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Data on fiscal systems of countries represented in the ICES model, with focus on fossil fuel subsidies and first test run

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SUMMARY This study details the first experiment conducted to couple the information relative to fossil fuel subsidies with the database and structure of the ICES CGE model developed at the CMCC, and to test the general performance of the model simulating their potential removal. Data for multi country and multi-fuel analysis derive from a "reconstruction process" based upon the price gap method, created by the IEA. The policy exercise consists in an instantaneous phasing out of existing subsidies in 2050. Removals are implemented imposing an ad valorem tax exactly equal to subsidies estimated by IEA (2009). We also compare our results with Burniaux and Chateau (2011) which conducted a similar analysis with the OECD ENV-Linkages model. Both models predict the expected decrease in CO2 emissions which is more pronounced in countries where the subsidy size is larger (Russian Federation, Former Soviet Union Countries and Oil exporting Countries). On the contrary the EU, where subsidies are small, increases its emissions due to a leakage effect. In the next phase of the research fossil fuel subsidies will be introduced explicitly in the price structure of ICES model.

Keywords: fossil fuel subsidies, climate change mitigation, general equilibrium

JEL: Q41, Q48, C68

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SUMMARY

1. INTRODUCTION

The phasing-out of fossil fuel subsidies represents a major issue in the debate on greenhouse gases emission reduction since decades. This reform is still considered one key mitigation option, as also recently emerged during the 19th session of the Conference of the Parties to the UNFCCC (COP 19), held in Warsaw in November 2013. Over the years, international institutions, such as World Bank (WB), the Organization for Economic Cooperation and Development (OECD), the International Monetary Fund (IMF) and the International Energy Agency (IEA), have tried to assess the potential economic and environmental consequences of removing fossil fuel subsidies. From a theoretical point of view, this policy is a *win-win* option for both the economic and the environmental systems. On the one hand it eliminates a price distortion and accordingly increases efficiency in resource allocation. On the other hand, by making the use of fossil fuel more costly, contributes to the reduction of the negative environmental externality associated to greenhouse gases emissions.

In fact, the subsidy removal has encountered much political resistance, especially in developing countries where subsidies are still high. There are many reasons for that. In developing countries subsidies are used as a policy instrument to alleviate poverty and facilitate the energy access of low and middle-income households; they favors not only households, but sometimes also strong industrial lobbies which can understandably oppose their removal; they are finally a way for policy making to maintain support or at least reduce social tensions in situations of widespread corruption and lack of institutional capacity.

After an introduction of the literature related to the phasing-out of fossil fuel subsidies, this report presents a first simulation in which fossil fuel subsidies data are linked to the multi-region, multi-sector ICES Computable General Equilibrium (CGE) model developed at CMCC. When fossil fuel subsidies are concerned, one of the biggest challenges stems from data limitations. To date, a consistent global database on subsidies does not exist. Data available, especially when they have a multi country or world coverage, derive from a “reconstruction process” based upon the *price gap* method, recently applied by the IEA. In this study we use exactly this information.

The purpose of this exercise is purely methodological and functional: namely we are trying to understand how the economic structure of the ICES model reacts when its energy price system is perturbed with shocks of an order of magnitude comparable with that of subsidy removal. We would also like to compare the behavior of ICES with that of other CGE models previously applied in a similar context. More specifically, we replicate with ICES the most recent experiment of fossil fuel removal conducted by Burniaux and Chateau, (2011) using the OECD ENV-Linkages model. Results will also allow us to identify the better way to introduce subsidies in the ICES data set.

The report is organized as follows. In the next section we offer some basic background information on fossil fuel subsidies today. In section 3 we briefly survey the main studies addressing subsidy removal using CGE models. In section 4 we present our simulation experiment and comment the results. Section 5 concludes.

