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Macroeconomic Impacts of the EU 30% GHG Mitigation Target

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SUMMARY

The reduction of GHG emissions is one of the most important policy objectives worldwide. Nonetheless, concrete and effective measures to reduce them are hardly implemented. One of the main reasons for this deadlock is the fear that unilateral actions will reduce a country's competitiveness, and will benefit those countries where no GHG mitigation measures are implemented. This kind of argument is also often used to explain why some governments and many business leaders are not in favour of the EU 30% GHG mitigation target that has been proposed to replace the previous 20% GHG emission reduction objective approved by the EU within the well known 20-20-20 climate and energy package. By developing and applying a recursive, dynamic, very detailed CGE model with energy generation from both fossil fuel and renewable sources, we address this issue by estimating the cost for different EU countries and industries of the EU climate and energy package under a set of alternative international scenarios on global GHG mitigation efforts. Results show that, thanks to the EU economic recession, achieving a 20% GHG emission reduction entails a moderate cost for the European Union - about 0.5% of EU GDP - even in the case of EU unilateral action. This cost could be reduced to almost zero if not only the European Union, but also the other major world economies, comply with the "low pledge" Copenhagen Accord. A 30% GHG emission reduction target would certainly be more costly: the total loss in the European Union would be 1.26% of EU GDP in the case of EU unilateral action, whereas the total cost would be 0.55% of EU GDP if all major economies reduce their own GHG emissions according to the "low pledge" Copenhagen Accord. Both border tax adjustments and free allocation of carbon permits are shown to be successful in reducing some adverse competitiveness effects of the EU GHG mitigation policy into energy intensive sectors, but at the expenses of the other economic sectors.

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Keywords: EU Climate Package, UNFCCC Conference of Parties, Kyoto Protocol, Computable General Equilibrium Analysis

JEL: C68, Q43, Q48, Q54

1. Introduction and background

Confirming a disappointing trend initiated at COP XV in Copenhagen, the last UNFCCC Conference of the Parties in Doha[1] delivered a negligible result in terms of commitments to reduce GHG emissions worldwide. Developed countries - with the exception of the European Union (EU), which has been able to maintain the architecture of its emission trading scheme - reconsidered their climate strategies after the end of the Kyoto Protocol's first phase. Namely, Canada and Japan, having failed to meet their Kyoto targets, decided not to embark in new commitments, thus joining the US that never ratified the Kyoto Protocol. Major developing countries emitters decided to stick to their low and totally voluntary Copenhagen Pledges.

In this picture, the EU has thus assumed the role of the "last part standing". On the one hand, it was the only developed party of the Kyoto Protocol to achieve its commitment. On the other hand, the EU confirmed its 2020 mitigation strategy. As defined by the 2007 EC Communications 1 and 2[2], the EU strategy can be summarized by three major targets: 20% greenhouse gas emission reduction by 2020 compared to 1990 levels, 20% share of Renewable Energy Source (RES) consumption over total energy consumption, and 20% increase in energy efficiency compared to 2020 Business-As-Usual (BAU) trends.

This paper assesses the possible macroeconomic costs for the EU to match its mitigation targets for 2020 and possibly to move to a more ambitious 30% GHG emission reduction target. This is done under two possible scenarios: (i) either by assuming a realistic, *rebus sic stantibus*, EU unilateral action; or (ii) by assuming that non EU economies will comply with the "low pledges" Copenhagen Accord.

This exercise is not new to the literature (Bohringer *et al.*, 2009; Durand Lasserve *et al.*, 2010; Peterson *et al.*, 2011). According to these studies, meeting the 20% emission reduction target could imply small GDP gains for the EU27 (Peterson *et al.*, 2011), or a loss reaching 2% of total welfare (Bohringer *et al.*, 2009) and a carbon price ranging roughly between 30 €/tCO2 (Durand Lasserve *et al.*, 2010) and 70 €/tCO2 (Bohringer *et al.*, 2009). These results are obtained by assuming that emission reductions are implemented at the lowest possible costs. Results range widens considerably if different distortions and second best outcomes are considered (Cf. Carraro *et al.*, 2012).

One of the major concerns in the case of unilateral mitigation action is the issue of carbon leakage, strictly associated to the potential international competitiveness loss for those countries implementing cap and trade systems. The literature typically quantifies the leakage effect at around 15-30%, even if higher values are not uncommon. In particular, the studies introducing oligopolistic competition in energy markets obtain a leakage effect higher than 100% (Bohringher *et al.*, 2010, 2012). Both leakages and competitiveness losses could be decreased (up to 1/3) adopting border tax adjustments; however, the global efficiency gain of these instruments is quite small as they shift

[1] (http://unfccc.int/meetings/items/6240.php)
[2] "An Energy Policy for Europe - Com(2007) 1 final"; "Limiting Global Climate Change to 2 Degrees Celsius – The Way Ahead for 2020 and Beyond - COM(2007) 2 final"

towards non abating countries or sectors the burden of the environmental regulation. In addition, they require a complex regulatory framework with high administrative and transaction costs, casting severe doubts on their concrete viability (Demailly and Quirion, 2005; Mathiesen and Maestad, 2002; MacKibbin and Wilcoxen, 2009; Bohringer *et al.*, 2010, 2012).

Probably the two most detailed analyses of the EU 20-20-20 policy are those offered by EC (2008) and EC (2010a). EC (2008) is an integrated modelling effort. According to the study, the macroeconomic costs for the European Union of the 20-20-20 package, quantified using GEM-E3[3], a computable general equilibrium model, could reach 0.54% of the EU GDP. This result is obtained under the assumption of unilateral EU action and efficient allocation of the abatement effort across countries and sectors. The cost could increase to 0.68% of the EU GDP if targets are allocated according to the actual burden sharing criteria settled for the EU ETS sectors and according to an "equity" criterion based on countries' per capita GDP in the NON-ETS sectors.

EC (2010a) assesses the costs of moving toward a 30% emission reduction target, which could be justified under the "pledges" that major world economies declared during the 2009 Copenhagen and 2010 Cancun Conference of Parties[4]. This last document bases its analyses on a revised baseline to 2020 incorporating the economic effects of the 2008 economic crisis. The GEM-E3 general equilibrium model estimates the macroeconomic cost of the 30-20-20 package under the assumptions that Non-EU regions implement either their low or high ends of the Copenhagen pledges. Moving from the 20-20-20 to the 30-20-20 scenario entails a doubling of EU GDP cost for the EU27 (from -0.4% to -1%) irrespective of the Non-EU countries deciding to pursue their own low or high Copenhagen pledges. Instead, the cost is halved when there is access to the 1/3 reduction on the international emission trading. Finally, the impact on EU GDP could be positive if the ETS allowances are auctioned, if a tax is imposed to the Non-ETS sectors and if the carbon revenues are recycled to reduce labor taxation.

This paper provides a similar CGE analysis, but with the following two differences: (i) it assesses the macroeconomic cost of the 20-20-20 and 30-20-20 packages for the EU assuming both that there are no mitigation commitments by Non-EU regions and that these regions comply with their Copenhagen pledges. This is crucial to clearly understand the cost for the EU of pursuing a 30% mitigation target; (ii) this paper also details results for the major EU economies and not only for the EU as an aggregate, as in EC (2010a).

