth for each region. The World GDP growth will converge in 2030 to 2.8% per year. The growth would be greater in developing and emerging countries. Our price assumptions assumes that oil price reaches 80 US $ per barrel in 2030.

Table 2 : GDP Growth in the BAU scenario

Regions	2010-2006	2020-2010	2030-2020
DEU	2.0%	1.7%	1.5%
FRA	2.4%	2.4%	2.1%
GBR	2.6%	2.3%	2.1%
ITA	1.7%	1.9%	1.7%
POL	4.3%	4.6%	3.9%
USA	3.5%	3.1%	2.4%
JAP	2.2%	1.5%	0.4%
ROE	3.9%	2.1%	2.1%
CAZ	2.9%	2.2%	1.2%
RUS	5.9%	5.4%	5.6%
BRA	4.2%	3.7%	3.0%
IND	8.6%	8.1%	6.5%
CHI	9.6%	6.3%	5.2%
ROW	4.7%	3.9%	3.0%
World	3.9%	3.3%	2.8%

4. Climate Policy Scenarios

The following five scenarios have been analysed and compared to the BAU scenario. They correspond to five different degrees of international commitments to international climate policy:

1. Failure of negotiations
2. Minimum agreement in OECD
3. Agreement in OECD plus Russia
4. Agreement wthin G20
5. International agreement (global)

From a fragmented climate regime to a unique price of carbon

Targets in climate policies are defined relative to a base year for developed countries. The base years have been indicated in the commitments of the countries (see Table 3). For developing countries, the base year is 2005.

Table 3 : Base year reference emissions (all GHG : *Kyoto basket*)

	Year	Emissions in Gt CO_2-eq	Source
EU	1990	4244	UNFCC exluding LULUCF
USA	2005	7107	UNFCC exluding LULUCF
Australia	2000	495	UNFCC exluding LULUCF
Japan	2005	1358	UNFCC exluding LULUCF
Canada	2006	721	UNFCC exluding LULUCF
Russia	1990	3326	UNFCC exluding LULUCF
China	2005	6739	WEO + estimation EPA
India	2005	2054	WEO 2005 + estimation EPA
Brazil	2005	1011	indicators OMD UN + estimation EPA
ROW	2005	11973	IEO2009 + estimation EPA

Currently the climate policies are characterized by what is commonly called a fragmented regime. Different countries of Annex 1 were individually engaged in the implementation of various measures (taxes, standards, incentive program, etc.) that result in a set of carbon prices (explicit or implicit) that have little chance to converge toward a common value. Only the EU ETS market does represent a successful attempt to reach a common price for CO_2 for a set of economic sectors in different countries. This fragmentation may eventually hinder the development of more ambitious policies and lead to very high disparities in CO_2 prices. Furthermore, according to economic theory this is a source of inefficiency, so there is real gain to make these prices converge to a single price (Tirole (2009)). The convergence of these prices necessitates a generalization of the ETS from European countries to other countries in Annex 1 and further, to developing countries.

The assumption of the study reported here, is that starting in 2020, a global market for CO_2 is in place leading to a single price for CO_2. Trading is set up to exchange rights that are equal to the commitments of each country. This assumption represents the best case for achieving cost effectiveness, even though it does not imply necessarily a global market accessible to all (household, business, government). Multiple markets (ETS Global, CDM, carbon market between nations, national tax, etc.) are also possible, provided permeability and monitoring are carried out effectively enough to get a single world price.

In these simulations the quotas allocated within EU are based on the population in 2001. For industrialized countries, the commitments or proposals made for 2020 and 2050 have been retained (see Table 4). For the intermediate years, the target is obtained by linear interpolation. No international market for tradable emission permits is established before 2020. After 2020 one assumes that an international tradable permit market is gradually established, leading to a single price for carbon.

