Welfare Cost for Europe of Non-Participation to the Market of Tradable Permits and Comparative Efficiency of Corrective Policies towards Energy Intensive Sectors[1]

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Abstract

European Union promotes the view that flexibility mechanisms provided by the Kyoto Protocol, and in particular tradable permits, should come in complement to domestic measures of GHG abatement, i. e. be very limited. For countries exhibiting abatement costs significantly higher than the price of permit which can be expected in a Annex B market, the welfare cost of limited participation may be fairly high. Correlatively, leakage in Energy Intensive Sectors can be expected to be more acute than for other Annex B countries.

The paper assesses, through a world – multi country – multi sector – dynamic – general equilibrium model (GEMINI-E3), the welfare cost in the extreme case of an auto-exclusion of European Union from the market of tradable permits and the consequences for its Energy Intensive Sectors, compared to other Annex B countries supposedly fully participating to the market.

Different European corrective policies in favor of EIS, and aimed at limiting leakage, are appraised and compared: leveling of the carbon tax applied to EIS to the world price of permit; output based allocations; derogatory participation of EIS to the market of tradable permits. The last policy emerges as the least costly for European Union, and able to capture most of the benefits which would accrue from a complete participation of European Union to the market of tradable permits.

The paper highlights the sensitivity of the results to the abatement policies possibly implemented in Former Soviet Union, and the large uncertainties due to low reliability of economic and statistical information.

Keywords: Kyoto Protocol, Tradable Permits, Energy Intensive Sectors, Welfare Cost, Leakage

JEL Classification: D58, H32, L61, Q43

Contents

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Introduction and main issues

The issue of "supplementarity" was one of the main points of disagreement during COP6 between the United States and Europe concerning the implementation of the Kyoto Protocol[2]. According to Article 17 of the Protocol, "*The Parties included in Annex B may participate in emissions trading for the purposes of fulfilling their commitments under Article 3. Any such trading shall be supplemental to domestic actions for the purpose of meeting quantified emission limitation and reduction commitments under that Article*." Article 17 is however fairly imprecise and leaves the room for several interpretations. It does not provide a clear rule or limit in the sharing between domestic efforts and purchase of pollution rights, and only forbids to any country to resort exclusively to tradable permits.

Of course, it is never efficient for a country to completely resort to permits, as clearly demonstrated by nearly all models of simulation. However, the European Union considers that rules limiting the use of tradable permits must be set, and in particular France asserts that resorting to them "*may only be supplemental to domestic efforts, which must represent the bulk in fulfilling the commitments*[3]." Several arguments have been put forward in order to limit or even forbid trade of permits between nations, some fundamentally ethical[4], other often based on unwarranted justifications. For instance, in his assessment on flexibility mechanisms, the French Committee of Sustainable Growth emits the warning that "*the trade of permits, in a country that would constrain its economy and population to a severe emissions abatement in order to get revenue from the sale of permits, could aggravate social inequalities*."

Restriction of tradable permits has been the topic of several works[5]. They usually come to the agreement that restricting the trade of permits has for result to decrease its market price, reduce the welfare gain of net sellers and benefit to net buyers, and essentially increase the total cost of implementing the protocol. Moreover, if a single country or group of countries decides unilaterally to limit its own access to permits, it would inflict to itself an additional cost which is the bigger, the larger is the difference between the marginal abatement cost and the price of permit in the international market. As is argued by Ellerman and Wing (2000), the question of "supplementarity" clearly illustrates how in economics best intentions can be source of inefficiency and additional burden for the economy and the population[6].

The aim of the present paper is to assess an aspect often neglected in analyses of "supplementarity", which is the effect on energy intensive industries and what is known as "leakage". In such a case, domestic industries sensitive in their competitiveness to energy costs would be twice penalized. On the one hand, with respect to non Annex B countries, which is the usual aspect of leakage considered in the literature. On the second hand relatively to other Annex B countries, which would allow to their firms an access to much cheaper energy, through a lower price of carbon (whether a carbon tax, or the price of permit). The latter distortion may reveal more acute than the former.

The paper has three sections. The first is a presentation of the model GEMINI-E3/*GemWTraP*, focusing on aspects which are the most relevant for the analysis. The second section presents the benchmark scenario consisting of a full participation of European Union to the market of tradable permits, and compares it to a scenario of non participation, in terms of welfare cost and leakage.

Section 3 is devoted to an assessment of various corrective policies, aimed at limiting leakage for European countries, and consisting to alleviate the distortion of competition in markets of energy

[2] The text of the Kyoto Protocol is available in the internet site http://www.unfccc.de
[3] See "Plan national de lutte contre l'effet de serre," MIES 2000.
[4] See for instance «Le respect de la création», Commission sociale des évêques de France, La documentation catholique, 6 février 2000, N°2219.
[5] See papers by Bernstein, Montgomery, Rutherford and Yang (1999), Bollen, Gielen and Timmer (1999), Criqui, Mima and Viguier (1999), Ellerman and Wing (2000).
[6] See also, on coordination of climate change policies within European Union and links with foreign trade, the paper of Viguier, 2000.

intensive goods, or in some case to implement compensatory counter-measures. Comparison of these policies, in terms of effectiveness and welfare, is the yardstick in the assessment of their efficiency and desirability. Conclusive comments are drawn, and main uncertainties highlighted, on simulations which give a major role to FSU and the climate change policies likely to be implemented in this area.

I. The structure and the calibration of GEMINI-E3/*GemWTraP*

GEMINI-E3 was the name of the first General Equilibrium Model developed jointly by the French Ministry of Equipment and CEA (French Atomic Energy Agency). It is now the name of a family of models, including GEMINI-E3/***GemWTraP***, which is a world dynamic semi-aggregate model, and GEMINI-E3/**XL France**, which is a static detailed one-country model (France, 88 sectors).

Table 1 Identification card of GEMINI-E3/*GemWTraP*

Full Name : **G**eneral **E**quilibrium **M**odel of **I**nternational-**N**ational-**I**nteraction for **E**conomy-**E**nergy-**E**nvironment/***G***eneral ***e***quilibrium ***m***odel for assessment of ***W***orld ***Tra***dable ***P***ermits

7 zones : France, Other European Countries (EU11), USA, Japan, Former Soviet Union (FSU), Energy Exporting Countries (EEC), Rest of the World (ROW)

3 Institutional Sector (IS) : Households (Incl. Private Administration), Firms, Government

12 sectors/commodities for France and EU11; **8** for USA, Japan, FSU, EEC and ROW (5 of which for Energy : coal, gas, electricity, crude oil, refined oil products)

Starting Year : 1990

Terminal Year : 2040 (with yearly steps)

Productions Functions : Nested CES with fix factors for fossil fuel sectors

Households' Demand Function : Linear Expenditure System (Stone-Geary model)

Function of Imports : Nested with domestic production (consistent with Armington assumption)

Indirect taxation and social contributions : 13 categories with rates differentiated :

- by commodity (taxes on production, on imports)
- by sector (social contributions, subsidies)
- by sector x commodity (intermediate consumption)
- by commodity x institutional sector (final demand)
- by commodity x sector x IS (investment)

Linkage of periods : with endogenous real rates of interest (determined by equilibrium between savings and investment)

Linkage of national/regional models : with endogenous real exchange rates (resulting from constraints on foreign trade deficits or surpluses)

Outputs : by country, annually :

- carbon taxes, marginal abatement cost and price of tradable permits when relevant
- effective abatement of CO_2 emissions, net sales of tradable permits (when relevant)
- total net welfare loss and components : net loss from terms of trade, pure deadweight loss of taxation, net purchases of tradable permits (when relevant)
- macro-economic aggregates : production, imports and final demand (change in volume and change in price); real exchange rates and real interest rates
- industry data : production and factors of production (change in volume and change in price or remuneration)

GEMINI-E3/***GemWTraP*** is a *multi-country, multi-sector, dynamic* General Equilibrium Model incorporating a *highly detailed representation of indirect taxation*. For some purposes, namely appraisal of energy policies directly involving the electric sector, e.g., implementation of nuclear programs, the model can incorporate a technological sub-model of power generation better suited for comparing investments in different types of plants. It is the third version in succession and has been especially designed to calculate the social marginal abatement costs (MAC), i. e. the welfare loss of a unit increase in pollution abatement, and then to simulate tradable permits markets based either on market prices (carbon tax) or on social marginal costs. Trade of permits based on MACs corresponds to the optimization behavior by countries in taxation and environmental policy implementation, and is in most cases more efficient than trade of permits based on market prices or equivalents[7].