The rest of the paper is organized as follows. Section 2 provides a general description of the methodology and the different scenarios (BAU and alternative policy schemes) considered in our analysis. Section 3 highlights our main results for the different policy scenarios (EU unilateral action, corrective measures such as grandfathering and Border Tax Adjustments, and uncoordinated/coordinated multilateral action). Finally, the last section draws some policy insights and conclusions.

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[3] http://ipts.jrc.ec.europa.eu/activities/energy-and-transport/gem-e3/

[4] The 2011 Durban COP requires the different countries to confirm or reject those targets by 1st May 2012 in light of a Post-Kyoto strategy (http://unfccc.int/meetings/durban_nov_2011/meeting/6245.php). The new targets will replace the ones previously defined in the ANNEX B of Kyoto Protocol (http://unfccc.int/files/meetings/durban_nov_2011/decisions/application/pdf/awgkp_outcome.pdf).

2. Modelling Framework

To perform the analysis of the EU 20-20-20 and 30-20-20 climate and energy packages, we extend the ICES model (Eboli *et al.*, 2010)[5] to incorporate alternative energy sources, thus enriching the set of policy schemes that can be analyzed. ICES is a computable general equilibrium model improved to capture the main dynamic features of economic systems (endogenous dynamics for investment and capital accumulation). Change in stock and productivity of primary factors (labor, land, natural resources) and population are the model exogenous drivers. International trade is explicitly modeled considering the possible switching from domestic to foreign production and vice versa.

The model includes CO_2 emissions from fossil fuel use in each sector and simulates the functioning of an international carbon market. The model is calibrated for 2004 relying upon the GTAP7 database (Narayanan and Walmsley, 2008). The database has been extended by considering several energy sources (Hydro, Nuclear, Solar, Wind) not explicitly included in the original version of the database and by allowing for more intra-energy substitutability.

As regards geographical and sector details, the EU27 is divided into 17 countries plus 1 region grouping the ten smallest countries. Non-EU countries include 7 regions that made specific pledges in the 2009 Copenhagen Accord (NonA1_T considers Indonesia, Mexico, South Africa and South Korea) plus 1 main bundle including all developing “unconstrained” countries. With reference to sectors, there are 9 energy sectors (5 power sources), 4 energy intensive ETS sectors and 4 Non-ETS sectors: agriculture, transport, other (light) industries and services.

A. The baseline scenario

The baseline (or BAU) scenario reproduces the main macroeconomics trends in a world not constrained by climate policies until 2020. Historical trends are replicated by the model from the base year 2004 until 2009. Data on population was taken from Eurostat (2010) and World Bank (2010) for EU and Non-EU, respectively. GDP growth rates replicate the information provided by the European Commission (EC, 2010b), which reports data for both EU and Non-EU countries. CO_2 trends are in line with the information found in IEA (2010). Finally, fossil fuels prices evolve according to Eurelectric (2010).

The model projections for 2010-2020 take into account the effects of the economic crisis. In particular, there is a low GDP growth trend until 2012. This is slightly higher in 2013-2015, at around 0.99% per year. Only after 2015, the economic growth rate will return in line with the pre-crisis trends at around 2% per year for the EU on average (EC, 2010b; EC, 2009).

For Non-EU countries, GDP projections evolve according to IEA (2009), with the exception of the RoW region, which uses data from IMF (2010). Both sources incorporate effects of the economic crisis. A convergent trend in which especially Asian countries reduce economic gaps with the most

[5] See also www.feem-web.it/ices/. Annex I provides an overview of technical aspects of the model.

developed world clearly emerges. With reference to carbon dioxide emissions, in 2020 the EU roughly would return to the same level of 2005 (-0.4%). Note that our BAU scenario is not comparable with the PRIMES baseline in EC (2010a), because the latter already considers the EU-ETS implementation of the 20-20-20. Finally, high fossil fuel prices foster the development of renewable energy sources (RES). Their share over total energy consumption in 2020 becomes 11.6% in Europe in the BAU scenario, still quite far from the 20% target.

B. Policy scenarios

Table I describes the various policy scenarios to be investigated. The first two scenarios refer to the EU27 unilateral policy with different emission reduction targets (20% vs 30% in 2020 with respect to 1990). The last three scenarios identify different pledge mixes in which both EU27 and Non-EU (except RoW) have commitments in line with those proposed in Copenhagen and Cancun. In each scenario, the EU mitigation effort is gradually implemented from 2010 until the final target achievement in 2020.

For each scenario the cost-efficient solution is determined. Within the EU, allowances and targets are initially allocated uniformly in the market across sectors and countries. Then, by allowing carbon permits trade among all the sectors and countries involved the equalization of marginal abatement costs is achieved and a single carbon price is determined.

In the case of EU unilateral policy, we also analyse a scenario with two separate markets for ETS and Non-ETS sectors. In this scenario, Non-ETS targets are set according to the EU Decision 406/2009 and achieved through a domestic carbon tax. Residual targets to achieve the -20% goal are imposed uniformly to ETS sectors through auctioning, as expected for the last EU-ETS commitment period. In this way, a single carbon price for ETS sectors emerges, whereas a country specific carbon price for Non-ETS sectors is implemented.

In the 30-20-20 scenario, a full auctioning allocation scheme is compared with two alternatives policy schemes aiming to alleviate the risk of leakage and competitiveness losses in the ETS energy-intensive sectors. These two policy schemes can be described as follows. (i) grandfathering, namely the free allocation of permits (but not extended to the electricity generation sectors), and (ii) auctioning, but coupled with border tax adjustments (BTA), to partially protect domestic production from cheap imports of carbon intensive goods.

In the Copenhagen/Cancun scenarios (20-20-20 Low, 30-20-20 Low, 30-20-20 High), in which also Non-EU countries/regions make specific commitments to carbon reductions, no access to an international carbon market is assumed. Therefore, each region implements its unilateral effort to meet its own target. Within the EU, the carbon market is efficient as the full auctioning allocation scheme involving all EU27 countries and sectors is assumed; as a special case, grandfathering for ETS sectors is also used as an alternative allowance allocation mechanism in the 30-20 Low case, whereas Non-ETS sectors achieve their national targets through a carbon tax.

Finally, we also consider the case in which all signatories match the 30-20-20 Low target by means of an international carbon trading system.

TABLE I - POLICY SCENARIOS

	EU27	*Non EU27*
20-20-20	-20% GHG 20% RES 20% Energy Efficiency	BAU
30-20-20	-30% GHG 20% RES 20% Energy Efficiency	BAU
20-20-20 Low	-20% GHG 20% RES 20% Energy Efficiency	Low pledges
30-20-20 Low	-30% GHG 20% RES 20% Energy Efficiency	Low pledges
30-20-20 High	-30% GHG 20% RES 20% Energy Efficiency	High pledges

GHG = GHG emissions reduction in 2020 wrt 1990
RES = Share of RES over total final energy use
Low, High Pledges = as defined in Copenaghen/Cancun Accord.