Table 4: GHG emission abatement commitments

	Year of reference	2020	2050	Remarks
EU	1990	-20% à -30%	-75%	
USA	2005	-17%	-80%	loi Waxman-Markey
Australia	2000	-5 à -25%	-60%	
Japan	2005	-15%		
Canada	2006	-20%	-65%	
Russia	1990	-20%	-50%	

Evolution of the European ETS market

GEMINI-E3 includes 6 European country separately[4], and assumes that until 2020 Europe will implement the energy-climate package, which means two CO2 price within the European Union:

1. a common carbon price in ETS sector;
2. another common CO_2 prices within non-ETS sectors, on the basis of allowances specified in the EU-directive on energy & climate.

Starting from 2021 one assumes the participation of the European Union in a global market for CO_2. The "burden sharing" of each country must then be defined and be negotiated taking into account the overall objective of -75% in 2050 compared to 1990 level. In this study, the scenarios assessed in the present study assume that the "burden sharing" between European countries is based on the population of each member.

Description of scenarios

Scenario 1: Failure of Negotiations

Negotiations break down. Countries prefer to emphasize their national interests. The USA abandon their climate policy objectives blocked in Congress. Canada, Australia and Japan eventually join the USA position. Only EU meets its commitments of -20% in 2020. However, in 2020, proven global warming revives the negotiations. The USA, Japan, Canada and Australia decide to reach -20% in 2030 (relative to 2005). The rest of the World does not commit. As regards the European carbon market, it is assumed that, within the EU, a market of emission permits is introduced at national level to arrive at a single CO_2 price for non-ETS sectors. Two CO_2 prices coexist for an ETS sector and another for non-ETS sectors.

Scenario 2: Minimum agreement in OECD

Industrialized countries (except Russia) will fulfil their commitments in 2020 and set up, gradually from 2021, an international market for emission permits to fulfil commitments consistent with the goals of industrialized countries for 2030. Russia and other countries are doing nothing until 2030.

Scenario 3: Agreement in OECD+Russia

Same as in scenario 2 except for the accession of Russia.

Scenario 4: Agreement within G20

Industrialized countries + China + India + Brazil, agreed to set up from 2020 an international market for emission permits. From 2020, China and India are allocated quota as 150% of their 2005 emissions, and Brazil 120%. For industrialized countries, quotas are equal to objectives consistent with their goals for 2050, the European Union deciding to -30% in 2020 given the participation of China, India and Brazil to the agreement. China, India and Brazil participate to the international carbon market. A restriction is imposed on the volume of permits they can sell during the first years (10% of their quotas), this restriction is gradually removed and trade is unlimited in 2030.

[4] Namely : Germany, France, United Kingdom, Italy, Poland and the rest of European Union.

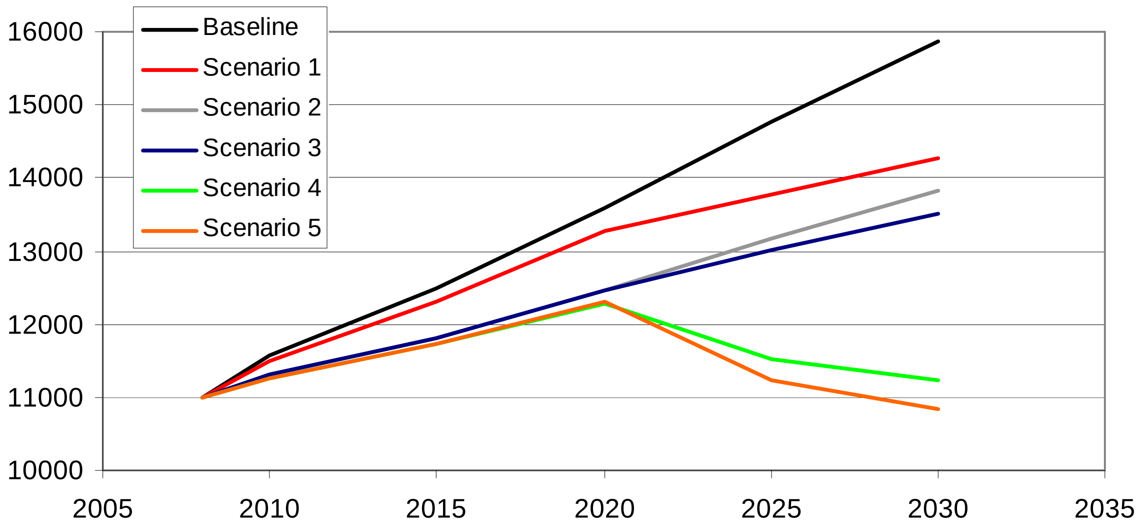
Scenario 5: International Agreement (World)