Table 1 gives an overall description and the main characteristics of the model. Beside a comprehensive description of indirect taxation (mainly for France), the specificity of the model is to *simulate all relevant markets*: markets for commodities (through relative prices), for labor (through wages), for domestic and international savings (through rates of interest and exchange rates). *Terms of trade*, i.e. transfers of real income between countries resulting from variations of relative prices of imports and exports, and then "real" exchange rates, can then be precisely measured[8].

I.1. The specification of production functions

Figure 1 represents the nesting of factors in production functions, for all sectors and all countries or regions. Important parameters are the various elasticities of substitution, between imports and domestic production, between aggregate domestic factors (capital, labor, energy, other inputs), and for the two last nests, between individual fuels and between commodities. Allowing more or less easy substitution between factors, they command much of the numerical results in scenarios: abatement of CO_2 emissions with a given carbon tax, and then cost of abatement; substitution of domestic factors to imports and then terms of trade, and so on. The values of elasticity of substitution employed in the model were determined according to various sources and econometric estimations.

Foreign trade is described by demand functions of import according to the classical Armington assumption. The latter amounts in considering that the "same" goods produced in two different countries are not perfect substitutes and that, as a consequence, economic agents (firms in this particular case) allocate demand between domestic goods and imports according to their relative price. This hypothesis, which raises difficulties because it tends to underestimate the effect of prices in the competition between countries, in particular for sensitive commodities such as intermediate goods (which, moreover, are usually energy intensive), is nevertheless unavoidable on account of the relatively high level of aggregation in this type of models.

The degree of competition is modulated by the value of the elasticity of substitution. In fact, simulations presented in this paper retain for the Energy Intensive Sectors an Armington elasticity the very high value of 9[9], while for other industrial goods the retained value is 3.

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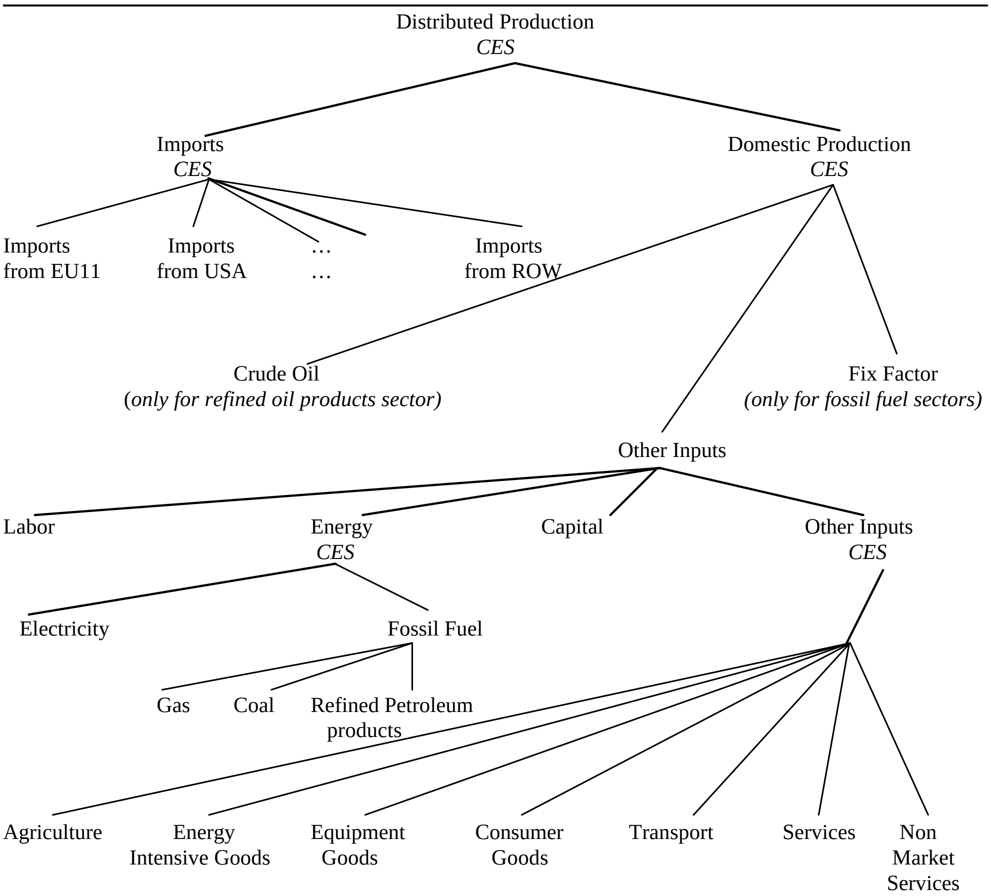
[7] See Bernard (1999) and Bernard and Vielle (2000a).

[8] The real exchange rate between two countries is the relative price of the numéraires chosen in each country (and usually based on a basket of goods representative of GDP). It is not identical to the monetary exchange rate of the currencies of the two countries: in particular, the real exchange rate can evolve between countries belonging to a same monetary union.

[9] The selection of such a high value for EIS results from debates within the Energy Modeling Forum. Some models, for instance MERGE (Manne and Richels, 2000), simulate a perfect substitutability in World markets of Energy Intensive Goods.

Figure 1
Nesting of factors in the production function (example of France)



I.2. Cost of pollution abatement: measurement and factors

Cost of abatement policies, in the various possible ways of implementation, is a key indicator of the efficiency of climate change policies. Effectively, when there exists a perfect substitute to the polluting good, or a de-polluting device, the additional cost of the good or of the device measures the welfare cost of abatement. In the case of greenhouse effect, this is rarely possible, and the bulk of abatement results from refraining from consuming polluting goods, and from replacing them by other goods and factors, through taxation and changes in relative prices. Measuring welfare cost is more complex, and in particular macro-economic aggregates such as GDP or Households' Final Consumption (HFC) are not relevant because they are calculated at constant prices, ignoring the welfare effects of changes in the structure of prices.

The only consistent measure of welfare cost is households' surplus, which can be based either on the Compensative Variation of Income (CVI) or on the Equivalent Variation of Income (EVI). Though theoretically slightly different, they yield very close results as the change in the structure of prices is limited (and energy is a small share in average production cost of the economy, as well as in households' budget). Deriving demand by households from a utility function then allows to have a direct economic measure of the welfare cost of abatement policies. Households' surpluses may be directly reckoned from the output of scenarios, for every year and every country/region, and they can be aggregated in various ways: either *weighted by exchange rates* and summed for a given year or period; or *discounted through interest rates* for a given country and then measuring the total discounted cost of the abatement policy.

