Is the European climate policy a jab against an oil shock? A CGE analysis

Abstract

The European Union has committed itself to reduce greenhouse gas (GHG) emissions by 20% in 2020 compared with 1990 levels. A number of studies have analyzed the impact of these policies for the EU economy and the competitiveness of its industries. However, few studies have looked to the possible benefits of the EU climate policy in terms of energy-security, and more particular to the interaction between high oil prices and climate policy.

In this paper, we try to evaluate the extent to which a climate policy protects Europe from an oil price rise. We use the GEM-E3 model to analyze the results of three scenarios. The first one refers to the impact of an increase in the oil price. The second scenario analyses the European climate policy and finally, the third scenario analyses the oil shock when the European climate policy is implemented.

We find that in the first scenario, the oil price rise reduces emissions significantly, and all the countries suffer economically. In the second scenario, the European economic slowdown has impacts on its trade partners. The last scenario, finds that Europe suffers less from the oil shock if a climate policy is implemented.

1- Introduction

Two of the major challenges facing the world's economies are climate change and energy security. The European Union is facing these inter-related issues as part of its Climate and Energy Package,[1] in which it commits to reducing greenhouse gas (GHG) emission by 20% in 2020 compared with 1990 levels (European Commission, 2008a). There is strong evidence that climate policies, which reduce GHG emissions, can effectively reduce the risk of damage from climate change (e.g. Mastrandrea and Schneider 2004; Stern, 2007). The EU is a major contributor of GHGs, so part of the rationale for the policy is the direct reduction of emissions. More importantly however, there is a desire to set an example so the world can move towards more ambitious *global* climate policies. The policy also has the effect of reducing future costs of adaption. Lastly, and crucially for this paper, the climate policy ought also to promote the energy security of the EU.

In particular, the security of supply and price of oil is of concern. Historically, the oil price shocks of the 1970s led to severe recession in many of the world's economies, and the 2007-08 oil price shock (when oil reached US$133 per barrel in July 2008, IEA, 2010a; current prices) was a contributing factor to the current world economic slowdown. Though the oil price fell again in late 2008, prices rose again to reach US$90 per barrel 2010. The IEA (2010b) forecasts a further increase of the oil price in the next decades. In addition, the same report forecasts that production will be even more concentrated among a few producers. In particular, the share of the OPEC production will rise from 41% in 2010 to 52% in 2035. This increased dependence on a small number of producing countries intensifies concerns about their influence of prices and secured supply. Without policies to address energy security, these factors would potentially have serious consequences for the EU economy.

In the Commission's impact assessment of the Climate and Energy Package (European Commission, 2008b,c) the macro-economic effects were analyzed with the multi-sector and multi-region Computable General Equilibrium models GEM-E3[2] and PACE[3]. Additionally, the partial equilibrium model PRIMES[4] was used to analyse the effect of higher energy prices on the 'package'. They find that higher energy prices reduce the addition cost necessary to meet climate policy targets (both for GHG and renewables). Böhringer et al. (2009b), using PACE, highlights the importance of the initial market distortions and imperfections, as well as the role of the baseline projections in the cost quantification of the EU policy. Though, he does not attempt to address issues of energy prices.

In another study using a global CGE model, Vielle and Viguier (2007) investigate the impact of high oil prices on GHG emissions. The study finds that higher oil prices do reduce GHG emissions, however the benefit is less than one might expect. The reason for this is that the higher oil price causes some substitution towards coal. Furthermore, the cost of reducing GHG emissions in this way greatly exceeds the cost that would be incurred from an efficient climate policy.

In this paper, we evaluate the extent to which the commitment to reduce the GHG protects Europe from the negative effects of an oil price rise. This is done by utilising the GEM-E3 model, a world dynamic computable general equilibrium model, especially designed to evaluate environmental policies (in particular greenhouse gas emissions). Using the model, we simulate firstly the impact of a rise in the world oil price, secondly, EU unilateral climate policy, and thirdly, both shocks simultaneously. Using a CGE model allows us to analyse not only the direct impacts of the changes, but also the subsequent, general equilibrium impacts (impact on trade, as well on redistribution on households' effects). The model records the amount of GHG emissions by region and sector for the whole economy. It is also possible to place limits on the permissible emissions, which is crucial for the analysis of this type of climate policy.

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[1] http://ec.europa.eu/clima/policies/brief/eu/package_en.htm accessed January 2011.