3. Simulation Results

A. The 20-20-20 vs 30-20-20 scenarios

Table II reports our main results for the EU unilateral policy. The cost-efficient achievement of 20% and 30% GHG emission reductions compared to 1990 levels implies a GDP loss of 0.56% and 1.26% respectively, and a carbon price of 30 and 70 €/ton CO_2 in 2020. Moving from the 20% to the 30% emission reduction target produces a more than proportional increase in macroeconomic costs (around +121%) as well as an increase in the price of CO_2 by 125%. This is close to what found in EC (2010a) using PRIMES and GEM-E3. However, our CO_2 price is considerably higher than the one obtained using PRIMES, but lower than the one reported in EC (2008).

The EU mitigation policy, by penalising fossil fuels use, stimulates RES production. RES reach a share over final energy consumption of 13.8% and 17.1% in 2020 (respectively with a GHG emission reduction of 20% and 30%). Therefore, the achievement of the emission reduction targets is not sufficient *per se* to stimulate RES diffusion according to the EU target. When emission reduction is 20%, it is necessary to introduce an average incentive on wind and solar of around 34.7 €/MWh to achieve the target on RES; when the target is 30%, an average incentive of 13.6 €/MWh becomes sufficient. Meeting the RES target does not imply much higher policy costs, which remain basically unchanged (0.56% and 1.26% of GDP). The increased costs due to the creation of new productive capacity for RES and to distortions induced by the subsidies are compensated by the emission reduction and by the lower abatement effort required. This also emerges by looking at CO_2 price patterns (30.2 €/t and 69.8 €/t), which are slightly lower than in the case of no target on RES.

Carbon leakage, even if negligible in economic terms, is severe if global emission reduction is considered: in 2020 Non-EU countries increase their emissions by 0.96% and 1.7% (respectively in the 20-20-20 and 30-20-20 scenarios), thus neutralising around 70%[6] of EU emission reductions.

TABLE II - MAIN MACROECONOMIC VARIABLES IN THE MITIGATION POLICY SCENARIOS

	Auct ETS Tax Non-ETS		Gdfn ETS, Auct Power, Tax Non-ETS	Auct ETS, Tax Non-ETS, BTA
EU 27				
	-20%	***-30%***	***- 30%***	***-30%***
GDP*	-0.56	-1.26	-1.38	-1.34
CO_2 price (€/t)	30.2	69.9	114	71
Total emissions*	-12.3	-22.6	-22.6	-22.6
ETS emissions*	-15.7	-27.9	-26.9	-27.1
Non ETS emissions*	-7.6	-15.2	-16.6	-16.4
Total emissions**	-12.7	-23.0	-23.0	-23.0
ETS emissions**	-14.1	-26.6	-25.5	-25.7
Non ETS emissions**	-10.8	-18.1	-19.5	-19.3
Subsidies on RES (€/MWh in 2020)	34.7	13.7	13.7	13.7
RES share (% in 2020)	20	20	23	20.5
Energy dependence (import/demand %)	49.8	49	52.3	48.4
Price index*	0.6	1.19	1.34	1.76
Non EU 27				
GDP*	0.09	0.17	0.14	0.17
Total emissions*	0.97	1.69	1.61	1.57
Leakage (%)	74	70	67	65
Price index*	0.09	0.27	-0.2	0.04

* % var. w.r.t. 2020 baseline
** % var. w.r.t. 2005 baseline

Figures 1 and 2 show results at the EU Member State level in the full auctioning case. Efficiency maximisation in 2020 requires a higher abatement effort for the new EU member states. This is because marginal abatement costs in these countries are lower due to a relatively lower efficiency of energy intensive sectors and a less binding fiscal system than in UE15 countries. GDP losses range from 2.3% and 2.7% in the -20% case and 5.2% and 5.6% in -30% case for the Czech Republic and Poland, respectively. Western EU countries generally suffer an economic loss lower or only slightly higher than the EU average: Germany: 0.46% and 1%, Italy: 0.54% and 1.18%, Spain: 0.62% and 1.38%, UK: 0.42% and 0.97% (see Figure 1). In the major European countries, the price index increases, but less than the European average (excluding Germany which is exactly on the EU

[6] This happens if the leakage definition proposed in IPCC (2007) is applied: i.e. emission reduction in EU over the emission growth in Non-EU member states. Using the 'leakage' definition adopted in EC (2008), i.e. the increase of Non-EU emissions as a percentage change compared to the EU emissions in 1990, it is possible to obtain a smaller value: 9% e 16%, respectively in the 20-20 and 30-20 scenarios. The biggest difference in our study with respect to (Böhringer *et al.*, 2010), which obtain a leakage of 27% for a unilateral European policy, is that they found a contraction and not an increase in Non-EU GDP. Leakage in their study depends uniquely upon a re-composition effect, while in ours it stems also from a scale effect.

average). This is due to the efficient abatement allocation across countries, which implies a greater burden for the new Member States and consequently higher costs and prices.

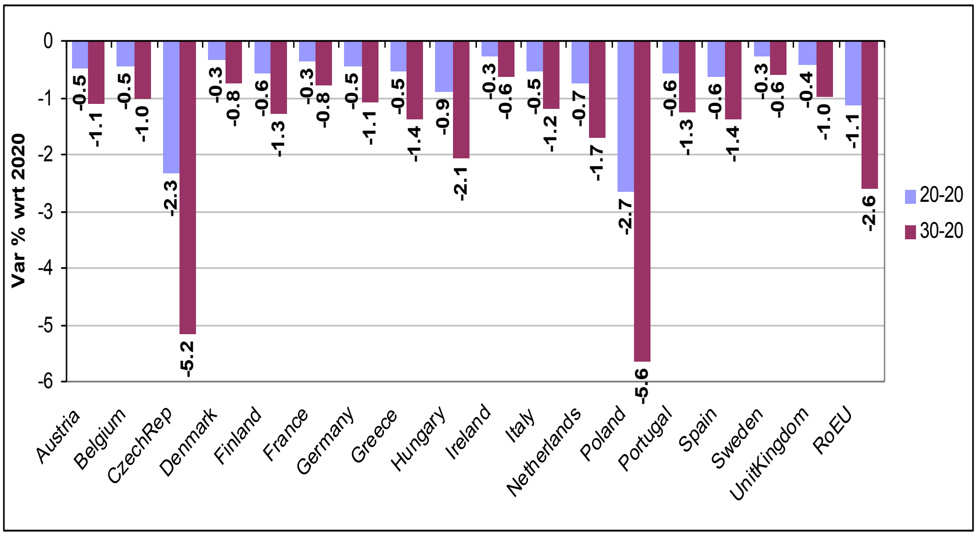

FIGURE 1 - GDP VARIATION IN THE EFFICIENT SCENARIOS IN THE EU27: % VARIATION WRT BASELINE IN 2020

Figure 2 shows that abatement at the country level may reach up to 26.4% and 42.8% with respect to the BAU (in Poland). Revenues from allowances sold to other EU countries do not compensate for the economic loss. However, the technological change induced by adopting the energy and policy package is expected to make new Member States more competitive in the post-2020 period.