For a given period, households' surplus is representative of the total welfare gain if the other elements of final demand (except exports) are held constant. This is the case of the final demand of government, which is exogenous in the model as in most general equilibrium models. Concerning productive investment, which is endogenous in the model and is sensitive to change in relative prices (and in particular to change in the relative price of consumption and capital goods), surpluses calculated annually are representative of welfare cost if its total investment - but not of course its allocation between sectors - is constrained to be constant in the scenario. Such a constraint has effectively been retained in the model[10].

In a closed economy, households' surplus reflects the pure substitution effect of taxation, i. e. the Deadweight Loss (DWL). In an open economy, income effects are added to the pure substitution effect, and they are channeled through the change in the relative prices of foreign trade. Corresponding gains or losses from "terms of trade", as they are known in the specialized literature, may be an important and in some cases a dominant part of the total welfare gain or loss for a given country (though of course, they represent transfers and consolidate at the world level).

Table 2 below recapitulates the "algebra" of welfare measurement in the case of an open economy, as described just above.

Table 2

Algebra of Welfare Measurement

S (Total Welfare Gain)	=	ΔR (Variation of Income)	-	CVI (Compensative Variation of Income)
	=	-DWL (Deadweight Loss of Taxation)	+	G (Gains from Terms of Trade)
G	=	$\Sigma EXP\ \Delta P_{EXP}$	-	$\Sigma IMP\ \Delta P_{IMP}$
	$\cong$	$\Sigma P_{IMP}\ \Delta IMP$	-	$\Sigma P_{EXP}\ \Delta EXP$

Total welfare gain and gains from terms of trade can be computed directly from the numerical detailed results of scenarios: formulas above then determine by difference the deadweight loss of taxation, which represents the pure substitution effect of domestic pollution abatement[11].

Definition of the marginal abatement cost may appear obvious, but its precise determination is more complex. According to theoretical analysis[12], what is relevant for exchange in a market of tradable permits is the marginal abatement cost defined as the *welfare loss at constant prices of foreign trade*. On the other hand, this welfare loss is to be deflated by the *social value of goods*, since the permit is exchanged against tradable goods. Social values[13] of goods differ from market prices of a quantity which is equal to the marginal cost of public funds (MCPF).

Calculating marginal abatement costs at constant prices of foreign trade[14] would normally require to operate separately for each country and for each period. However, it is possible to operate globally, and to eliminate the effects of change in the relative prices of foreign trade by subtracting to marginal surplus the marginal gain or loss from terms of trade. In other terms, the marginal abatement cost is equal to the marginal deadweight loss of taxation deflated by MCPF:

[10] Retaining such a constraint is not necessary. It is possible to implement a simulation in two steps: first without constraint, to assess the effects on productive investment; secondly, at constant total investment, to measure welfare loss. In fact, experience shows that the effect of climate change policies on the allocation of GDP between final consumption and investment is very small.
[11] In case of tradable permits, corresponding sales or purchases must be taken into account.
[12] See Bernard (1999).
[13] They are determined by measuring the welfare gain of a unit additional resource of the given good.
[14] This is also the case for the MCPF.

$$MAC = \frac{1}{MCPF} \frac{\partial DWL}{\partial A}$$

I.3. The Baseline Scenario

The main assumptions or exogenous data for designing a baseline scenario in a general equilibrium model are the rate of growth of the economy and the rate of growth of energy demand, the difference representing the autonomous index of energy efficiency (A.I.E.E.). Prices of energy products, and oil in particular, in world markets are also important exogenous data.

Baseline Scenario (or Business as Usual) is calibrated, for the period 2000 to 2020, on the long term forecast worked out by the Energy Information Administration of the US Department of Energy and published in the 1999 International Energy Outlook. For the subsequent period, 2020 to 2040, trends of economic growth and energy intensity are extrapolated. Concerning world oil price, considerations of relative exhaustion of resources lead to the assumption of a yearly price increase of 2% in constant dollars from 2020 to 2040.

Table 3 recapitulates the resulting rates of growth of GDP, energy and electricity consumption, and CO_2 emissions for each country/region.

Table 3 : Baseline Scenario
(annual average growth 1995-2040 in %)

Countries / Regions	GDP	Energy Consumption	Carbon Emissions
France	2.1	1.1	1.0
EU11	2.2	1.0	0.7
USA	2.1	1.0	0.9
Japan	1.9	0.8	0.6
Former Soviet Union	2.4	1.3	1.1
Energy Exporting Countries	4.2	2.8	2.7
Rest of the World	4.0	2.6	2.4
World	2.9	1.9	1.8

I.4. Energy related emissions consistent with the Kyoto Protocol

Commitments on emissions abatement set in the Kyoto Protocol concern all kinds of GHG and all sources. Accounting of emissions and sinks from activities related to agriculture, land use and forestry, and expected reductions from other GHG determine, by difference, the targets for CO_2 emissions related to fossil fuels. The resulting rates of abatement are given in table 4 below.

Table 4 : CO_2 Emissions abatement in energy consumption consistent with the Kyoto Protocol

	Kyoto Protocol Abatement of total CO_2 emission (relatively to 1990)	Abatement in energy related emissions taking into account abatement in other greenhouse gases (relatively to 1990)	Effective abatement in 2010 (relatively to BaU scenario)
France	0%	+1.5%	-16%
European Union (except France)	-8%	-6%	-26%
USA	-7%	-3%	-29%
Japan	-6%	-6%	-22%
Former Soviet Union	0%	0%	+44%

For years 2010 to 2040 we retained, as most other modeling teams, the assumption of *Kyoto forever*, based on the stability of emissions from then on in annex B countries and no constraint or commitment for non Annex B countries.

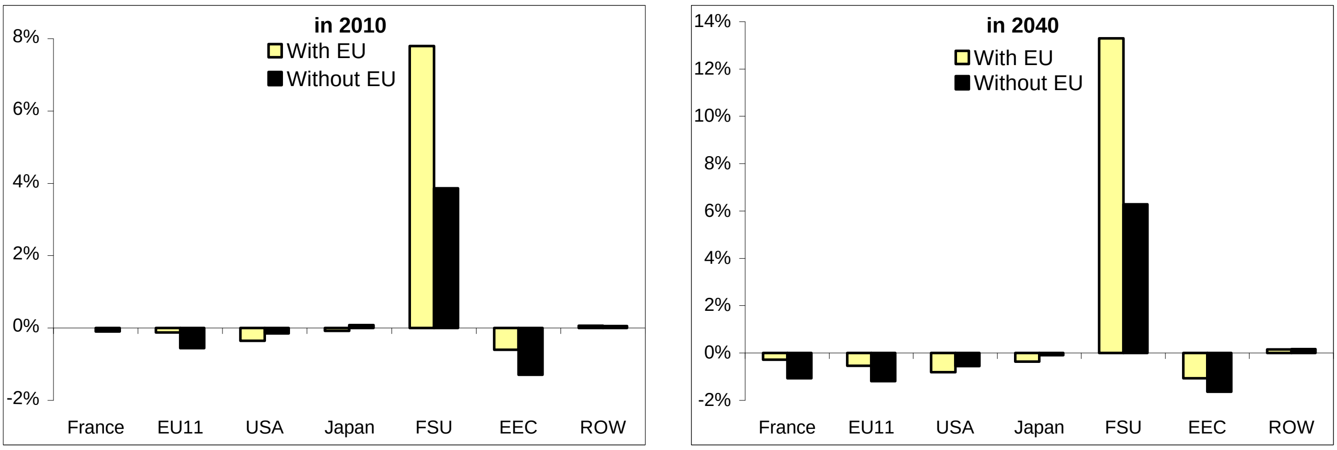
An important aspect in the simulations is the allocation of fiscal receipts accruing from the carbon tax or the sale of permits. In all our simulations we supposed that they are redistributed in the form of tax abatements. Considering efficiency, abating indirect taxation is on theoretical grounds preferable to lump sum transfers because it allows to alleviate fiscal distortions. This was verified within GEMINI-E3, for each OECD country or region described in the model (Bernard and Vielle, 2000a).