[2] General Equilibrium Model for Energy, Economy and Environment (see Capros et al., 1997)

[3] Policy Analysis based on Computable Equilibrium, Böhringer et al (2009a)

[4] Partial Equilibrium Model for the European Energy System

The remainder of the paper is structured as follows. The second section describes the modelling framework, giving a description of the model, the model calibration and describing the scenarios. The third section explains the results, and the final section concludes.

2- The modelling framework.

In this section we present the main features of the modelling framework. First, we review the main characteristics and structure of the GEM-E3 model. We also explain the calibration of the base year and the baseline scenario, and the way the different scenarios have been implemented.

2-1: Model structure:

In order to evaluate the implications of an oil shock and the EU climate policy, we use the GEM-E3 model, a world recursive dynamic computable general equilibrium model, especially designed to evaluate environmental policies (in particular GHG emission reduction policies). In this section, we introduce the structure of the model, in particular the behaviour with respect to production, domestic consumption and trade, and also the model closure choices.

Producers are assumed to maximise profits subject to their technology, which is represented in a four-level production structure. Producers are able to partially substitute between inputs at each level, subject to constant elasticity of substitution (CES) functions. At the top level, capital can be substituted with an aggregate (or composite factor) of labour, energy and materials. At the second level, this aggregate is split between electricity and an aggregate of labour, materials and fuels, which can again be substituted subject to a CES function. At the third level, this aggregate is split into its components: labour, materials and fuels, which are partially substitutable (CES). Finally, at the lowest level, the substitution between types of materials is defined by a CES function, as is (separately) the substitution between types of fuels (coal, oil and gas). We assume full labour mobility between sectors but no international mobility. Capital is fully mobile for all sectors except the oil sector, and country specific.

Total domestic demand is constituted by the demand of products by government, producers and consumers. Households maximize their utility function, whose arguments are leisure and consumption. In other words, the household determines the amount of leisure he is willing to give away to get the desired amount of income. In a second stage, total consumption is decomposed into demand for specific consumption goods. The split refers to demand for durable and non durable goods, following Conrad and Schröeder (1991).

Total demand is allocated between domestic and imported products, following the Armington (1969) specification. According to this specification, products are imperfect substitutes given their origin. Each region buys and imports at the prices set by the supplying regions following their export supply behaviour. The balance of payment constraint, which is warranted through flexible exchange rates, incorporates the initial deficit or surplus for each region.

As explained in the GEM-E3 manual[5], the environment module contains two parts. Firstly, there is a "behavioural" module, which represents the effects of different policy instruments on the behaviour of the economic agents. Secondly, there is a "state of the environment" module, which uses all emission information and translates it into deposition, air-concentration and damage data.

The emissions of the primary pollutants are differentiated by countries, sectors, fuels, and durable goods (e.g. cars, heating systems) that use the fuels and the emissions are linked to the use of oil, coal, and gas. This link concerns the energetic use of these inputs only. The non-energetic use, such as like refinery and processing, is treated separately. For private consumption the major links between energy inputs and consuming durable goods are the following: cars and gasoline, heating systems and oil, coal, gas and electricity and electrical appliances and electricity.

To meet its obligations to reduce GHG concentrations for 2020, the EU established the Emissions Trading System (ETS), a cap-and-trade system for carbon dioxide emissions[6]. The ETS is a traditional cap-and trade system, only applied to European countries, that determines an absolute quantity limit on CO2 for Europe as a whole, and tradable permits are distributed to firms.

The ETS is not applied to all the sectors of the economy, only specified industrial sectors. According to Ellerman and Joskow (2008), these sectors represent about half of the EU CO2 emissions and around 40% of the GHG emissions covered by the Kyoto protocol.

In our model, we take this mechanism into account. We first split the sectors between energy intensive sectors that will be under ETS and the non energy intensive sectors that won't be affected by the cap-and-trade system.

To represent the free permits allocation to firms, mainly two methods have been considered in the literature: grandfathered allocated (GFA) and output-based allocation (OBA). While GFA represents a wealth transfer to firms, OBA provides an implicit output subsidy to them that could help them

[5] The 2 next paragraphs are directly taken from the GEM-E3 manual (2010). For a more detailed explanation of the GEM-E3 model and list of equations, please refer to the manual

[6] For a complete description of the ETS, please refer to Ellerman and Joskow (2008)

lowering the negative competitiveness impact of GHG mitigation policy caused by increased production cost[7].