2. A SNAPSHOT OF FOSSIL FUEL SUBSIDIES

As anticipated, a global and consistent dataset on fossil fuel subsidies does not exist. Opacity characterizes the data in many developing countries, where governments are not willing to provide easily this type of information even though for research purposes. Consequently, a widely used method to estimate indirectly fossil fuel subsidies is the *price-gap* IEA approach (Koplow, 2009). Basically, the subsidies are computed as the difference between the observed end-user consumer price (paid by both households and firms) and a given reference price. For tradable energy vectors the reference price is their international price. For a non-traded energy vector, like electricity, the reference price is the supply cost “cleaned” of internal margins, taxes and excise duties.

Albeit standard in the literature, this method presents some limitations. Firstly, a huge variability can be noted in international energy vector prices due to a multiplicity of factors like e.g. speculative pressures, market power of suppliers etc. This makes the estimated values and the analyses based on them very time dependent. Secondly, as for subsidies, also reliable data on taxes and transport costs are not always available and this can cause non-negligible distortions in the computation of the reference price.

This said, according to the most recent study using the IEA *price gap* approach (IMF, 2013), in 2011 fossil fuel subsidies amounted to $480 billion (0.7 percent of world GDP). Oil, electricity and gas subsidies accounted for about 44, 31 and 23 per cent of the total, respectively, while coal covers the small residual part.

Table 1 reports the geographical distribution of subsidies in 2011.

Table 1: fossil fuel subsidies, shares by macro-region in 2011

Emerging and Developing Asia	20.5
Central and Eastern Europe and Former Soviet Union	15
Middle East and North Africa	50
Latin America and Caribbean	7.5
Sub Saharan Africa	4
High Income Countries	3

Source: IMF (2011)

The biggest regional share pertains to Middle East and North Africa (50 per cent of total) where subsidies are common in both net oil exporting and importing countries. In this area, oil represents one half of the total subsidy volume. The share of Emerging and Developing Asia is also important (about 20 per cent). In these countries around 90 per cent of total subsidies are concentrated in the oil and electricity sectors. Central-Eastern Europe and Former Soviet Union build up about 15 per cent of global energy subsidies, but their share is the highest, 36 per cent, if we look just at the gas sector. The Latin America and Caribbean account for 7.5 per cent of total subsidies (nearly 65 percent of it deriving from oil subsidies), but with, Ecuador and Venezuela where subsidies are huge (amounting to more than 5 per cent of national GDP). The share of the Sub Saharan Africa is about 4 per cent, mostly concentrated in the electricity sector to facilitate the market access by households. Finally, energy subsidies in high income OECD countries build only the 3 per cent of the world total.

The subsidy phasing-out is likely to be beneficial for the environment as it reduces GHG emissions deriving from a distorted (artificially high) use of negative externality-generating production factors. It is expected to benefit also the economic system as a whole because it allows a more efficient allocation of resources eliminating a major source of distortions in price signals. Anticipating impacts on social equity is more complex. On the one hand, public resources, which can be dedicated to more useful social programs, would become available; on the other hand, energy prices are expected to increase with potential adverse distributional effects on poorer income classes.

In practice, different barriers exist preventing the subsidy reform process from taking place, especially in developing countries. First of all, well organized and powerful lobbies can succeed in blocking the subsidy suppression. Both the industrial sector and Unions (like for instance in Mexico during the 1999 electricity sector reform (Carreon-Rodroguez et al., 2003)) which benefit from the subsidies, can put pressure on political institutions in order to maintain them. Second, in regions where the social safety net is not well-functioning and/or corruption and institutional capacity is weak, both policy makers and households may be particularly reluctant to accept phasing out. The former, as low energy prices are used as a partial compensation to citizens for other inefficiencies and as such are a means to reduce social conflict; the latter because they fear that government will waste money or that poor households will be adversely hit without any compensation. Finally, as said, complete and reliable information regarding the magnitude of subsidies in the public budget is missing, making population unaware about their effective costs for the society.