II. Welfare Cost for Europe of Non Participation to Tradable Permits

The first step in the analysis is to implement a "benchmark" scenario, in which all Annex B countries exchange pollution rights in a market of pollution permits, supposedly competitive. Results are very close to those presented in Bernard and Vielle (2000a). The main losers in this scenario are Energy Exporting Countries[15], because of the losses from terms of trade which represent more than 1% of the household's final consumption in 2040.

Industrial OECD bear a lower welfare cost (around 0.8% of HFC in 2040), the deadweight loss of taxation being partially compensated by the gains from terms of trade. With a welfare gain of 8% of HFC in 2010 and 13% in 2040, Former Soviet Union benefits mainly from the sales of permits (made possible by the available resource represented by Hot Air[16] and additional abatement of emissions resulting from domestic implementation of the permit and reduction of existing energy subsidies). As for the Rest of the World, which represents mainly developing countries, it is not significantly affected by the implementation of the Kyoto protocol.

Graph 2 : Welfare Loss with and without European Participation to the market of Tradable Permits



II.1. Carbon price and macro-economic indicators

The non-participation of Europe to the market of tradable permits would lead to an important additional cost for the concerned countries, the welfare loss jumping in 2040 from 0.28% to 1.06% of HFC in the case of France. And from 0.54% to 1.18% for other European countries altogether. As is

[15] The situation of Energy Exporting Countries is not very sensitive to the existence or non-existence of a market of the tradable permits between Annex B countries.

[16] (Positive) difference between the emissions credit allocated in the Kyoto protocol to FSU and the expected Business as Usual emissions. The case of FSU is the most complex of all countries because reducing energy subsidies generates a welfare gain (a "double dividend") and, as a net energy exporter, FSU bears a loss from terms of trade when a climate change policy is implemented at the World level.

shown in graph 3, the additional loss is mainly domestic (increased Deadweight Loss of Taxation), terms of trade being approximately unaffected.

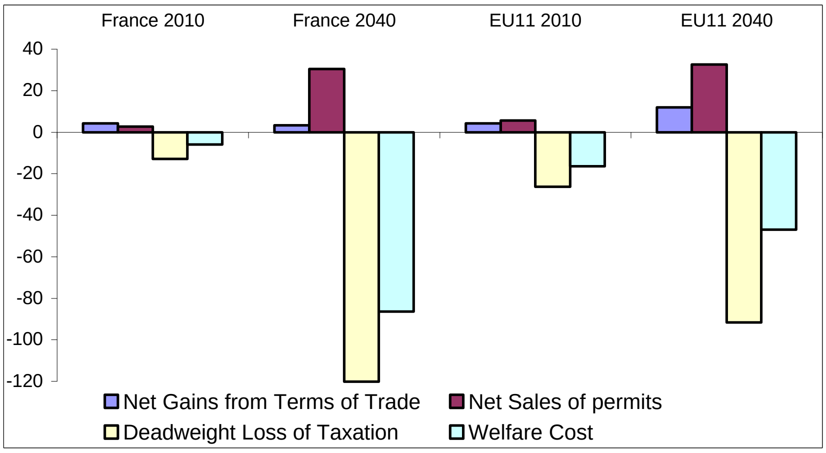
Comparison of carbon prices in both configurations (with or without participation of Europe) explains the increased cost borne by Europeans. Price of carbon jumps from 43$[17] in 2010 and 178$ in 2040 to 210$ for France (and 309$ for EU11) in 2010 and 971$ (and 777 $ for l'EU11) in 2040.

Non participation of Europe has also effects on other countries. As expected, the price of permit decreases (of 47% in 2010, and 40% in 2040) and this change obviously benefits to net buyers (USA and Japan), and is very costly to Former Soviet Union, with a welfare gain divided by two. The Energy Exporting Countries bear an additional cost, but very limited and due to increased losses from terms of trade.

Table 5 : Carbon Price

	2010	2020	2030	2040
With EU Participation				
Permit price	43	80	122	178
Without EU Participation				
Permit Price	23	45	71	108
French Tax	210	456	694	971
EU11 Tax	309	467	615	777

Graph 3 : Differences in welfare loss and components between Participation and Non Participation
(in National Currencies at constant prices of 1990)



II.2. Industry Impacts

Taxing emissions or implementing a market of permits increases the cost of energy for firms, with an effect which varies according to their energy intensity. In the case of the Kyoto protocol, competition is known to be distorted in Energy Intensive Sectors, between Annex B and non Annex B countries (effect labeled "leakage"). Conversely, non energy intensive sectors of Annex B countries benefit, because only relative prices and relative costs are relevant, as was taught by RICARDO in the mid eighteen century.

However governments in industrialized countries are sensitive to the possible disruption in the localization of energy intensive industries (EIS), and desirous (most often under the pressure of concerned industrialists) to implement corrective or compensative policies. Non participation of European countries to the market of permits has obviously significant impacts on leakage, and mainly for them: an additional decrease in the market shares, i. e. a decrease of production and an increase of imports.

[17] At the prices of 1990. From now on, the carbon prices will be measured in $ of 1990, at constant prices.

Table 6 below shows the changes in activity of sectors in France and in other European countries, with and without participation to tradable permits, as measured by Value Added at constant prices[18]. Leaving aside energy sectors, most (negatively) affected are energy intensive industries, both in France and in other European countries.

The most affected sectors are on one hand, as predictable, the producing sectors of fossil fuels, on the other hand the energy intensive sectors.

In the case of a participation, the impact on the value added of EIS would be weak, their value added would increase in 2040 by 0.5% for France and would decrease for EU11 by 0.4%. On the contrary the decision to not participate would burden very strongly the competitiveness of these industries leading to a drop of added value by 4.9% for France and by 6.9% for l'EU11 in 2040. “Gainers” are light industries, such as consumer goods and equipment goods.

Table 6 : Change in Value Added at constant prices by sector in 2040

	Annex B permits	Annex B permits Without EU
France		
Agriculture	0.3%	1.3%
Coal	--	--
Crude Oil	--	--
Refined Petroleum Products	-4.6%	-20.3%
Natural Gas	-9.4%	-27.1%
Electricity	-1.6%	-6.6%
Energy Intensive Industries	0.5%	-4.9%
Equipment Goods	0.7%	3.7%
Consumer Goods	0.4%	2.5%
Transport	0.2%	0.9%
Services	-0.1%	-0.3%
Non market Services	0.1%	0.6%
EU11		
Agriculture	0.7%	2.3%
Coal	-45.3%	-65.8%
Crude Oil	-0.4%	-1.3%
Refined Petroleum Products	-4.9%	-21.2%
Natural Gas	-6.1%	-21.4%
Electricity	-4.4%	-13.7%
Energy Intensive Industries	-0.4%	-6.9%
Equipment Goods	0.7%	2.5%
Consumer Goods	0.8%	3.7%
Transport	0.5%	1.7%
Services	-0.1%	0.1%
Non market Services	0.0%	0.3%

Table 7 recapitulates change in gross production of EIS for all countries/regions of the model. It shows the importance of leakage, and the effect of non participation of EU to tradable permits. With participation of Europe to tradable permits leakage appears of very limited importance, except for FSU which would experience a sharp increase in the price of energy in percentage, in comparison to a BaU situation of very low energy prices.