This is a similar to policy scenario 4 but with all countries agreeing to act. From 2020, the Rest of the World obtains a quota equal to 120% of their 2005 emissions. China, India and Brazil and the Rest of the World participate to the international carbon market. A restriction is imposed on the volume of permits they can sell during the first years (10% of their quotas), this restriction is gradually removed and trade is unlimited in 2030.

Main results of the scenarios

This section stresses the main results of the scenarios. Figure 1 presents the GHG emissions in the different scenarios. Only the scenarios 4 and 5 lead to a decrease of GHG emissions, this result shows the importance of the integration of emerging and developing countries in the climate change policy.

Figure 1 : GHG emission in MT C equivalent



Tables 5 and 6 show the CO_2 price respectively in 2020, 2025 and 2030. In the scenario 1, the price of the ETS would be equal to 32 € in 2020 and 73 € for the non-ETS. In the scenario 2, the integration of other OECD countries (USA, Japan, Canada, Australia and New Zealand) leads to a much more decrease of world energy demand and therefore a much more important decrease of energy prices (mainly for crude oil and natural gas), this requires an increase in the price of CO_2 in the non ETS sector for European countries (the price reaches 83 €), but not in the ETS sector where coal is the main fossil energy consumed. For non European countries the CO_2 price is around 40 € in the scenario 2 for the year 2020. Scenario 3 does not modified the CO_2 price because the commitment of Russia (-20% in 2020 in respect to 1990 levels) is already reached in the baseline. In scenario 4 and 5 the only difference concerns the European Countries which decides to reach a more stringent commitment (-30% in 2020) this requires an increase of the CO_2 price in the ETS (the price is now equal to 90 €) and in contrary a decrease of the CO_2 price in the other sectors. The raison is that the increase of electricity prices due to the important increase of the ETS price induces a decrease of energy consumption in all sectors and of course a decrease of CO_2 emissions, the prices required to reach the new CO_2 target is therefore less important.

After 2020, the implementation of international tradable permits leads to an unique CO_2 price. The table 5 gives this price in 2025 and 2030. It is worth mentioning that when the emission abatement increase with a greater participation of regions the CO_2 price decreases over this period. This is due to the lower CO_2 abatement of emerging and developing countries.

Table 5 : price of CO_2 in 2020 (in € 2005)

	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5
EU					
ETS price	32	33	33	90	90
Non ETS price	73	83	83	71	71
USA		37	37	37	37
JAP		34	34	33	33
CAZ		44	44	44	44
RUS			0	0	0

Table 6 : price of CO_2 permit in 2025 and 2030 (€ 2005)

	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5
CO2 permit					
in 2025	28	84	64	19	13
in 2030	83	168	131	39	23

Leakage

We have computed the leakage in the different scenario[5], Table 7 presents the leakage in MT C and in %. As it was noted in Paltsev (2001) there are several sources of leakage:

- the first one is linked to the decrease of energy consumption coming form the regions which are taking commitment in CO_2 abatement, this decrease of fossil energy consumption lead to a lower world energy prices which induces in regions which are not taking into account any commitment an increase of energy consumption and therefore an increase in CO_2 emissions;
- The second raison is due to trade effect; the higher cost of fossil energy leads to an increase of production prices in energy intensive industries in countries which are implementing a climate policies, this loss of competitiveness induces increase of imports from other countries and increase emissions.