3. LITERATURE REVIEW

The use of CGE models to study fossil fuel subsidy removal is not new to the economic literature. Six main contributions, which are illustrated in Table 2, can be found.[1] They differ in terms of geographical/sectoral coverage, time frame, model calibration year, model underlying economic assumptions, experiment design and implementation. Nonetheless the overall structure of the exercise is similar: CGE models are used to project the economy into the future (2000, 2010, 2020 or 2050) by building a business as usual (without policy) scenario. Then subsidies are removed from the baseline and results are shown in differences between the policy and the baseline.

Table 2: past works on fossil fuel subsidy removal

Larsen and Shah	1992
Burniaux, Martin and Martins-Oliveira	1992
Saunders and Schneider	2000
OECD	2000
Burniaux, Chateau, Dellink, Duval and Jamet	2009
Burniaux and Chateau	2011

3.1 LARSEN AND SHAH (1992)

They include 13 regions: Former Soviet Union, China, Poland, India, South Africa, Czechoslovakia, Mexico, Brazil, Argentina, Venezuela, Indonesia, Saudi Arabia and Egypt. Their model is calibrated in 1987 and simulates until 2020. The *Price gap*

[1] For an extensive review on the first five contributions see Ellis (2010).

method is used to estimate fossil fuel consumption subsidies in 1987. The policy analyzed consists in a full removal of existing fossil fuel subsidies from 1990 to 2020.

They do not model the inter fuel substitution which in fact is a fundamental assumption to address the subsidy removal issue. This may be justified if subsidies were equally distributed across fuels (coal, oil gas), but can be highly misleading in the case of subsidies uneven distribution. As a consequence the model is likely to overestimate the CO2 emissions reduction from removal because the switching possibilities across fuels by firms is neglected while the only possibility is to decrease usage in response to higher energy prices following subsidies suppression. However this approach is one of the first attempts trying to shed light on the issue.

Ultimately, CO2 global emissions decrease by 5 per cent in 2020 while GDP in non-OECD countries increases by 1.8 per year from 1990 to 2020 compared to the no policy baseline. Impacts on world GDP are not reported, thus it is not possible to judge the net efficiency implication of the policy.

3.2 BURNIAUX, MARTIN AND MARTINS-OLIVEIRA (1992)

This study applies the OECD GREEN model, a multi-region multi-fuel dynamic general-equilibrium model, to assess the effects of subsidy removal in both OECD and non-OECD countries. The model considers twelve regions: four OECD regions (U.S., Japan, EU-15 and other OECD) and eight non-OECD regions (the Former Soviet Union, Eastern Europe, China, India, Brazil, Energy-Exporting Lesser-Developed Countries, Dynamic Asian Economies and the Rest of the World). The model base year and p*rice-gap* data refer to 1985. The simulated policy consists in a total removal of fossil fuel consumption subsidies in 2000 implemented through a gradual phasing out between 1990 and 2000. Policy effects are however assessed on the longer term, until 2050. The model embeds accordingly also some long-term assumptions like availability of renewable energy sources since 2010 and increasing scarcity of crude oil reserves since 2030, resulting in rising oil prices.[2] Inter-fuel substitution applies only to the non-energy producing and the electricity generation sector, but not to the remaining energy producing sectors (coal mining, crude oil, natural gas, refined oil). All in all it is shown that CO2 emission can be reduced by the 18 per cent wrt baseline in 2050. Effects on the world GDP are positive even though moderate: 0.7 per cent per year over the period 1990-2050, 0.1 per cent for OECD countries and 1.6 per cent for non-OECD countries.

[2] The renewable energy sources include a carbon-based synthetic fuel, a carbon-free synthetic fuel and a carbon-free electric source

3.3 SAUNDERS AND SCHNEIDER (2000)

This study applies the multi-region, multi-sector dynamic general-equilibrium, Global Trade and Environment Model (GTEM), of the Australian Bureau of Agricultural and Resource Economics (ABARE). GTEM models inter fuel substitution and changes in trade patterns among countries and sectors. It depicts 17 macro-regions (Australia, Canada, U.S., Japan, European Union, Former Soviet Union, Eastern Europe, China, Indonesia, Korea, Thailand, India, South Africa, Middle East, Mexico, Argentina and the rest of the world) and 15 main industries (among which the most energy-intensive likely to be affected by subsidy changes). In addition to CO2, the model provides data on methane and nitrous oxide emissions.