[18] As is well known, production is the sum of value added and intermediate consumption. Increasing price of energy decreases the energy demand, and then production even at constant value added. Value added is then a better indicator of activity, in comparison between sectors, than gross production.

Table 7 : Change in production of Energy Intensive Sectors (year 2040)

	Annex B permits with EU	Annex B permits without EU
France	-0.4%	-8.9%
EU11	-1.5%	-10.9%
USA	-2.5%	-0.1%
Japan	-2.2%	-0.4%
Former Soviet Union	-31.5%	-15.5%
Energy Exporting Countries	4.2%	6.5%
Rest of the World	2.2%	3.6%

Non participation of Europe to tradable permits displaces market shares, from Europe in direction of all other countries, and particularly FSU which regains approximately half of the losses. Other OECD countries (USA and Japan in the model) see their (small) losses approximately cancelled. For Europe, the loss in 2040 reaches 9 to 11%, according to the countries.

III. Implementation of corrective measures in favor of Energy Intensive Sectors

Climate change policies drafted by Governments, particularly in Europe, provide specific measures in favor of energy intensive industries in order to limit their loss of competitiveness. For example, the program decided in France (MIES 2000) asserts that *« the government is favorable to the possibility that energy intensive industries benefit from a mitigation of their carbon tax »* and suggests measures such as tax exemption or tax cap. Similarly, during the discussions within European Union in mid-nineties aimed at implementing a common tax on energy, it was contemplated to impose a tax duty on the energy content of the imported non EU goods or to exonerate partially, or even totally, energy intensive industries.

Various measures can then be considered in order to limit the impact of the Kyoto Protocol on EIS, particularly in the case of non participation of European Union to tradable permits.

III.1. Carbon Tax Exoneration for Energy Intensive Industries

We suppose in this scenario that European countries exonerate totally EIS of the carbon tax implemented in each country. EIS have then no incentive to abate carbon emissions, and the burden of abatement is reported to other industries and households. Obviously, the price of carbon climbs steeply in Europe, particularly in France on the longer run, as shown in table 8 below. As for the price of carbon in other Annex B countries (represented by the price of permit), it remains approximately unchanged.

Table 8 : Carbon Price – Tax Exoneration for EIS

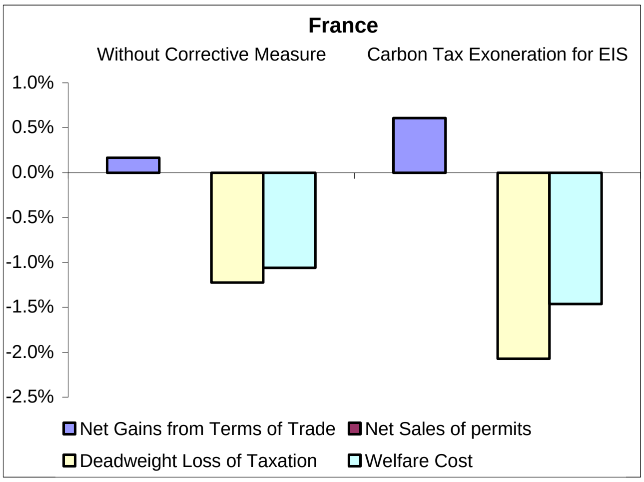
	2010	2020	2030	2040
Permit Price	22	45	72	108
French Tax	361	844	1346	1975
EU11 Tax	516	837	1171	1576

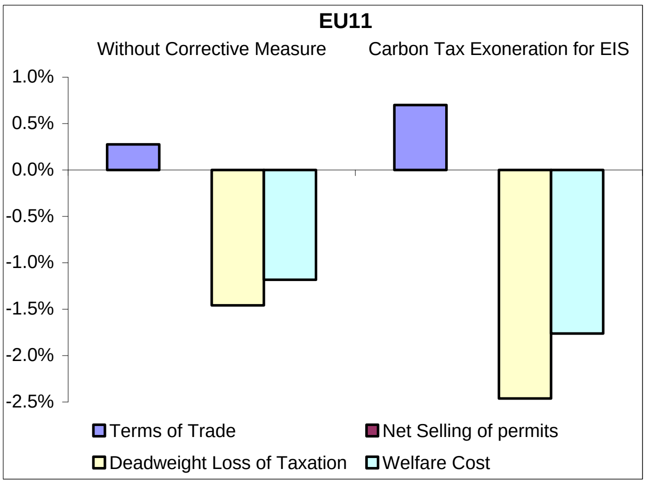
Compared to the previous scenario, additional emissions by EIS appear fairly limited (4% for France and EU11 in 2040). However, the correlative inefficient allocation of abatement between sectors has significant welfare effects. Welfare loss in 2040 increases to 1.5% of HFC (compared to 1.1%) in France and to 1.8% of HFC (compared to 1.2%) in other European countries[19]. This results from an

[19] A similar study realized with the model EPPA and concerning only the USA, shows that the exemption of the EIS yields results close to ours, notably concerning the global cost of the measure (Babiker. et alii, 2000).

higher Deadweight Loss of Taxation, partly compensated by slightly increased gains from terms of trade, as shown in the graph 4 below.

Graph 4 : Welfare cost and components in 2040 – Carbon Tax Exoneration for EIS
(in % of HFC)





Concerning EIS, clearly the exoneration has the expected effects. Leakage is significantly reduced, approximately cancelled (case of France). Other OECD countries, such as the US and Japan, which benefited from non participation of Europe to tradable permits, the gains in market shares by their energy intensive industries are cancelled.

Table 9 : Change in gross production of Energy Intensive Industries in 2040

	Tax exoneration
France	0.3%
EU11	-1.2%
USA	-2.0%
Japan	-1.7%
Former Soviet Union	-18.2%
Energy Exporting Countries	5.6%
Rest of the World	0.7%

III.2. Tax Mitigation for Energy Intensive Industries

Tax exoneration may be considered as giving an undue advantage to European EIS compared to those of other Annex B countries which bear a carbon cost equal to the price of permit. Though the level of this price is very small compared to the carbon tax in European countries, there is a distortion with respect to European industries which are totally exonerated.

Such a discriminatory distortion can be wiped off by imposing to European EIS a carbon tax equal to the price of permit in other Annex B countries. This tax mitigation has the same kind of effects than total exoneration, but to a smaller extent. The carbon tax, applying to other industries and households, are smaller than in the previous scenario, as shown in table 10 below.