In the model, we take into account the two allocations systems: the energy intensive sectors face an output based allocation of emissions permits whereas non energy intensive sectors benefit from the grandfathering system. Note that the electrical sector relies on auctioning.

The key closure rules for the model are as follows. It is assumed that the current account balance as a percentage of GDP remains unchanged in the scenarios, being the same as that of the baseline scenarios. Another closure rule relates to the net savings of the public sector, which remains also constant in the scenarios and equal to its baseline value. Markets are assumed to respond to price changes in a perfectly competitive manner

2-2: Model calibration:

The model is calibrated on 2004 data using the GTAP-7 data base[8]. The model features a disaggregation of the economy into 20 industries among which are 5 energy intensive industries (electricity, ferrous and non ferrous metals, chemical products, other energy intensive and petroleum products). These particular sectors are included in the emission trading scheme (ETS). The remaining sectors include agriculture, coal, oil, gas, electric and other equipments goods, transport equipment, other industries, consumer goods industries food, consumer goods industries textile, construction, land transport, services of credit and insurances, gas distribution and non market services.

As to regional disaggregation, the model covers 21 regions, setting apart the big actors since the Copenhagen conference (2009): EU27, USA, Japan, Canada, Australia and New Zealand, China and Hong Kong, India, Mexico, Turkey, Russian Federation, Brazil, South Africa, South Korea, Ukraine and Belarus, Commonwealth of Independent States, Middle East and North Africa, East Asia, Rest of Latin America, Rest of Asia, Rest of Europe and the rest of Sub Saharan Africa.

The baseline scenario (or business-as-usual, BAU) to the year 2030, with which we will compare the results of our simulations, does not assume any climate policy in any region of the model. The baseline is built given certain projections on GHG emissions, GDP, active population and total population. For the latter, we use the United Nations data (2004), and active population projections come from the International Labour Organization (2004). For the future GDP path, we used the

[7] See Dissou and Robichaud (2003), Dissou (2005), Fischer (2001) and Fischer and Fox (2004)
[8] Global Trade Analysis Project (GTAP, https://www.gtap.agecon.purdue.edu/). The elasticities in international trade functions come from the GTAP database.

World Economic Outlook (2008) from the International Monetary Fund (IMF), which takes into account the current economic crisis.

Finally, regional GHG emission projections are based on the emission trajectories from the POLES (Prospective Outlook for the Long term Energy System) model (see Russ et al., 2007). This model computes projected levels of GHG emissions for all the countries given assumptions about efficiency improvement and other determinants of emissions, such as GDP and population, which are consistent with those of the GEM-E3 model. Factor productivity parameters in the production function and other model parameters are adjusted to attain the baseline scenario.

2-3: Description of the scenarios:

Three scenarios are investigated. The first scenario (S1) corresponds to an increase of the world oil price by 50% in 2020, 100% in 2025 and 150% in 2030 compared to its BAU values for the corresponding years. To reach these increases in the world price, we simulate a scarcity in capital stock for the crude oil sector across the world. The capital scarcity induces an increase in the production price and therefore in the sale price. We assume that all the countries face the same oil price shock. This shock should have a major impact on all the economies, notably through an intermediate consumption effect as most sectors in all countries use oil as an input. We thus expect a decrease in world trade, and the more open a country is, the harder it will be hit.

The second scenario (S2) represents a unilateral EU climate policy. Specifically, a commitment to decrease GHG emissions by 20 percent in 2020 compared to their level in 1990. Note that after 2020 there is no extra GHG emission reduction effort in the EU and the absolute GHG emission target is the same as in 2020. The other regions have no restrictions on their GHG levels. The European climate policy starts in 2015, and will directly affect EU. Indeed, European firms and households have to decrease their levels of emissions from 2015 to comply with the 2020 target. Technically, from 2015, the restriction on the "supply" of emissions leads to an increase in production prices, as emissions are one of the inputs in the production function. In other words, in this scenario, we expect Europe to suffer more than other countries as it is the only country directly involved. However, the European slowdown will have some impacts on the other countries through trade channels. The more the other countries are exporting to Europe, the more they will be affected by the decrease in European demand.