The leakage ratio is estimated in the worst case scenario to 12% in 2030 concerning CO_2 emissions, of course when we increase the participation in the climate agreement this reduces the leakage effect and conducts in scenario 5 to a leakage equal to 0. These results show that when the agreement encompass the main emerging countries (Brazil, Russia, India and China) the leakage could be reduced to very low level, 3% in 2030. The leakage ratio found is in line with the numbers that we can find in the literature (Paltsev, 2001; Babiker and Rutherford, 2005).

[5] Leakage is equal to the increase of GHG emissions in the regions which are not binding by any commitment.

Table 7 : Leakage in Mt C

	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5
GHG Emissions					
			2020		
Emission Abatement	-349	-1204	-1206	-1346	-1346
Leakage	43	96	83	86	86
%	-12%	-8%	-7%	-6%	-6%
			2030		
Baisse d'émission	-1773	-2231	-2559	-4739	-5038
Leakage	154	169	187	97	0
%	-9%	-8%	-7%	-2%	0%
			2020		
CO2 Emissions					
			2020		
Emission Abatement	-271	-930	-916	-1049	-1049
Leakage	43	108	94	100	100
%	-16%	-12%	-10%	-10%	-10%
			2030		
Baisse d'émission	-1490	-1935	-2186	-4107	-3940
Leakage	172	194	187	106	0
%	-12%	-10%	-9%	-3%	0%

The introduction of border adjustment measures will be done within the scenario 2 which suppose that only industrialized countries are willing to do something in order to reduce GHG emissions. Table 8 presents in the case of the scenario 2 the source of leakage at the regional and industrial level. BRIC represents 45% of the leakage and energy intensive industries (including refined petroleum industries and electricity generation) 81% of the increased emissions.

Table 8 : Leakage in Gt C by region and sector in scenario 2 in 2030

	RUS	BRA	IND	CHI	ROW	**Sum**
Sector						
Coal	0	0	0	-3	0	**-3**
Oil	0	0	0	0	-2	**-2**
Gas	0	0	0	0	-4	**-3**
Petroleum Products	1	6	2	2	35	**45**
Electricity	1	16	5	10	26	**58**
Agriculture	0	0	0	0	1	**0**
Forestry	0	0	0	0	0	**0**
Mineral Products	0	1	0	3	7	**12**
Chemical, rubber, Plastic	1	3	1	5	14	**24**
Metal and Metal products	1	3	1	5	6	**17**
Paper products publishing	0	0	0	0	1	**1**
Transport nec	0	1	1	3	4	**10**
Sea Transport	0	0	0	1	1	**3**
Air Transport	0	1	0	1	0	**2**
Consuming goods	0	0	0	-1	1	**0**
Equipment goods	0	0	0	0	1	**2**
Services	0	0	0	1	3	**5**
Dwelings	0	0	0	0	0	**0**
Households	0	1	3	8	11	**24**
Sum	**5**	**32**	**14**	**37**	**106**	**194**

5. Border Adjustment Measures

We have simulated different BAMs and we have chosen to use the scenario 2 to analyse the impacts of these instruments. The following simulations will suppose the implementation of BAM and will be compared to the scenario 2 without any corrective measure

Tariff protection

Tax on import based on direct CO_2 content

We suppose that in OECD countries a carbon price is imposed on imports coming from non OECD countries and that this carbon price is based on the price supported by domestic firms. The duties are collected by each OECD government. The CO_2 content used to determine the tax is based on the fossil energy consumed by firm in non OECD countries.

We defined the following

$$\alpha_r^i = \frac{\sum \beta_j \ En_r^{j,i}}{XD_r^i} \qquad (1)$$

where α_r^i is the CO_2 content of good *i* produced in region *r*, β_j the CO_2 content of energy *j*, $EN_r^{j,i}$ the energy consumption in toe by sector *i* in energy *j* and XD_r^i the production of sector *i* in region *r*.