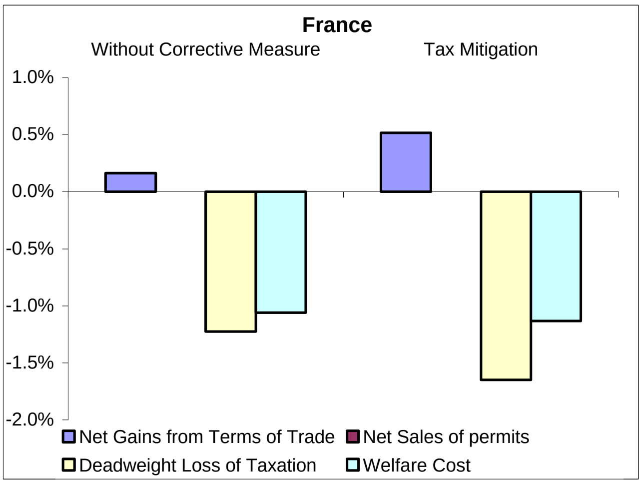
Table 10 : Carbon Price – Tax Mitigation in EIS

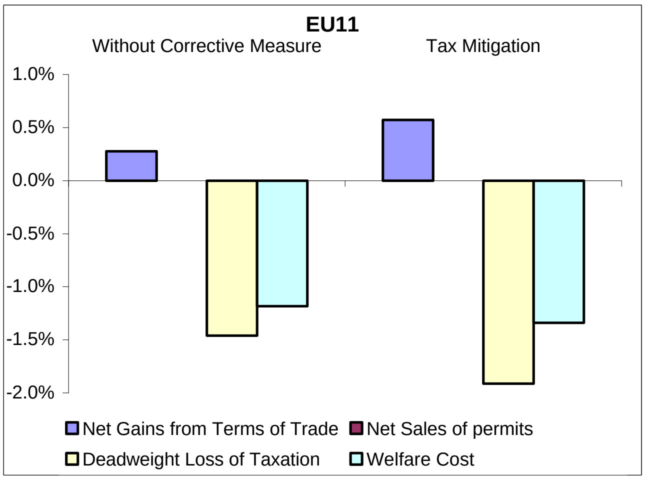
	2010	2020	2030	2040
Permit Price	22	45	71	108
French Tax	332	751	1151	1598
EU11 Tax	484	748	991	1241

Concerning emissions by European EIS, there is a positive abatement, but smaller than in absence of the corrective measure (14% for France and other European countries in 2040 against more than 20% without corrective measure).

Welfare loss incurred by Europe is intermediate between the previous scenario and the scenario without corrective measure for EIS. Particularly in the case of France, increased gains from terms of trade have for result that the welfare cost is practically the same than without corrective measure, as shown in graph 5 below.

Graph 5 : Welfare cost and components in 2040 – Tax Mitigation in EIS
(in % of HFC)





Finally, alignment of European EIS to other Annex B countries has for result that the losses in market share are now very similar, in the range 1% to 3%, which is in fact a very low figure.

Table 11 : Change in gross production of Energy Intensive Industries in 2040

	Tax Mitigation
France	-1.0%
EU11	-2.9%
USA	-1.6%
Japan	-1.4%
Former Soviet Union	-17.7%
Energy Exporting Countries	5.6%
Rest of the World	1.3%

III.3. Carbon Tax Rebating in Energy Intensive Industries

Compensation to industries can take the form of a tax rebate, i. e. an abatement of indirect taxes such as tax on production or VAT in the case of European countries, eventually a subsidy. The rate of rebate is calculated in such a way as the total tax reductions equal the receipts of the carbon tax.

Mechanisms such as “output based allocations” can be considered for allocating pollution rights between firms and exonerate globally firms from the carbon tax (see in particular Fischer, 2000).

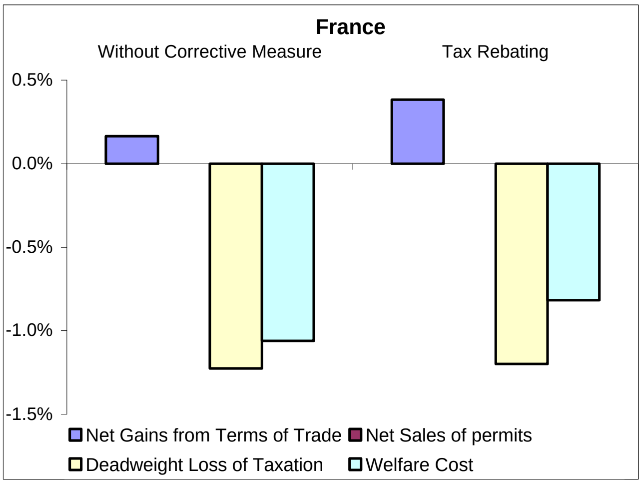
This system maintains the incentive to abate pollution and at the same time has a corrective effect on the distortion in competition with non Annex B countries. In the present scenario, the corrective effect works towards non Annex B countries and also towards other Annex B countries. However, like in the previous scenario, and in order to avoid discrimination towards other Annex B countries, the basis for rebate is not the total carbon tax but the difference with respect to the price of permit.

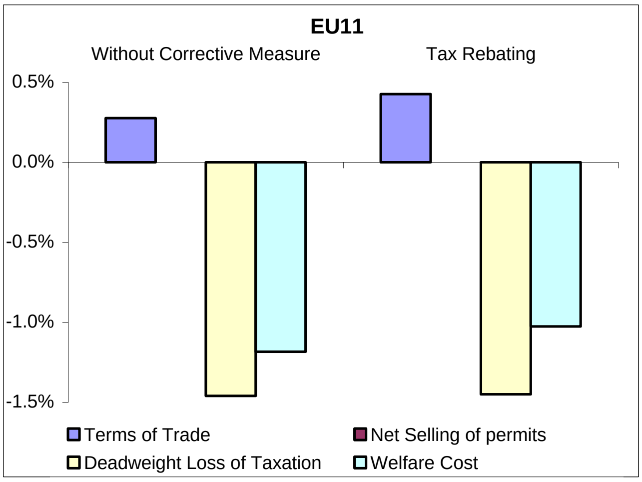
Carbon taxes in European countries are now significantly reduced and though higher, are very comparable to the taxes obtained in the scenario without corrective measure. The reason is that abatement is in this scenario allocated to all sectors, though not as efficiently as in the scenario without corrective measure. Effectively, efficient allocation of abatement requires that each firm be submitted to the carbon tax for its carbon emissions, but also bear the cost of carbon tax incorporated in intermediate consumption of goods, and in particular energy intensive goods. This second effect is wiped off in the case of carbon tax rebating for EIS, and consequences in terms of equilibrium carbon tax (table 12) and welfare cost (graph 6) can be measured.

Table 12 : Carbon Price – Tax Rebating in EIS

	2010	2020	2030	2040
Permit Price	22	45	71	112
French Tax	215	477	730	1026
EU11 Tax	329	496	655	825

Graph 6 : Welfare cost and components in 2040 – Tax Rebating in EIS
(in % of HFC)





Paradoxically, European countries are better off than in the case without corrective measure, which effectively contradicts the above statement. The explanation is that, though the domestic welfare cost (DWL of taxation) is slightly higher, at the same time the gains from terms of trade are also higher (of a bigger amount). Rebating carbon tax in EIS then appears an advantageous policy, both in terms of welfare and in terms of leakage. As table 13 below shows, leakage is significantly reduced in European EIS.

Of course the situation is not as favorable than the full participation of European countries to tradable permits, particularly in terms of welfare.

Table 13 : Change in Energy Intensive Industries production in 2040

	Tax Rebating
France	-2.5%
EU11	-3.6%
USA	-1.2%
Japan	-1.2%
Former Soviet Union	-17.3%
Energy Exporting Countries	5.4%
Rest of the World	1.8%

III.4. Access of European EIS to the market of tradable permits

Another way for setting European energy intensive industries in fair competition with industries of other Annex B countries is to allow them (and only them) to participate to the market of permits. This scenario could be considered as equivalent to the Mitigation scenario described above. However, there is a fundamental difference which is that the abatement effort is not reported to other industries and households. Purchases of permits by EIS contribute to the fulfillment of the commitments of European countries, insulating EIS from other polluting sectors and activities.