Finally, the third scenario (S3) combines S1 and S2. It investigates the combined effects of both a high oil price and a climate policy for the EU. This scenario can be seen as testing two hypotheses. Firstly, is a climate policy cheaper to implement if there are high oil prices?[9] Secondly, is having a climate policy in place a protection against a high oil price? This is the idea of a vaccination jab, which offers protection against the "disease" of an oil shock.[10]

3-Results:

This section presents the main results of the analysis, focusing on the EU, the USA, China and the world economy. Firstly, we focus on the impact of the scenarios on production and trade. Secondly, we explore the implications of the scenarios in terms of household welfare changes. Finally, we analyse the GHG and CO2 emissions changes in the different scenarios. In addition, as all the scenarios are expected to produce significant impacts on trade, summary statistics for the main trading partners of the key regions are included in the Appendix.

Impact on GDP and trade

The rise the world oil price (S1) affects the world economy negatively, and also has negative impacts on the three main regions of interest (EU, USA and China) – see Table 1 below. Recall that the scenario implements a 50% price rise in 2020, 100% in 2025 and 150% in 2030 (with respect to the BAU prices). For the world economy as a whole, the 50% increase in 2020 reduces GDP by 1.3%, rising to 2.7% by 2030 (for a 150% increase). The EU is somewhat less affected than the world average (a 2.2% decrease in 2030) and the USA slightly less again (a 1.9% decrease in 2030). China's decline is about in line with the world average (a 2.6% decrease in 2030).

The USA and the EU's relative insulation compared with China can be partly explained by China's higher sensitivity to trade effects – see Table 2 and Table 3. Under the rising oil price scenario (S1), there is a substantial curtailment of world trade, which overall falls by 5.7%. However, China's exports fall by slightly more than this amount (6.2% in 2030); whereas the USA and the EU falls are much less (3.2% and 1.0% respectively).

Regarding imports, all three regions experience falls roughly in line with the world average with the USA experiencing the largest decrease (6.2%) followed by China (6.1%) and the EU (5.5%).

[9] This hypothesis focuses on comparing the differences between S1 and S3 versus the differences between BAU and S2.
[10] This hypothesis focuses on comparing the differences between S2 and S3 versus the differences between BAU and S1.

Table 1: Impact on GDP: (in % with respect to the BAU)

	EU			USA			CHINA			WORLD		
	2015	*2020*	*2030*	*2015*	*2020*	*2030*	*2015*	*2020*	*2030*	*2015*	*2020*	*2030*
S1	0.0%	-1.1%	-2.2%	0.0%	-0.9%	-1.9%	0.0%	-1.3%	-2.6%	0.0%	-1.3%	-2.7%
S2	-0.4%	-1.1%	-1.0%	0.0%	-0.2%	-0.3%	0.0%	-0.3%	-0.4%	-0.1%	-0.4%	-0.5%
S3	-0.4%	-1.7%	-2.5%	0.0%	-0.9%	-1.9%	0.0%	-1.3%	-2.6%	-0.1%	-1.4%	-2.8%

Table 2: Impact on exports (in % with respect to BAU)

	EU			USA			CHINA			WORLD		
	2015	*2020*	*2030*	*2015*	*2020*	*2030*	*2015*	*2020*	*2030*	*2015*	*2020*	*2030*
S1	0.0%	-0.5%	-1.0%	0.0%	-1.4%	-3.2%	0.0%	-2.6%	-6.2%	0.0%	-2.8%	-5.7%
S2	-1.7%	-1.2%	-0.3%	-0.1%	-0.8%	-0.8%	-0.1%	-0.6%	-0.9%	-0.3%	-0.7%	-0.7%
S3	-1.7%	-2.4%	-2.5%	-0.1%	-1.6%	-3.2%	-0.1%	-2.7%	-6.1%	-0.3%	-3.2%	-5.8%

Table 3: Impact on imports (in % with respect to BAU)

	EU			USA			CHINA			WORLD		
	2015	*2020*	*2030*	*2015*	*2020*	*2030*	*2015*	*2020*	*2030*	*2015*	*2020*	*2030*
S1	0.0%	-3.0%	-5.5%	0.0%	-3.1%	-6.2%	0.0%	-2.7%	-6.1%	0.0%	-2.8%	-5.7%
S2	-1.7%	-3.6%	-3.6%	0.1%	0.1%	0.0%	0.0%	0.0%	0.0%	-0.3%	-0.7%	-0.7%
S3	-1.7%	-5.1%	-6.4%	0.1%	-2.9%	-6.2%	0.0%	-2.5%	-6.1%	-0.3%	-3.2%	-5.8%