The price of imported good *i* in region *r* coming from region *t* is the following:

$$Pimp_{r,t}^i = pd_t^i * \left({ex_t}/{ex_r} \right) + \alpha_r^i \times Tco2_r^i \qquad (2)$$

where *ex* is the exchange rate, *pd* the production price and *Tco2* the carbon tax.

Tax on import based on direct and indirect CO2 content

In this section we take into account not only direct emission but also indirect emissions representing the carbon content of goods used as intermediate input. The coefficient α_r^i is now computed by the following equation:

$$\alpha_r^i = \frac{\sum_j \beta_j \ En_r^{j,i} + \sum_{k,t} \alpha_t^k \ MA_t^{i,k}}{XD_r^i} \qquad (3)$$

Where MA_t^k represents the intermediate input in good *k* used by sector *i* and produced in region *t*.

Leakage

In these two first simulations we suppose that the tax on imports is imposed on all goods and not only on goods produced by energy intensive industries (EII). Therefore in a third simulation we study the case where only the EII are subject to tariff protection. Concerning climatic impacts the gain coming from tariff imports ranges from 20 to 50 Mt C, which corresponds in the best case to a reduction of 26% of the leakage.

Table 9: Leakage in Mt Carbone and in % in 2030

	Scenario 2	Scenario 2 +BAM based on direct content	Scenario 2 +BAM based on direct & indirect content	Scenario 2 +BAM based on direct & indirect content only applied to EII
Leakage	194	174	144	152
in %	10%	9%	7%	8%

CO_2 price and welfare cost

Tables 10 and 11 report the impacts of BAM on the price of carbon and on the welfare cost respectively in 2030. With the adoption of a carbon tariff on imports the price of carbon decrease slightly. In contrary the impact on welfare is important, in line with Babiker and Rutherford (2005) we find that the tariff protection is welfare improving to countries that impose this tariff and in contrary that the other group of countries is worse off[6]. The reason for this welfare impact is the large implicit rent transfer conferred to countries which impose a tax on imports.

Table 10: CO_2 permit in 2030 (€ 2005)

	Scenario 2	Scenario 2 +BAM based on direct content	Scenario 2 +BAM based on direct & indirect content	Scenario 2 +BAM based on direct & indirect content only applied to EII
CO2 price	168	166	166	166

[6] We one exception concerning India which has a low welfare gain when the tariff is only applied to Energy Intensive Industries.

Table 11: Welfare cost in % of household consumption in 2030

	Scenario 2	Scenario 2 +BAM based on direct content	Scenario 2 +BAM based on direct & indirect content	Scenario 2 +BAM based on direct & indirect content only applied to EII
OECD countries				
DEU	-5.5%	-4.4%	-3.1%	-4.6%
FRA	-1.4%	-0.1%	0.7%	-0.3%
GBR	-4.3%	-3.4%	-2.5%	-3.6%
ITA	-2.1%	-0.6%	0.4%	-0.6%
POL	-13.3%	-10.8%	-9.7%	-10.9%
USA	-1.9%	-1.6%	-1.6%	-1.6%
JAP	-1.4%	-0.5%	0.4%	-0.6%
ROE	-1.3%	1.1%	2.5%	0.8%
CAZ	-1.1%	-0.3%	0.7%	-0.5%
Non OECD Countries				
RUS	-2.0%	-8.3%	-10.2%	-8.9%
BRA	-0.4%	-1.0%	-2.0%	-1.0%
IND	0.0%	-0.1%	-1.6%	0.2%
CHI	-0.8%	-1.4%	-5.1%	-1.0%
ROW	-1.8%	-3.6%	-4.9%	-3.5%