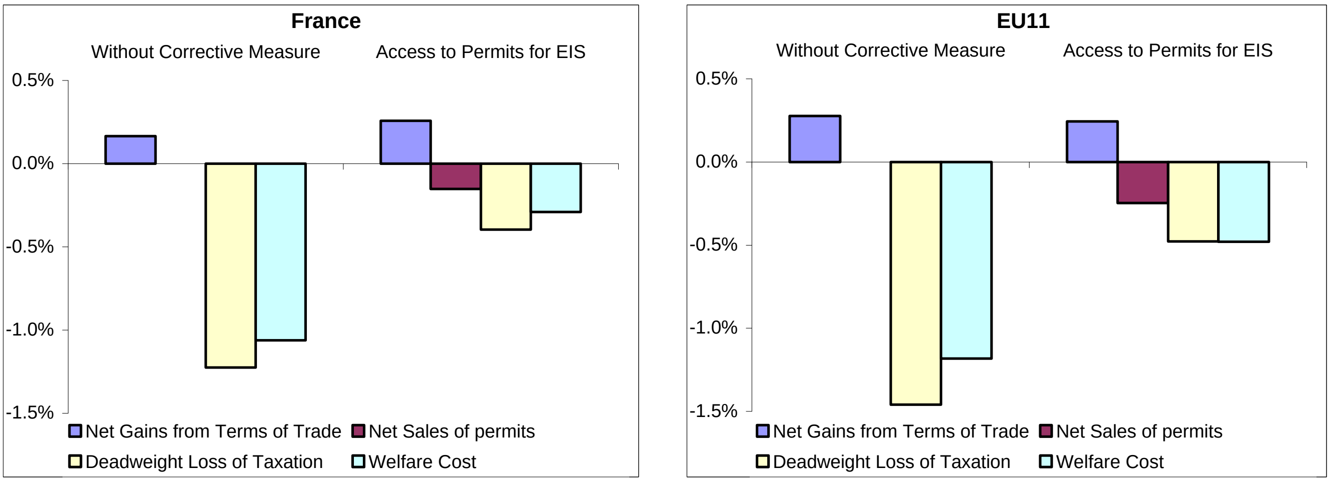
The effects of this strategy are spectacular. Though the carbon tax in European countries remains higher than the price of permit, the gap is significantly reduced as shows table 14 below.

Table 14 : Carbon Price – Permit Access for EII

	2010	2020	2030	2040
Permit Price	34	71	105	150
French Tax	35	82	258	488
EU11 Tax	158	175	280	401

Notwithstanding this price gap, the welfare cost in Europe is now very close to the one obtained in the benchmark scenario of full participation of Europe to tradable permits, as shown in graph 7 below.

Graph 7 : Welfare cost and components in 2040 –Access of EIS to Tradable Permits
(in % of HFC)



Allowing an important sector (in term of carbon emissions) to participate to the market of tradable permits is very close, in terms of welfare, to full participation and is in fact a diverted way. An this is also true concerning leakage in EIS, which is also very similar to the case of full participation (table 15).

Contrary to previous simulations, the access of EIS to tradable permits affects the welfare cost in other countries, penalizing net buyers and benefiting to net sellers because of the higher price of permit. As for Energy Exporting Countries, they register a reduction of their losses from terms of trade.

Table 15 : Change in Energy Intensive Industries production in 2040

	Permits Access for EII
France	-0.8%
EU11	-1.9%
USA	-2.1%
Japan	-1.9%
Former Soviet Union	-26.4%
Energy Exporting Countries	4.6%
Rest of the World	1.9%

Comparison between this scenario and the benchmark scenario of full participation is also instructive concerning the sharing in Europe between domestic abatement and purchase of permits. In the present scenario, France would buy 24 millions tons of carbon in 2040 (compared to 36 millions in full participation case) and EU11 158 millions tons (compared to 239 millions), i. e. approximately the two thirds. But knowing the sharp increase of cost (marginal and total) with abatement, this may explain the rather limited differences between the two scenarios.

III.5. Taxation of imports of energy intensive goods from non EU countries

The last scenario appraised in the present study is the imposition of import duties to energy intensive goods from non EU countries. Such a scenario, which is not in accordance to the rules of the WTO, does not aim at any political realism but represents a simple exercise giving some orders of magnitude[20]. More precisely, the customs duty is such as to leave unchanged the trade balance in volume for energy intensive goods with respect to BaU scenario. The rate of the customs duty would be in 2040 of 10% for France and 12% for other European countries.

Effects of this policy are very close to the carbon tax rebate, both in terms of costs and in terms of leakage. Detailed figures are presented below, in Tables 16 and 17 and in graph 8. Such a result could be easily expected, as subsidies to domestic production are of the same nature than import duties. Slight differences appear, as of course taxing imports has not the same effects on domestic customers, other sectors and households, than a subsidy to production.

Its implementation allows to limit the impact of the carbon tax on the production variation of the EII in Europe: the French EII production would decrease in 2040 by 2.2% , for the other European countries the decrease would be equal to 3.4%.

Table 16 : Carbon Price – Customs duty

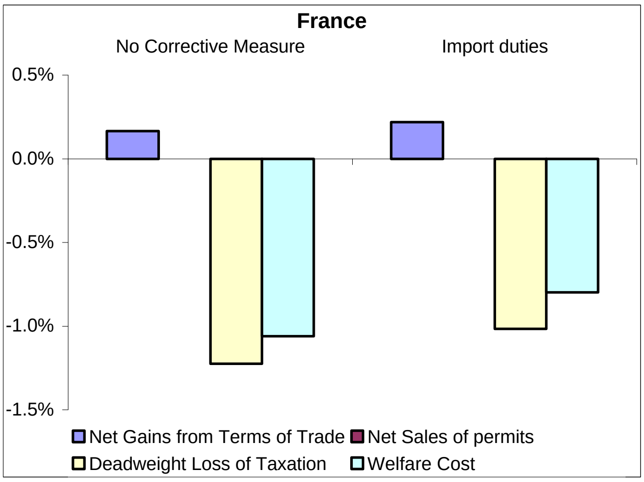
	2010	2020	2030	2040
Permit Price	22	44	70	106
French Tax	214	481	740	1041
EU11 Tax	333	502	663	835

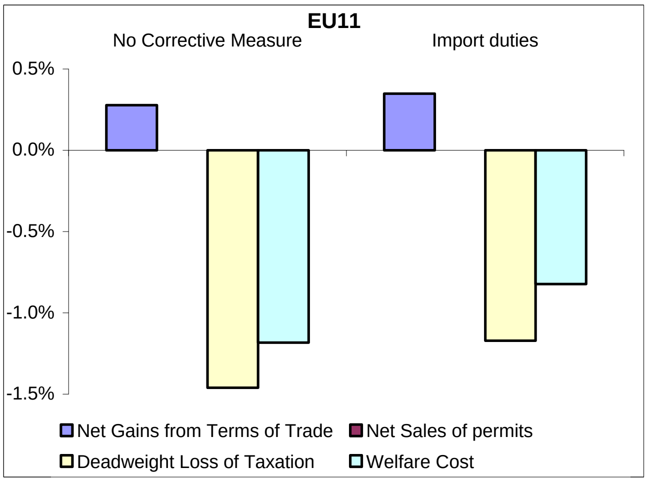
[20] Nevertheless this temptation exists and the European Union had examined this possibility at the beginning of the years ninety within the framework of its tax on the energy.