The introduction of a unilateral EU climate policy (S2) imposes a constraint on EU firms. In effect, the production price for EU firms rises as they need to take account of the cost of emitting GHGs (see section 2-1 above for an explanation of how this is implemented). This is the main cause of the reduction in EU GDP of 1.1% in 2020 and 1.0% in 2030. In addition, these extra costs make EU slightly less competitive internationally, and there is some loss of export markets, especially in 2015 and 2020. By 2030, where emissions are merely kept at the same reduction as 2020, some recovery has taken place, and overall, only a 0.3% reduction in exports occurs.

Though the largest impacts are naturally on the EU itself, there are indirect effects for other regions, with the USA experiencing a 0.3% fall and China a 0.4% fall in GDP (both in 2030). The impact on other regions occurs through two channels of transmission. Firstly, there is the loss of competitiveness already mentioned. *Ceteris paribus*, we expect this to be beneficial to other regions. Secondly, a smaller EU economy means that exports to the EU decrease. This is a key market for many exporters. For the USA, the EU is the largest regional market for their exports (27%) and for China, the EU is the second largest (26%) – see the Appendix for more details. *Ceteris paribus* this second impact would be damaging to other regions. Our results show that the second impact is dominant, with both the USA and China experienced both a fall in exports (of 0.8% and 0.9% respectively in 2030) and a fall in GDP (of 0.3% and 0.4% respectively in 2030).

The third scenario (S3) combines the oil shock and the European climate policy. For the EU, facing both impacts together causes a fall in GDP of 1.7% in 2020 and 2.5% in 2030. That the fall is the largest of the three scenarios is expected, however the interesting point is by how much extra GDP falls. Focusing on the GDP figures for the EU in 2030, the following table can be drawn:

Table 4: EU GDP losses under different scenarios in 2030

	No oil shock	Oil shock	Cost of oil shock
No climate policy	BAU	- 2.2% (S1)	2.2%
Climate policy	- 1.0% (S2)	- 2.5% (S3)	1.5%
Cost of climate policy	1.0%	0.3%	

What this table clearly shows is that the oil shock is less costly when a climate policy is in place. As already noted, without climate policy, an oil shock costs 2.2% of GDP. With a climate policy in place, the same oil shock costs 1.5% of GDP, approximately one-third less. In this respect, the results demonstrate that the climate policy offers limited protection against an oil shock, i.e. there is some vaccination jab effect.

An alternative way of viewing these results is to look at the cost of implementing the climate policy. As previously shown, with no oil shock, climate policy costs 1.0% of GDP to implement. However, if oil prices are high, the climate policy is more easily implemented, costing only an additional 0.3% of GDP.

Impact on welfare

The welfare index is computed from the consumer's utility function and an environmental welfare base index based on the valuation of the damage generated by the policy.[11] One would expect a decrease of the welfare index in the first scenario, as every country faces the oil price increase. The loss is mainly driven by the drop in households' consumption (leisure levels remain almost the same). Note that for some regions in the world, as Middle East North Africa and Russia, welfare is increasing strongly, as they benefit from the increase of oil price.

Table 5: Impact on welfare (in % to the BAU)

	EU			*USA*			*CHINA*			*WORLD*		
	2015	*2020*	*2030*	*2015*	*2020*	*2030*	*2015*	*2020*	*2030*	*2015*	*2020*	*2030*
S1	0.0%	-2.1%	-4.0%	0.0%	-1.0%	-2.1%	0.0%	-1.6%	-3.2%	0.0%	-0.9%	-2.1%
S2	-0.3%	-1.4%	-1.5%	0.0%	-0.1%	-0.2%	0.0%	-0.1%	-0.2%	0.0%	-0.3%	-0.3%
S3	-0.3%	-2.6%	-4.0%	0.0%	-1.0%	-1.6%	0.0%	-1.5%	-3.1%	0.0%	-1.0%	-2.1%