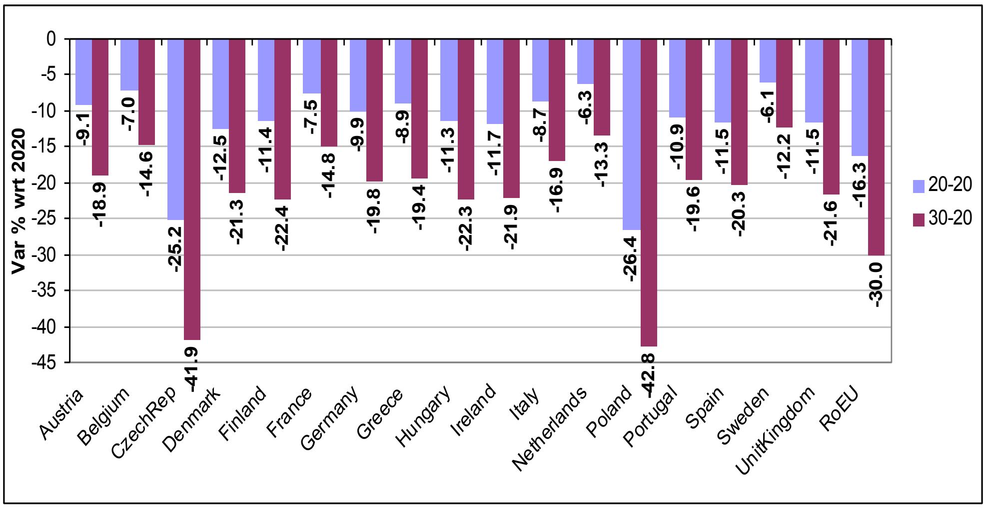

FIGURE 2 - EFFICIENT ALLOCATION OF ABATEMENT EFFORT IN THE EU27: % VARIATION WRT BASELINE IN 2020

Because of the EU mitigation effort, GDP in Non-EU countries slightly increases (on average 0.1% and 0.17% in the 20-20-20 and 30-20-20 scenarios). This is the well known "leakage effect": goods can be produced at lower costs where environmental legislation is less stringent, thus becoming more competitive in the international markets. Their demand increases, which provides an advantage to exporting countries. These dynamics are well captured in our model, for example by inducing changes in regional price indexes. In the EU27, they increase on average by 0.6% and

1.2% respectively. It is a small change on average, yet larger than what occurs in Non-EU regions (0.1% and 0.2%). The increases are concentrated on energy intensive sectors, from 6% in the power production sector to 1% in the other sectors (above all iron and steel). Non-ETS sectors are generally not hit by price increases (even though in the transportation sector prices increase by 2.3%[7]) (see Figure 3).

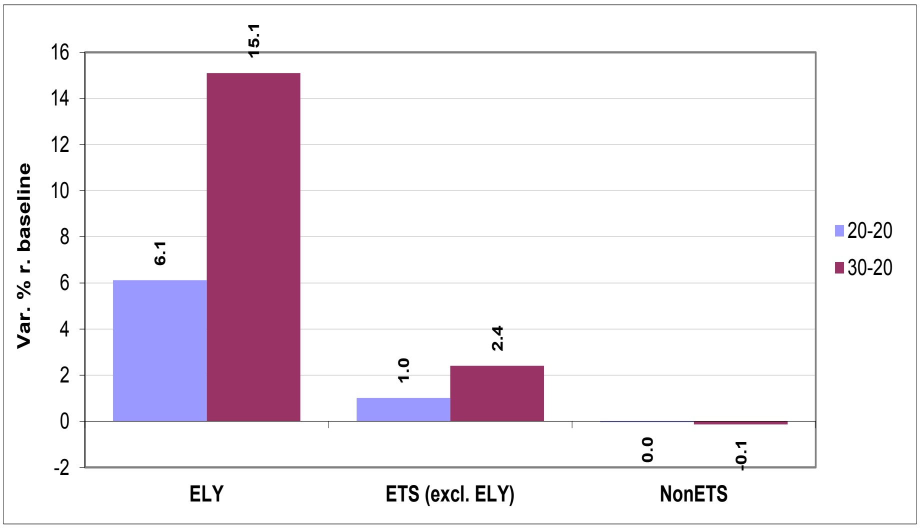

FIGURE 3 - COMMODITY PRICES IN THE UE27: % VARIATION WRT BASELINE IN 2020

Larger contraction in production is experienced by energy intensive sectors (Figure 4). In the 20-20-20 scenario, the average output contraction ranges between 1.5% and 2%. The other sectors suffer a contraction in aggregated demand, which induces an output reduction of around 0.3% compared to the baseline. Solar and wind power sectors display a remarkable development, with a production growth of 60%. Hydroelectricity also increases, but the percentage change is reasonably limited.

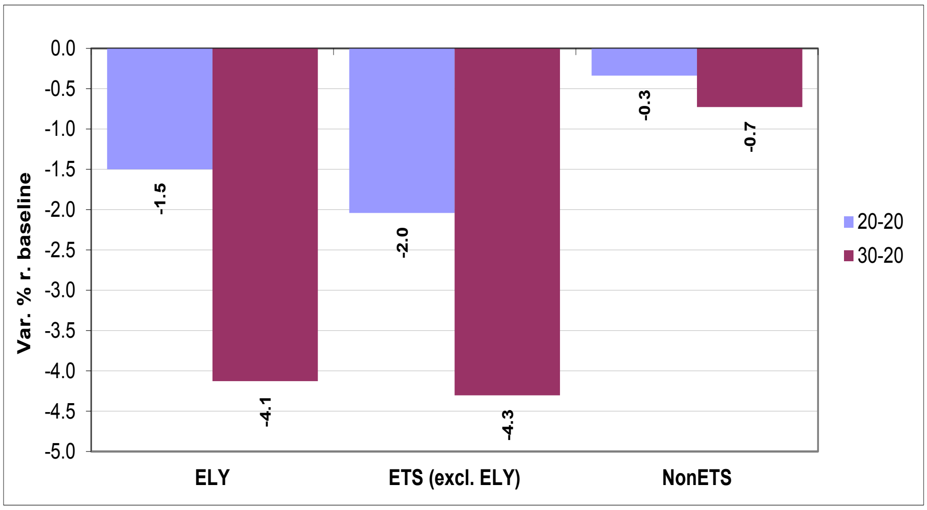

FIGURE 4 - SECTORAL PRODUCTION IN THE UE27: % VARIATION WRT BASELINE IN 2020

[7] In interpreting results for the transport sector, it is necessary to consider its particular characterisation in ICES, taken directly from GTAP7. The transport sector represents the "production of mobility services" and therefore, besides transport on road, water and air, it also includes the services of intermediation of travel agencies and the "transport via pipelines", i.e. the distribution costs through gas and oil-pipelines.

In the 30-20-20 scenario, these numbers almost double, with the exception of the solar and wind power generation, which shows a small increase with respect to the 20-20-2' scenario. Two effects are at work: a switch in favour of the hydroelectric sector and, above all, a lower increase of total energy demand compared to the 20-20-20 scenario. Therefore, given the same target on final energy consumption, a lower RES development becomes necessary.