Table 17 : Change in gross production of Energy Intensive Sectors in 2040

	Customs Duty
France	-2.2%
EU11	-3.4%
USA	-1.6%
Japan	-1.3%
Former Soviet Union	-19.2%
Energy Exporting Countries	5.4%
Rest of the World	0.6%

Graph 8 : Welfare cost and components in 2040 – Import duties
(in % of HFC)





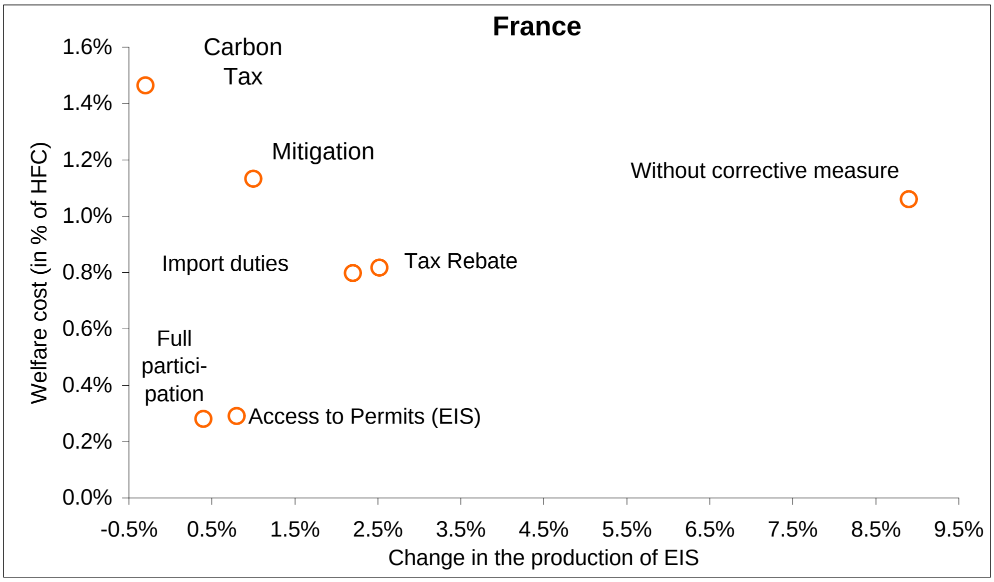
III.6. Summary: Comparison of the corrective policies

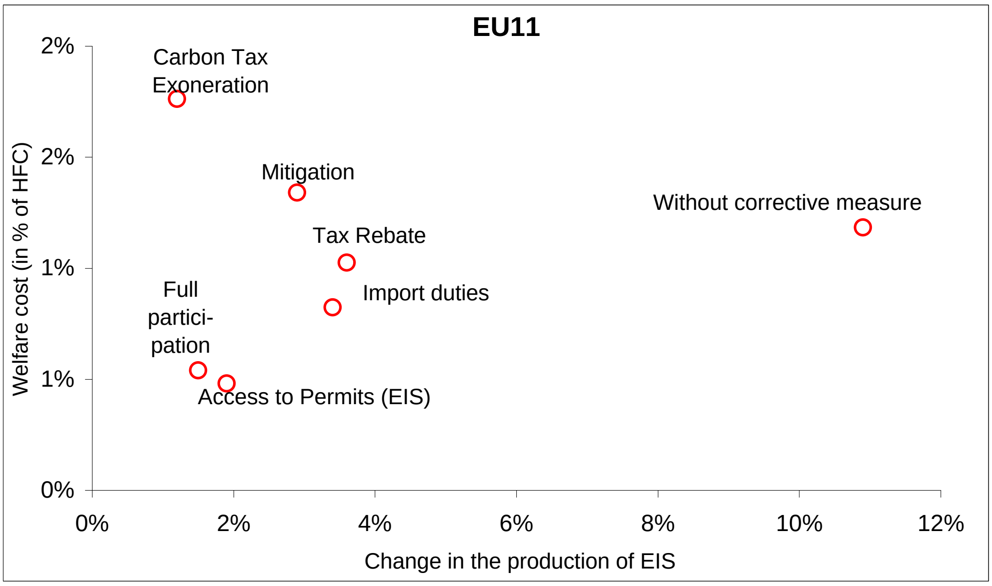
Corrective policies aim at reducing or even wiping off the leakage in Energy Intensive Sectors, i. e. regaining the market shares lost to other Annex B countries and non Annex B countries due to the differential in energy prices and correlatively the distortion of competition. They have effects on costs, the "marginal" cost represented by the price of carbon (either the carbon tax or the price of pollution permit) and the total cost, i. e. the welfare loss[21].

Though terms of trade, which are very sensitive to climate change policies implemented in various countries, it can be considered as a first approximation that they are correlated, and increasing or decreasing together. It is then convenient to present the results of the scenario in a graph, with leakage in the *x* axis and welfare loss in the *y* axis. Extreme scenarios are on the one hand the benchmark full participation of Europe to tradable permits, on the other hand the non participation without any corrective measure.

[21] Our results appear consistent with those obtained in comparable simulations recently worked out with the EPPA model of MIT (see Babiker, Viguier & alii).

Graph 9 : Hierarchy of the various scenarios for France and other European countries in 2040





Clearly the results are very close for all European countries, France and other European countries (aggregated in a single region in the model). Obviously the corrective measures are efficient with respect to their target, which is reducing leakage. Less obvious though expected is the effect on welfare.

Policies which delete any incentive to emissions abatement, such as carbon tax exoneration and to a lesser extent mitigation are costly, though the differences with the no corrective policy are fairly small.

In the middle, policies which maintain an incentive to abatement, such as carbon tax rebating and import duties are more efficient in terms of welfare, even allowing to gain slightly compared to the no corrective policy.

Most efficient is the policy of allowing access of EIS to tradable permits, which is a diverted way for the European countries to participate significantly to the market. Effectively, the purchases of permits are in this case approximately the two thirds of what would have been purchased in case of full participation. In other terms, the upper and then costlier part of emissions abatement most costly has been reported to the market through this diverted participation.

Conclusion

The decision not to participate to the tradable permits would be costly for Europe, and the results of the simulations confirm those obtained by other models. It would lead, without corrective measure, to a welfare cost multiplied by four for France and by two for other European countries. Symmetrically, it would benefit to other Annex B countries which are net buyers of permits (in particular the United States and Japan) and would then have the possibility to buy more permits and at a lesser cost, and penalize countries which are net sellers, especially the Former Soviet Union.

At the industry level, the results are very sensitive to the assumption retained for the elasticity of substitution between domestic goods and imports, which measures the competitiveness in international markets, and in particular in markets of energy intensive goods. Considering the long term scope of climate change policies, it has been retained a high value (elasticity of 9) for energy intensive goods. Nevertheless leakage, i. e. transfers of market shares from Annex B to non Annex B, are fairly limited even in the long run.

The phenomenon is somehow exacerbated by non participation of Europe to the market of tradable permits, which sets a ditch between participating and non participating countries in terms of carbon cost for firms. It has been shown in the paper that corrective policies can limit or even cancel the discriminatory effect for European countries, either at a positive welfare cost, or without significant cost but by transgressing the rules of WTO (import duties, subsidies to domestic firms). The third possibility, which is efficient both in terms of welfare and limitation of leakage, resembles to a loophole, consisting in effective participation without official participation.

In the various simulations performed in the present paper, a major role is played by FSU which is a net seller of permits. Part of the available resource is “Hot Air”, difference between the endowment of rights to FSU and the effective “capacity” to emit. This hot air is meant to vanish in the long run, around 2030.

The other part comes from domestic abatement, through domestic implementation of the pollution permit. Effects of such a policy are particularly uncertain and difficult to forecast, knowing the high level of subsidization of energy in the countries resulting from the dismantling of Soviet Union. In fact, even the existing fiscal system is far from being well known, and a major expected contribution from GTAP databases would be a clearer view and more reliable knowledge of the fiscal system in these countries.

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