[11] For extra details, refer to the Manual (2010) p.27

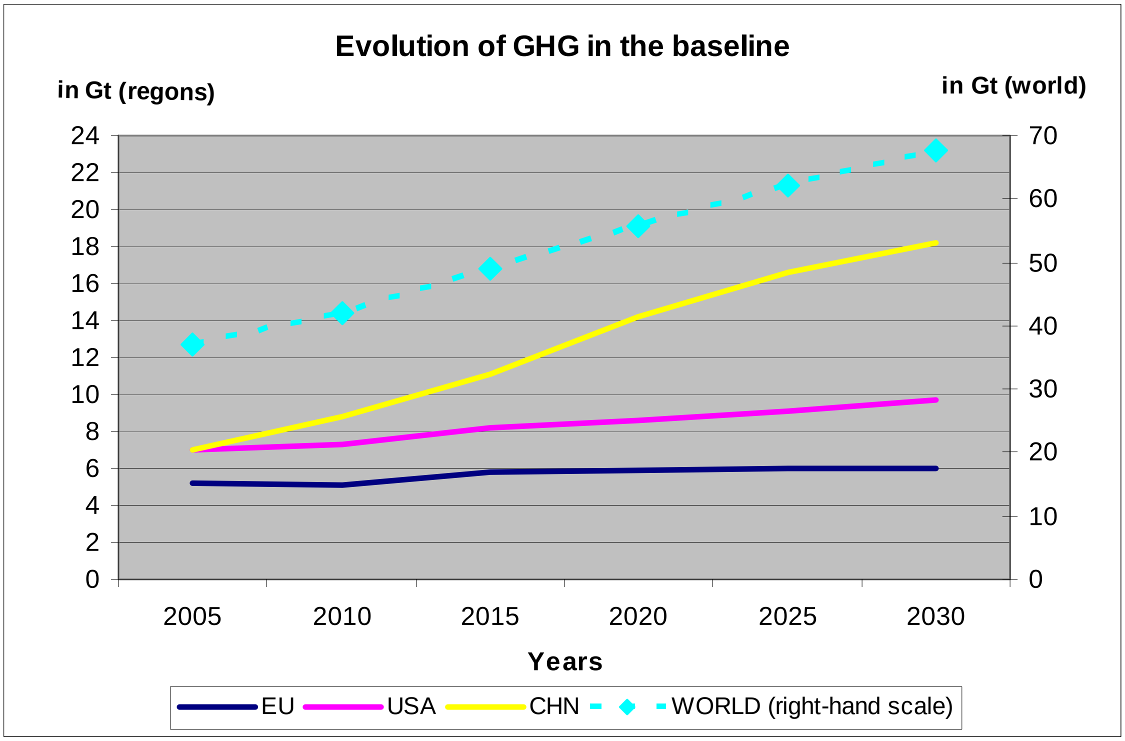
The results for the EU are similar as those already noted on GDP. In 2030, the oil shock scenario (S1) would lead to a 4.0% fall in welfare. The unilateral climate policy would induce a 1.5% welfare loss, which is partially driven by the higher costs of production being passed onto consumers. If an oil shock also occurs, the welfare loss would rise to 4%. The additional cost due to the oil shock is 2.5%, versus the 4.0% welfare loss of the oil shock only scenario (scenario S1).

Note that in the EU climate policy scenario (S2), the impact on welfare is hardly perceptible for the USA and China. The slight fall in welfare loss is driven by the fall in consumption. Finally, in the third scenario, we obtain almost the same results as in the S1. Welfare is decreasing, by 2.1% for the World in 2030.

Impact on emissions

As early mentioned, all the scenarios have an impact on environment, and more specifically on GHG and CO2 emission levels. Before analyzing the results, it is worthwhile to look at the BAU scenario. Figure 1 describes the evolution of GHG emissions in the BAU scenario, in other words, without any shock or policy affecting the economy. The pattern is that total emissions are sharply increasing. The pace of the increase is different for every region, being much higher in China than in the EU or the USA.