B. The 30-20-20 Scenario: Grandfathering and Border Tax Adjustments

The cost of the EU 20-20-20 policy package is altogether mild, because of the slower GDP and emission growth that followed the 2008 economic crisis. However, the EU 30-20-20 policy package costs are not negligible. Therefore, two different strategies to alleviate these costs can be analysed: a free allocation of permits to ETS sectors (grandfathering), with the exclusion of the power sector thus mirroring the current EU legislation, and the implementation of Border Tax Adjustments (BTA).

As for grandfathering, the free allocation of permits dispenses ETS sectors from the purchase of allowances through an auction. In the BTA case, a tax is imposed on imports from Non-EU countries, according to carbon intensity of the productive process in the origin country. Therefore, as soon as these goods are in the EU market, they will be equalised to European ones, losing the original price advantage. These strategies are expected to benefit relatively more ETS sectors, as they include the majority of energy intensive sectors.

With grandfathering, the overall macroeconomic cost of the EU 30% mitigation policy is 1.38% of GDP compared to 1.26% under full auctioning (see Table 2 above). The cost increase is around 9.5%. This is a direct consequence of the lack of revenues that could have been produced from auctioning the allowances. Usually, these revenues are assumed to be transferred as a lump sum to the households. The multiplicative effects on aggregated demand overcompensates the higher cost suffered by firms in energy intensive sectors[8].

The price in the carbon market (114 €/t CO_2 in 2020) is much higher than in the auctioning case. When the allocation is free, ETS sectors initially have a lower incentive to reduce carbon intensity and the system leans towards emitting more. This also has a direct influence on RES development. On the one hand, energy intensive sectors are richer than in the full auctioning scenario and therefore are willing to increase their demand of all productive inputs (income effect). On the other hand, the higher demand for power is fulfilled with a greater use of RES, given that fossil fuel electricity is more costly.

Compared with auctioning, free allocation benefits energy intensive sectors and penalises the others, as highlighted by Figure 5. Therefore, grandfathering reduces mitigation policy costs in

[8] This analysis agrees with EC (2010a). However, it is not easy to draw general conclusions, given the complex interactions among tax revenues, demand and competitiveness of different sectors and countries. In a simulation (here omitted, but available on demand), the *grandfathering* appears as less penalising for EU GDP than *auctioning*, (of around 30%) in the less ambitious reduction target of 20%. In this case, tax revenue effect would not compensate anymore the competiveness loss in energy intensive sectors.

energy intensive sectors and the overall loss of competitiveness in the EU, but generates higher costs for low energy intensity sectors (light industry, services and agriculture). This, in addition to the impossibility of obtaining revenues to sustain aggregated demand, increases the macroeconomic costs of achieving the EU 30% mitigation target.

Let us consider border tax adjustments. Compared to grandfathering, in addition to levelling the competitive advantages of those goods not subjected to environmental taxation, a BTA policy generates higher revenues. Nevertheless, this implies a price increase not only for imported goods, but also for all goods produced in the EU that use imports as intermediate inputs. The literature on this issue agrees on the positive effects of BTA for the protected sectors (see, for example, Demailly and Quirion, 2005; Mathiesen and Maestad, 2002), but not on the potential net effects on the GDP of countries implementing this policy. However, the substantial agreement on the small size of these positive and negative effects leads several authors to conclude that BTA is not worth the complex administrative implementation cost.

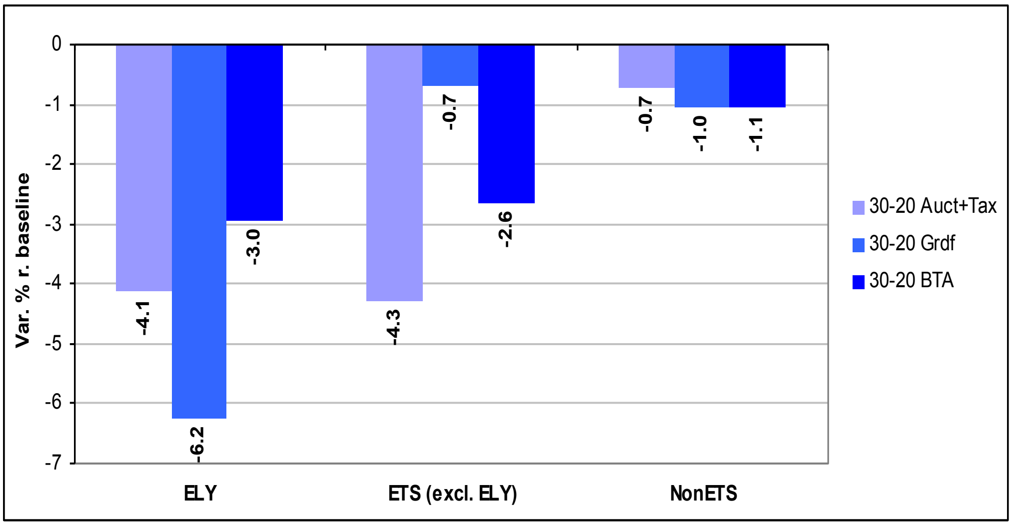

FIGURE 5 - SECTORAL PRODUCTION IN THE EU27: % VARIATION WRT BASELINE IN 2020

In our analysis, the EU 30% mitigation cost with BTA is around 1.34% of GDP (Table 2 again). It is higher than in the auctioning and tax case, but lower than in the grandfathering one. The overall improvement in net competitiveness is very modest, given that there is almost no change in Non-EU GDP with respect to the non-BTA case. It is interesting to highlight the two effects at work. On the one hand, the BTA generates a greater demand and lower contraction of production in the EU, particularly in energy intensive sectors, with respect to the auctioning case, but higher on average than in the *grandfathering* case (see Figure 5). However, sectoral results are indeed mixed with paper, minerals, iron and steel, coal and gas reducing their production less with BTA than with grandfathering. On the other hand, the resulting price increase is higher (see Figure 6).