Inclusion of imports in a national emissions trading scheme

We consider now that exporters have to buy emission allowances for selling their products in the regions that have adopted binding commitment of GHG emissions, if of course they are not localized in these regions. As our international emissions trading scheme begins at the worldwide level in 2021, we suppose that before 2021, a tariff protection is imposed with the same protocol described above. We assume also that only Energy Intensive Industries are faced to the new rule, the other sectors are exempted to any border adjustment measure. A crucial assumption is linked to the allocation rule of the CO_2 allowances for the foreigner producers, if we suppose that no additional allowances are created, the new demand for emission permits will increase sharply the CO_2 price. We have retained two assumptions:

1. No additional allowances are given;
2. Allowances are given to exporters which is equal in 2021 to 80% of the CO_2 content of imports for a reference year which is fixed to 2000, and this allocation is equal to 50% in 2050 for this same reference year.

The table 12 reports the CO_2 price and the leakage, the table 14 presents the trading of emission permits. In the case where no additional allowances are given the CO_2 price increases by 50%, the additional demand for permits forced OECD countries to reduce by more than 267 millions of CO_2 their emissions compared to the scenario 2. The OECD countries become net sellers of permits, and the U.S. sell more than half of the demand from the EII exporters. The leakage is equal to 157 Mt CO_2. Concerning the welfare cost of OECD countries there is two opposite effects of the inclusion of imports in the national emission trading scheme:

1. first, the increase of CO_2 price induce a increase of the deadweight loss of the taxation;

2. next, the selling of permits to non OECD producers create extra revenue.

At the end the impact is welfare decreasing for Germany, and USA, and welfare increasing for the other OECD countries. For non OECD countries the result of the scenario is of course an increase of the cost.

When we create extra allowance dedicated to EII imports the increase of the CO_2 price is less important (30% to be compared to 50%), the impact are similar to the previous simulation but with a magnitude less important.

Table 12: CO_2 permit (€ 2005) and leakage in 2030

	Scenario 2	Scenario 2 + inclusion of Import in Emission trading	Scenario 2 + inclusion of Import in Emission trading + Extra Allowances
CO2 price	168	243	218
Leakage	194	157	155
OECD GHG abatement	-2231	-2498	-2387
CO2 buying by EEI exporters		2498-2231=267	156

Table 13: Welfare cost in % of household consumption in 2030

	Scenario 2	Scenario 2 + inclusion of Import in Emission trading	Scenario 2 + inclusion of Import in Emission trading + Extra Allowances
OECD countries			
DEU	-5.5%	-5.7%	-5.2%
FRA	-1.4%	0.0%	-0.2%
GBR	-4.3%	-4.3%	-4.0%
ITA	-2.1%	-0.4%	-0.6%
POL	-13.3%	-11.2%	-11.4%
USA	-1.9%	-4.1%	-2.9%
JAP	-1.4%	-0.6%	-0.6%
ROE	-1.3%	2.2%	1.5%
CAZ	-1.1%	1.4%	0.4%
non OECD Countries			
RUS	-2.0%	-10.4%	-9.8%
BRA	-0.4%	-1.6%	-1.4%
IND	0.0%	-0.4%	-0.2%
CHI	-0.8%	-1.8%	-1.5%
ROW	-1.8%	-4.3%	-4.0%

Table 14 : Trading of permits (+ selling – buying) in Mt C in 2030

	Scenario 2	Scenario 2 + inclusion of Import in Emission trading	Scenario 2 + inclusion of Import in Emission trading + Extra Allowances
DEU	-53	-32	-41
FRA	6	14	11
GBR	-12	1	-4
ITA	6	13	10
POL	-3	4	1
USA	7	144	88
JAP	16	37	28
ROE	2	32	19
CAZ	31	52	44
EEI Exporters		-267	-156
Sum	0	0	0

Introduction of tax rebate on exports done by OECD countries

We suppose that OECD apply a tax rebate on goods exported to Non OECD regions. We assume also that only Energy Intensive Industries are faced to the new rule, the other sectors are exempted to any border adjustment measure. We combine these scenarios with tariff on imports. Tables 15 and 16 report the impacts of this measure on the price of carbon and on the welfare cost respectively in 2030. The leakage decrease slightly and the welfare impact is also quite limited.