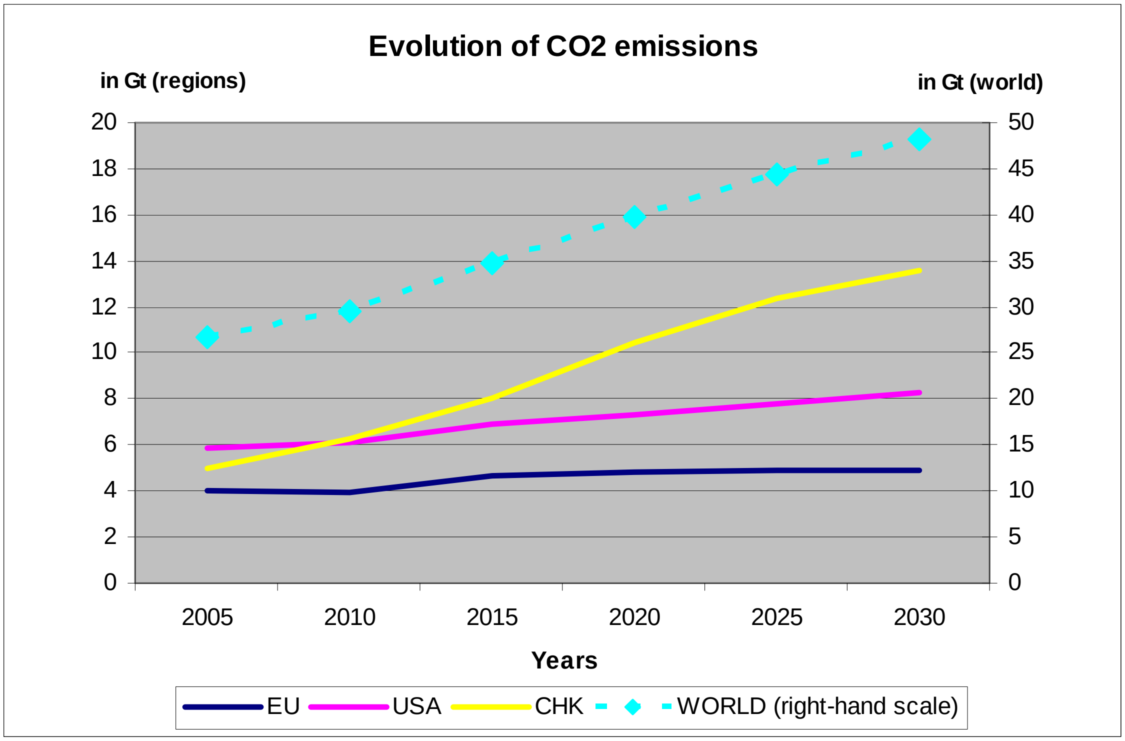
Figure 1: Evolution of the Green House Gases without any shocks



Source: Computations from the model

We observe the same path for the CO2 emissions (Figure 2). If there is no appropriate policy, CO2 emissions are going to increase and here again, we can see that China's growth rate for CO2 emissions is higher than the EU's or USA's.

Figure 2: Evolution of CO2 emissions in the baseline



Source: Computations from the model

Regarding the effects of the scenarios on GHG and CO2 emissions, as expected, the level of emissions is sharply decreasing in the case of an oil shock (Table 4 and Table 5). At the world level, GHG and CO2 emissions are respectively decreasing by -2.9% and -3.5% in 2020, and even sharply in 2030 as the increase in oil price rise is more significant.

Table 4: Impact on GHG emissions:

	EU			*USA*			*CHINA*			*WORLD*		
	2015	*2020*	*2030*	*2015*	*2020*	*2030*	*2015*	*2020*	*2030*	*2015*	*2020*	*2030*
S1	0.0%	-4.2%	-9.2%	0.0%	-4.1%	-9.0%	0.0%	-0.1%	-0.7%	0.0%	-2.9%	-6.3%
S2	-16.5%	-23.9%	-24.4%	0.4%	0.6%	0.4%	0.0%	0.0%	0.0%	-1.7%	-2.2%	-2.0%
S3	-16.5%	-23.9%	-24.4%	0.4%	-3.6%	-6.4%	0.0%	-0.1%	-0.6%	-1.7%	-4.7%	-7.5%

In the baseline scenario, EU's GHG represent almost 12% of total GHG emissions in the world in 2015, whereas the USA's represent 16.7% and China's 22.7%. As far as CO2 emissions are concerned, China's contribution would be 23%, the USA almost 20% and the EU 13.4% of total CO2 emissions in the world. These three regions are among the highest emitters in the world. The fact that one of them unilaterally decides to decrease its emissions will have an impact on total emissions.