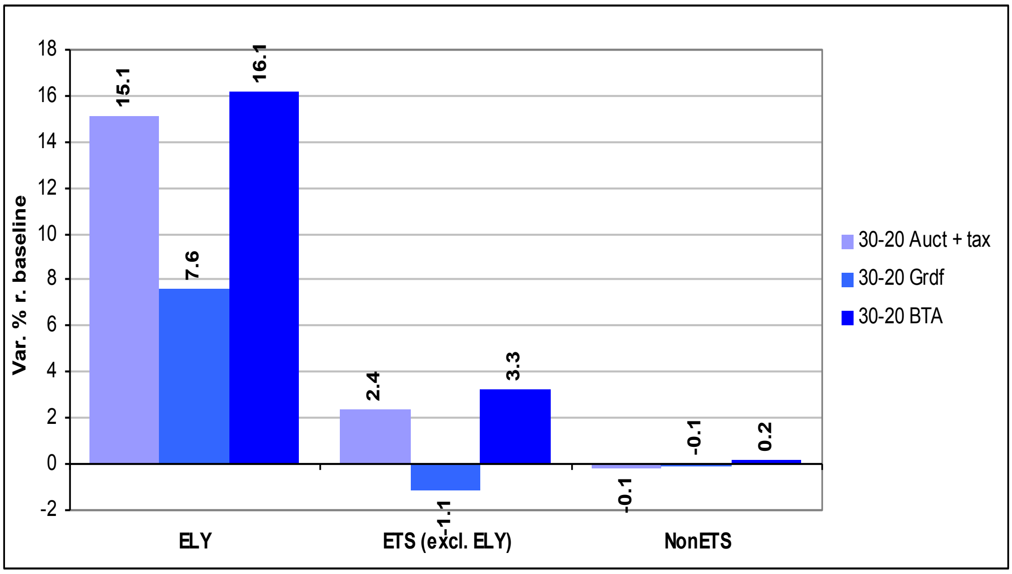

FIGURE 6 - COMMODITY PRICES IN THE EU27: % VARIATION WRT BASELINE IN 2020

C. The 20-20-20 Low, 30-20-20 Low, 30-20-20 High Scenarios

The presence of mitigation policies outside the EU generates two opposite effects on the costs of implementing the EU climate and energy package. The first effect reduces the overall cost. When non-EU developed and in transition countries, including China, India and Brazil, pursue an emission reduction policy, they impose additional costs to their economies as well as an increase in the price of goods and services produced. As a result, their relative competitiveness with respect to the EU worsens. This, in turn, lessens the decline of the EU demand for goods and services resulting from the implementation of the policy package. The second effect instead increases the EU policy cost. When a climate policy is into force also in non-EU developed and in transition countries, the aggregate demand in Non-EU countries declines: the total demand for imported goods, also including the European ones, declines as well, negatively affecting the EU GDP.

The final impact of the sum of the two effects just described depends on how EU and Non-EU final demand reallocates between national and foreign goods. In our analysis, the introduction of mitigation policies in Non-EU economies reduces the mitigation policy costs in Europe (Table III). Specifically, if Non-EU countries apply Copenhagen's low pledges, the 20-20-20 policy does not entail a macroeconomic cost for Europe in 2020, but actually a small benefit (a 0.12% gain compared with the previous 0.56% GDP loss). Similarly, the 30-20-20 policy scenario would entail a 0.66% EU GDP loss in 2020 compared to the previous 1.26%, again in the case of the adoption of low Copenhagen's pledges in Non-EU countries.

TABLE III - MAIN MACROECONOMIC VARIABLES IN FOUR MITIGATION POLICY SCENARIOS

		20-20-20 Low	30-20-20 Low	30-20-20 High	30-20-20 Low Full Trading
EU27	GDP *	0.12	-0.66	-0.55	0.2
	CO_2 price	57	102	110	40.8
	RES Subsidies	34.2	10.4	9.6	
	Energy dependence	52.2	51.2	51.6	53.4
Non EU27	GDP	**-0.97**	**-0.91**	**-1.30**	**-0.75**
Non EU27 with pledges			*-1.25*		*-0.8*
USA		-0.63	-0.60	-0.56	-0.37
Russia		-2.17	-2.37	-4.81	-4.1
RoA1		-1.23	-1.18	-1.40	-0.06
China		-1.66	-1.62	-3.04	-3.8
India		1.49	1.64	1.97	-2.2
Brazil		-0.04	0.00	-0.26	-0.18
NonA1_T		-6.81	-6.79	-8.55	-1.12
RoW		2.05	2.24	2.62	1.65

* % var. w.r.t. 2020 baseline

The reduction in the EU macroeconomic cost is mainly due to the lower competitiveness loss in international markets. Indeed, the carbon price in the EU market is higher than in the case of a unilateral EU policy (57 €/t for the 20-20-20 scenario and 102 €/t for the 30-20-20 scenario with low pledges; 110 €/t in the 30-20-20 scenario with high pledges). This shows that the demand for EU goods, including energy and carbon intensive ones, shrinks less and emissions are higher than in the case of unilateral action. In particular, the chemical sector increases its production, both in the 20% low and 30% high scenarios. Competitiveness effects are also important in Non-EU countries. For regions applying Copenhagen pledges (with the exception of Russia), the resulting costs are lower when the EU adopts the 30-20-20 package than in the 20-20-20 case. Accordingly, benefits resulting from higher EU prices compensate the reduction of its demand. Similarly, gains in countries without a pledge (RoW) increase when more stringent climate policies are applied outside their borders.

As in the case of a unilateral policy, EU losses are concentrated in energy intensive sectors (Figure 7). Within the energy sectors, a substitution of coal in favor of natural gas and oil is seen. The increasing production of RES reduces fossil fuel based electricity between 3.4% and 6.1%.

The increase in EU prices (Figure 8) is much higher for the 20-20-20 low pledges scenario compared to the unilateral action scenario and further increases for higher reduction efforts. This is not surprising as all major economies are undertaking emission reduction policies. Nevertheless, European competitiveness rises in relative terms.