Table 15: CO_2 permit (€ 2005) and leakage in 2030

	Scenario 2	Scenario 2 +tariff based on direct & indirect content only applied to EII	Scenario 2 +tariff based on direct & indirect content + tax rebate on export only applied to EII
Leakage	194	152	144
in %	10%	8%	7%
CO2 price	166	166	169

Table 16: Welfare cost in % of household consumption in 2030

	Scenario 2	Scenario 2 +tariff based on direct & indirect content only applied to EII	Scenario 2 +tariff based on direct & indirect content + tax rebate on export only applied to EII
OECD countries			
DEU	-5.5%	-4.6%	-4.7%
FRA	-1.4%	-0.3%	-0.3%
GBR	-4.3%	-3.6%	-3.5%
ITA	-2.1%	-0.6%	-0.6%
POL	-13.3%	-10.9%	-10.9%
USA	-1.9%	-1.6%	-1.4%
JPN	-1.4%	-0.6%	-0.5%
ROE	-1.3%	0.8%	0.9%
CAZ	-1.1%	-0.5%	-0.5%
Non OECD Countries			
RUS	-2.0%	-8.9%	-9.1%
BRA	-0.4%	-1.0%	-1.2%
IND	0.0%	0.2%	0.2%
CHI	-0.8%	-1.0%	-1.0%
ROW	-1.8%	-3.5%	-3.8%

Introduction of tax on exports done by non-OECD countries

Finally, we suppose that non OECD countries impose a tax on their exports sold to OECD countries. The tax is collected by non OECD countries and the revenue of this tax is redistributed through lump-sum transfer to their households. We suppose that this export tax is applied only to Energy Intensive Industries and we use the direct & indirect carbon content. We compare this scenario with the scenario 2 with tax on import based on direct and indirect CO2 content and applied by OECD countries on Energy Intensive Industries. In respect to scenario with tariff we find that this scenario is welfare improving to countries which impose the tax and in contrary that the other group of countries is worse off at least at an aggregated level. Of course the situation of non-OECD countries is worse off if we compare with a scenario without any BAM. The impact in term of leakage is nearly the same, the leakage decreases by 5 Mt in respect to scenario 2.

Table 17: CO_2 permit (€ 2005) and leakage in 2030

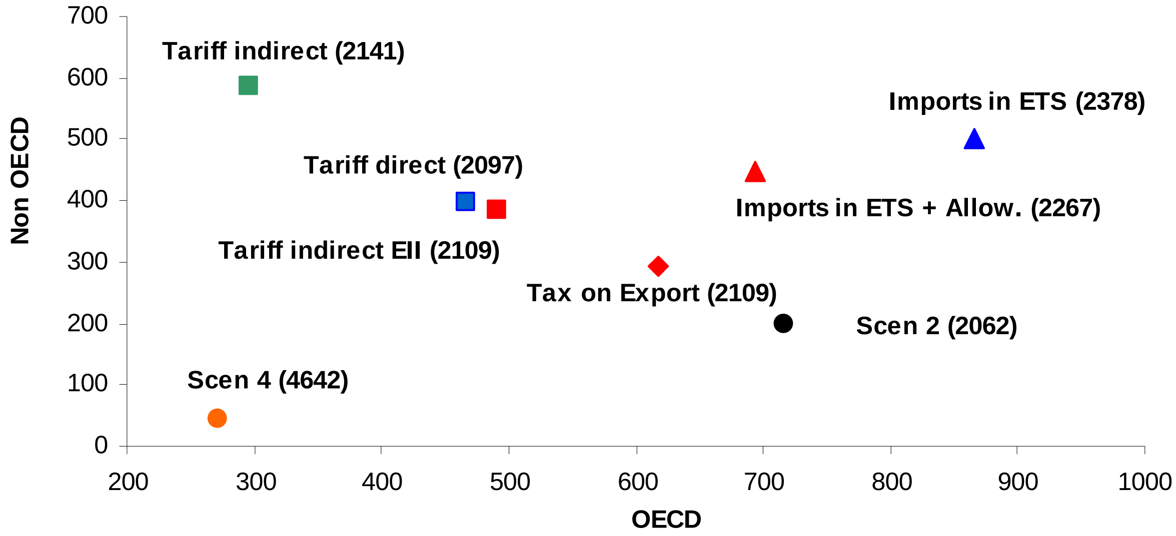
	Scenario 2 +tariff based on direct & indirect content only applied to EII	Scenario 2 + tax on export by non-OECD countries only applied to EII
Leakage	152	147
in %	8%	8%
CO2 price	166	170