Table 5: Impact on CO2 emissions

	EU			*USA*			*CHINA*			*WORLD*		
	2015	*2020*	*2030*	*2015*	*2020*	*2030*	*2015*	*2020*	*2030*	*2015*	*2020*	*2030*
S1	0.0%	-5.0%	-11.0%	0.0%	-4.6%	-10.1%	0.0%	0.0%	-0.4%	0.0%	-3.5%	-7.4%
S2	-19.2%	-27.4%	-27.9%	0.4%	0.7%	0.5%	0.0%	0.0%	0.0%	-2.3%	-2.9%	-2.6%
S3	-19.2%	-27.6%	-28.4%	0.4%	-4.1%	-9.9%	0.0%	0.0%	-0.4%	-2.3%	-5.8%	-9.0%

In the second and third scenarios, the level of European emissions is fixed. As previously explained, the European climate policy has consequences on European trade partners, and given that trade is decreasing due to the economic slowdown, the level of emissions is falling as well.

4- Conclusion:

The EU has unilaterally decided to reduce GHG emissions in 2020 by 20% compared to their levels in 1990. This not only imposes a cost for the EU economy, but an anticipated benefit of this decision is that it will encourage the economy to become less reliant on fossil fuel, hence boosting European energy security.

In this paper, we investigate whether climate policy boosts energy security. In the first scenario (S1), we firstly introduced a world oil price rise, which caused a 2.7% fall in world GDP, and a 2.2% fall in EU GDP in 2030. The second scenario (S2) investigated the introduction of EU unilateral climate policy, and estimated a consequent fall in EU GDP of 1.0% in 2030. The third scenario (S3) considered the situation where an oil shock occurs when a climate policy is in place. This resulted in a 2.5% fall in EU GDP in 2030. Whilst this is the largest fall of our three scenarios, the important comparison is the extent of the additional fall due to the oil shock. With climate policy there was only an additional fall of 1.5% of GDP. This is still a serious cost, but considerably less than the 2.2% fall when there is no climate policy in place (S1). In this respect, the climate policy offers some protection against high oil prices, so we do find some vaccination jab effect.

An alternative way of interpreting the results is to look at how expensive it is to introduce EU climate policy. With baseline oil prices, the cost was 1.0% of GDP in 2030 (S2). However, if oil prices are high (a plausible situation, which the EU has little capacity to influence), the cost of implementing the climate policy is only an additional 0.3% of GDP in 2030 (the difference between S3 and S2). If oil prices are high, climate policy becomes much cheaper to implement. Note also that for both interpretations of the results, the same stories can be told in terms of EU welfare.

It should be noted that the results of this study are subject to a number of caveats, which also suggest future directions for the research. Firstly, the introduction of oligopolistic modelling of the oil sector would improve the representation of the market. Secondly, one suspects that in light of rising oil prices, agents would be able to anticipate the changes and respond appropriately, such as doing even more to invest in less polluting technologies, and thus, an intertemporal version of the model would be more adequate. Thirdly, another interesting study would be to analyse the situation where many (or all) regions commit to a reduction in emissions. This is likely to occur not only because of a commitment to tackle climate change, but also, as we show in this paper, such a policy increases energy security.

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6-Appendix:

Trade Partners for Major Regions

The following tables show the main trade partners for the EU, USA and China. The destinations of exports and origin of imports are split according to the 21 regions within the GEME3 model.[12] In each case, the largest four regions are shown.

Main destinations of exports from selected regions[13]

from EU		from USA		from China	
Destination	% of total	destination	% of total	destination	% of total
USA	25%	EU	27%	USA	27%
non-EU Europe	12%	Canada	18%	EU	26%
M. East & N. Africa	11%	Mexico	11%	Japan	14%
China	7%	China	7%	East Asia	9%

Main origins of imports from selected regions[14]

to EU		to USA		to China	
Origin	% of total	origin	% of total	origin	% of total
USA	18%	EU	23%	East Asia	26%
China	13%	Canada	15%	EU	17%
non-EU Europe	11%	Mexico	11%	S. Korea	12%
E. Asia	10%	China	6%	USA	10%

[12] The 21 regions are: EU27, USA, Japan, Canada, Australia and New Zealand, China and Hong Kong, India, Mexico, Turkey, Russian Federation, Brazil, South Africa, South Korea, Ukraine and Belarus, Commonwealth of Independent States, Middle East and North Africa, East Asia, Rest of Latin America, Rest of Asia, Rest of Europe and the rest of Sub Saharan Africa.

[13] Own computation from the database. As we have 21 regions, we decided to report only the 4 main partners.

[14] Own computation from the database. As we have 21 regions, we decided to report only the 4 main partners.