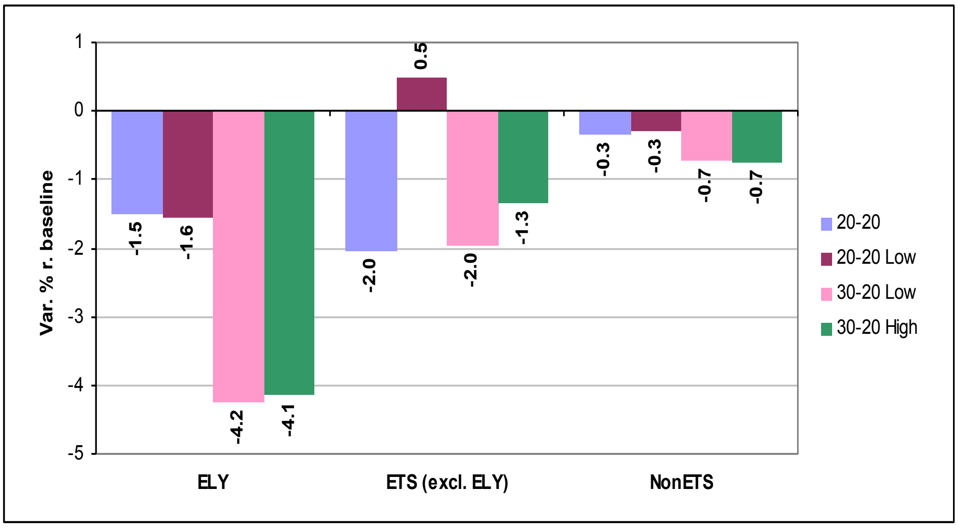

FIGURE 7 - SECTORAL PRODUCTION IN EU27: % VARIATION WRT BASELINE IN 2020

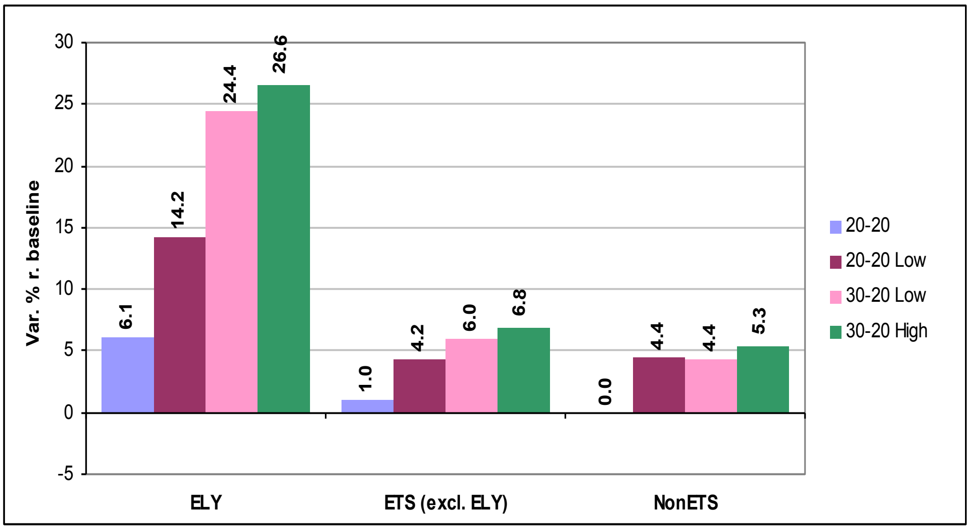

FIGURE 8 - COMMODITY PRICES IN EU27: % VARIATION WRT BASELINE IN 2020

We finally analyse the possible effects of introducing full flexibility in the 30-20-20 Low pledges scenario, thus assuming the existence of an international market for carbon in all countries implementing the Copenhagen pledges. Every region has an initial allocation of allowances, which is equal to the corresponding pledges. In this scenario, total mitigation costs for participating countries drops from 1.25% in the case of a unilateral implementation to 0.8% of GDP in the case of full flexibility (Table III). World market CO_2 price reaches 41 €/t in 2020.

A second important consequence of full flexibility concerns emissions. Abatement effort is transferred to less developed countries, i.e. to most carbon intensive countries such as Russia, China and India. Interestingly, this cost reallocation favors Europe, whose GDP would still grow despite the allowances purchase corresponding to 572 Mtons of carbon. This result represents the sum of two beneficial aspects: the lower abatement effort and the higher relative competitiveness. Although they receive revenues from the sale, GDP declines in countries that export allowances such as Russia, China, and India. The additional abatement effort more than offsets the increase in national income following the direct liquidity injection from the sale of permits. In the absence of ex-post compensation mechanisms, higher carbon intensive countries would not find it convenient to enter into an international carbon market. However, the trading of permits generates a net advantage, which translates into a cost reduction of 0.45% of GDP for involved countries.

4. Conclusions

This paper analyses the economic and environmental impacts on EU economies of the implementation of the EU climate and energy package, taking into account the set of pledges agreed in the Copenhagen, Cancun, and Doha COPs. The analysis focuses first on a unilateral EU action, and then moves to consider scenarios in which Non-EU countries adopt mitigation targets coherent with the voluntary pledges of the Copenhagen Accord.

Two alternative policy schemes have also been discussed: (i) the introduction of BTA measures based on the carbon intensity of imported goods, and (ii) the establishment of an international emission trading scheme that entails maximum efficiency and flexibility in achieving a global climate target.

Our main results can be summarized as follows:

1) The EU macroeconomic cost of the 20-20-20 package is approximately 0.56% of EU GDP when the EU implements its energy and climate policy unilaterally. The cost becomes a small gain when Non-EU regions implement their low Copenhagen pledges. In this latter case, the improvement of EU competitiveness in international markets outweighs the EU climate policy costs. Independently from the net outcome, EU energy intensive sectors are penalized: prices increase and production diminishes (min. -0.4% in the paper sector, max -2% in the chemistry, iron and steel sectors with the EU unilateral action; -0.3% in the paper sector, -0.4% in the iron and steel sectors in the low pledge scenario in Non-EU regions).

2) Moving from the 20-20-20 to the 30-20-20 policy package entails substantive additional costs: a loss of 1.26% of EU GDP in the case of EU unilateral action, and of 0.66% of EU GDP when Non-EU regions implement their low Copenhagen pledges. The cost becomes 0.55% of EU GDP when high pledges are implemented in Non-EU regions. The loss in energy intensive sectors increases proportionally.

3) Notwithstanding the burden on European energy intensive sectors, in the case of EU unilateral action, the benefit for Non-EU countries is not large, varying from 0.09% to 0.17% of their GDP. However, the effect on emissions is relevant: a redistribution of the demand in favour of Non-EU carbon and energy intensive goods, associated to the increase of aggregate demand, induces an increase of global GHG emissions between 1.1% and 1.7% that erodes about 70% of the EU abatement effort.

4) The EU mitigation policy leads to a “greener” European production system and to a switch from fossil fuels to renewable. Achieving the 20% emission reduction target rises the price of one ton of CO_2 from a minimum of 30 €/t, in the case of EU unilateral action, to a maximum of 57 €/t within a Copenhagen low pledge framework. In the 30% emission reduction case, the carbon price ranges from 70 €/t to 110 €/t. The higher the Non-EU abatement effort, the higher the demand for EU goods (which become more competitive) and the higher the price signal needed to induce the desired abatement. Subsidies necessary to achieve the 20% target for renewables vary from 34 €/MWh (in the 20-20-20 scenario) to 10 €/MWh (in the 30-20-20 scenario with high Copenhagen pledges). Subsidies decrease as more ambitious targets make the development of renewable technologies and energy efficiency more convenient.

5) Costs for energy intensive sectors could be successfully reduced either by using free allocations of allowances or by imposing border tax adjustments (BTA). In both cases, the highest benefits are for the chemical, iron, and steel sectors in which losses reduce on average by 30% to 50%. BTA seem to be on average less effective than grandfathering in terms of lowering negative impacts on sectoral production (even though sectoral productive performances are mixed). The import tariff indeed increases the price of EU products that use foreign commodities as intermediate inputs. With either grandfathering or BTA, the benefit for energy intensive sectors is counterbalanced by a more than proportional loss in the primary sector, light manufacturing and services.

6) Not surprisingly, the most effective way to reduce mitigation costs would be to establish an international carbon market. The 30% emission reduction target with low pledges would cost 0.8% of GDP of participating countries (instead of 1.25% of their GDP). Some gains are expected in more energy efficient economies that can shift part of the abatement burden on the less energy and carbon efficient ones, where low cost abatement options are still available.

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ANNEX I – THE ICES MODEL

The Inter-temporal Computable Equilibrium System (ICES) model is a multi-regional recursively dynamic general equilibrium model based on the GTAP database, version 7 (Narayanan and Walmsley, 2008) and shares the core structure of the GTAP-E model (Burniaux and Troung, 2002), which in turn is an extension of the basic GTAP model (Hertel, 1997). The calibration year is 2004, which also constitutes the beginning year for simulations. The model is recursively dynamic: each year of simulation is solved statically, but features of the period *t-1* are taken in account in period *t*.

The agents considered in each economy are *n* industries, a representative household and government. Industries are "typically" modelled through a representative cost-minimising firm, taking input prices as given. In turn, output prices coincide with average production costs. Each firm is characterised by a general production functions, specified via a series of nested CES functions to consider both primary factors (Natural Resources, Land, Labour and the aggregate Capital&Energy) and intermediates.