Table 18: Welfare cost in % of household consumption in 2030

	Scenario 2 +tariff based on direct & indirect content only applied to EII	Scenario 2 +tariff based on direct & indirect content + tax on export by non-OECD conutries only applied to EII
OECD countries		
DEU	-4.6%	-4.4%
FRA	-0.3%	-0.1%
GBR	-3.6%	-3.5%
ITA	-0.6%	-0.4%
POL	-10.9%	-10.5%
USA	-1.6%	-2.5%
JPN	-0.6%	-0.5%
ROE	0.8%	1.0%
CAZ	-0.5%	-0.6%
Non OECD Countries		
RUS	-8.9%	-6.7%
BRA	-1.0%	-0.2%
IND	0.2%	0.6%
CHI	-1.0%	-1.2%
ROW	-3.5%	-2.6%

Finally, in Figure 2 we summarize the different scenarios analyzed showing the cost of OECD countries against those supported by non-OECD countries, in parenthesis we give also the level of World GHG abatement. From Figure 2 we can observe three main outcomes, first, as it can be seen if the implementation of a tariff by OECD countries always increase their welfare in respect to scenario without BAM, the reason for this welfare impact is the large implicit rent transfer conferred to countries that impose a tax on imports. Second, concerning the integration of imports in a national emissions trading scheme, a crucial assumption is linked to the granting of new allowances. When no additional allowance is given, we find that the welfare of OECD decreases in respect to the scenario without BAM, making unlikely the adoption a such rule. The difficulty is in this case the definition of extra allowances that are given to the market. Third, the implementation of a tax on exports by non OECD decreases their welfare but limits the welfare loss of this group of countries in respect to other BAMs scenarios.

Figure 2: OECD welfare loss versus non-OECD welfare loss in billion US $ (in parenthesis World GHG abatement in MtC) in 2030



6. Conclusion

We find that the level of leakage is rather limited concerning GHG emissions (12%) and output losses of Energy Intensive Industries. This does not mean that, at the industry level, the problem is not serious. Our general conclusion is that that although leakage may be reduced after the introduction of a BAM, this reduction is not really important. Moreover, we find that the welfare effects are not always unambiguous.

However, the concrete implementation of a BAM is not obvious from an economic point of view (e.g. measures of CO_2 content, definition of instrument, administrative cost). It could be interesting to compare all this BAMs scenarios to our scenario 4 in which we suppose the BRIC participation into GHG abatement policy. We find that the welfare is increasing for both group of countries (OECD and non-OECD), OECD benefit from low price of CO2 coming from the low MAC of non-OECD countries, and in contrary non OECD could gain from large selling of permit to OECD countries. The integration of main emerging countries into the climate agreement seems more efficient and BAMs could be used as a stick to force the participation of these countries. However, a crucial assumption of our analysis is linked to the Armington elasticities that represent the substitution between domestic good and imported goods. Removing this assumption will bring changes into the analysis and results, but this is topic that we will explore in future works.

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