Similarly to the GTAP-E production tree, the energy inputs are isolated from intermediates and are considered as primary production factors in a nested level of substitution with capital. The purpose of drawing such a complex and nested production function is to have more degree of freedom in specifying elasticises of substitution among productive inputs. As described in Burniaux and Troung (2002), the main innovation of GTAP-E with respect to GTAP is moving away from the assumption of a Leontief relationship between the set of primary factors and the group of intermediates for commodity production. Based on strong empirical evidence, energy sources are no longer considered a perfect complement of primary factors. Rather, they are at some extent substitutes of capital stock, through a Constant of Elasticity of Substitution (CES) function.

For this paper we developed a new version of the ICES model, which improves the original energy sub-tree through the introduction of several energy sources not originally explicit in both database (nuclear, biofuels, wind, solar, hydro) and model. The database required the collection on physical data (International Energy Agency - Extended Energy Balances[9]) and monetary data (GTZ, 2009; IEA, 2005; IEA country profiles[10]; Ragwitz *et al.*, 2007; REN21[11]) for each source. The new model specification is as follows. Energy is produced using Electric and Non Electric commodities in the third level of the production function. The Non Electric commodity is produced using Nuclear and Non Nuclear commodities. The latter in turn is a combination of Coal or Other Fuels. Then, it is possible to choose between Oil&Gas and Non-Oil&Gas aggregates: Oil&Gas is a composite of Oil and Gas, Non-Oil&Gas includes Petroleum Products and Biofuels. The electric branch differentiates between Intermittent and Non Intermittent electricity. The former considers Solar and Wind power, the latter Hydropower and all Other Electricity typologies. Relevant intra-energy substitution elasticities come from previous literature on extended computable general equilibrium and integrated assessment models such as EPPA (Paltsev *et al.*, 2005), GTEM (Pant, 2007) and WITCH (Bosetti *et al.*, 2009).

In addition, it is worth noting that domestic and foreign inputs are not perfect substitutes, according to the so-called "Armington assumption", which accounts for - amongst others - product heterogeneity. In general, inputs grouped together are more easily substitutable among themselves than with other elements outside the nest. For example, imports can more easily be substituted in terms of foreign production source, rather than between domestic production and one specific foreign country of origin. Analogously, composite energy inputs are more substitutable with capital than with other factors. Figure I.1 reports the overall nested production function.

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[9] http://www.oecd-ilibrary.org/energy/data/iea-world-energy-statistics-and-balances/extended-world-energy-balances_data-00513-en;jsessionid=13asge82moedm.x-oecd-live-02?isPartOf=/content/datacollection/enestats-data-en
[10] http://www.iea.org/country/index.as
[11] http://www.ren21.net/

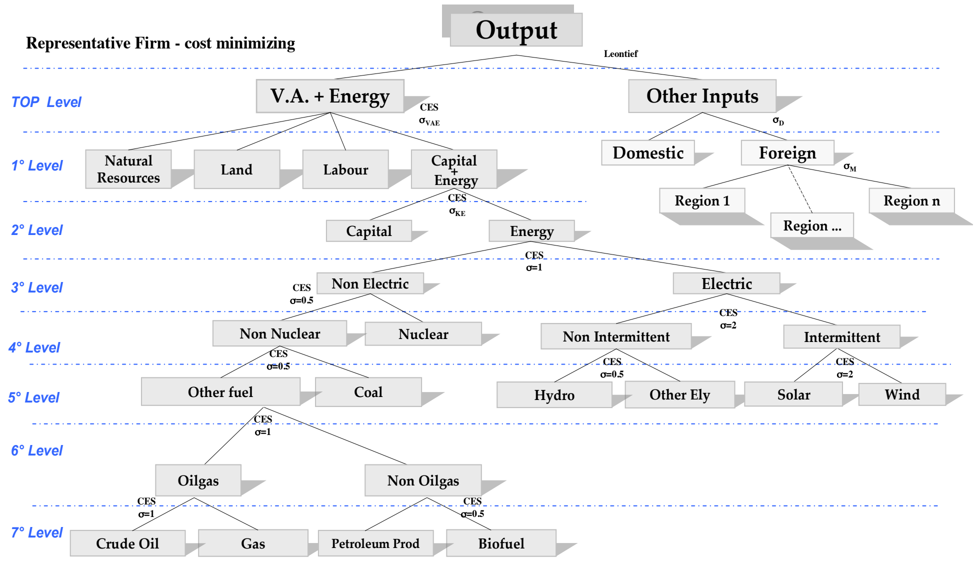

FIGURE I.1 – THE ICES NESTED PRODUCTION FUNCTION

Two industries are treated in a special way and are not related to any country, namely international transport and international investment. International transport is a world industry, which produces the transportation services associated with the movement of goods between origin and destination regions, thereby determining the cost margin between f.o.b. and c.i.f. prices. Transport services are produced by means of factors submitted by all countries, in variable proportions. In a similar way, a hypothetical world bank collects savings from all regions and allocates investments in order to equalise the current rates of return.

A representative household in each region receives income, defined as the service value of national primary factors (natural resources, land, labour, capital). Capital and labour are perfectly mobile domestically but immobile internationally. Land and natural resources, on the other hand, are industry-specific. This income is then used to finance three classes of expenditure: aggregate household consumption, public consumption and savings. The expenditure shares are generally fixed, which means that the top-level utility function has a Cobb-Douglas specification (see Figure I.2).

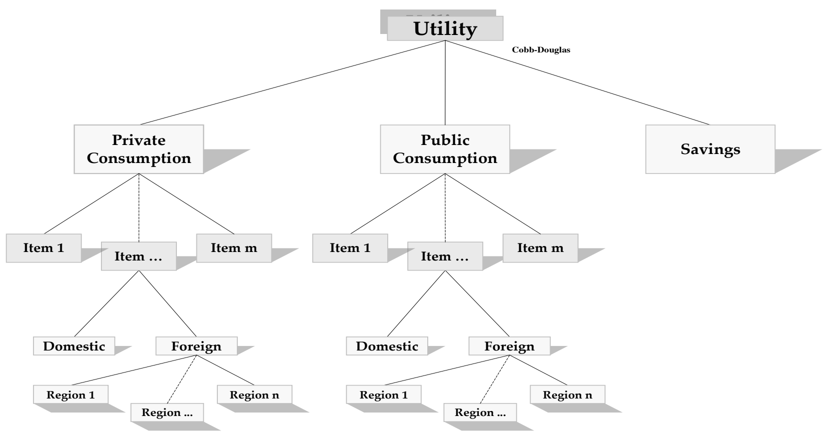

FIGURE B.2 – THE ICES CONSUMPTION DECISIONAL TREE

Dynamics inside the ICES model are driven essentially by two different sources: one endogenous and one exogenous to the model. The first involves two components: one, the most important, is the capital and foreign debt evolution process governed by endogenous investment decisions. The other concerns a peculiar treatment of the evolution of natural resources stock. On the other hand, there is a set of assumptions concerning the changes in some key economic - mainly supply-side - parameters and exogenous variables, which are imposed to the model in order to reflect their possible evolution. These assumptions are made consistently with existing statistical sources, other modelling exercises and economic scenarios.

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