Instead of applying directly the price gap approach, Saunders and Schneider use 1995 World Bank estimates of energy consumption subsidies. Data from the World Bank includes subsidies for 10 non-OECD regions: the Former Soviet Union and Eastern Europe (aggregated), China, Indonesia, Korea, Thailand, India, South Africa, Middle East, Mexico and Argentina on petroleum products, gas, and coal, broken down by three classes of user (the power sector, industry and households). The authors' estimates of subsidies are lower than those of the IEA (1999). In the policy scenarios, it is assumed that fossil-fuel consumption subsidies are removed over the five-year period 2001-2005. Results show that global GHG emissions reduce by 1.1 per cent while GDP is 0.45 and 0.1 higher in non-OECD and OECD countries in 2010, respectively.

3.4 OECD (2000)

This study also uses the Green model. In this version the *price-gap* data stem from 1996 IEA estimates (IEA, 1999). The OECD computes both positive and negative price wedges in order to capture subsidies that lower prices to consumers, and subsidies that raise prices for consumers, but provide support to producers. The OECD excludes taxes to both reference and end-use prices. The geographical aggregation is the same of Burniaux et al. (1992a) but the base year is 1996. The temporal horizon covers the period 1996-2010. Inter fuel substitution cross-elasticities are assumed to be 2.0 in the original model. CO2 emissions fall by 6.2 per cent in 2010. Interestingly, the non-OECD countries reduce by 6.3 per cent while in the OECD countries they increase by 0.1 per cent as fossil fuel production slightly reallocate from developing to developed countries. Looking at welfare gain, the GDP increase is small, only 0.1 per cent in 2010 compared to the baseline.

3.5 BURNIAUX, CHATEAU, DELLINK, DUVAL AND JAMET (2009)

The authors use the OECD computable general equilibrium model ENV-Linkages, which is the upgraded version of the old GREEN model. The model database is GTAP (*Global Trade Analysis Project*) 8 (Narayanan et al., 2012). This work analyzes four non-OECD countries (China, India, Brazil and Russia), two non-OECD macro-regions (Oil exporting countries and non-EU Eastern European Countries) and the Rest of the World). 2007 IEA *price-gap* estimates (IEA, 2008) are included in the database for the base year 2005. The simulation period is extended to 2050, the subsidy removal takes place between 2013 and 2020. Results show that the world CO2 emissions are reduced by 13 per cent and GHG emissions by 10.2 per cent in 2050 compared to the baseline. The increase in the global GDP is tiny, about 0.2 per cent in 2050.

3.6 BURNIAUX AND CHATEAU (2011)

This last study is described in more detail as it is closer to the exercise we are performing with the CMCC ICES CGE model. Burniaux and Chateau use the ENV-Linkages model as in Burniaux et al, (2009), but with some important differences. Twelve regions are considered: China, India, Brazil, Russia, Oil exporting countries, Former Soviet Union Countries, Japan, Canada, USA, EU27 and the macro-region made up of Australia and New Zealand. The economic context is based on long-term economic growth scenario described in Duval and de la Maisonneuve (2010) taking into account the 2008 world financial and economic crisis. In addition, the *price gaps* are those estimated by the IEA in 2008 for 37 non-ECD countries (IEA, 2009). These estimates are introduced in the model as subsidies on final consumption of households and intermediate consumption of firms. It is worth noting that Burniaux and Chateau include the actual monetary values of subsidies in the GTAP database, which does not consider them explicitly and clearly. This requires a laborious re-calibration and re-balancing process that in principle would allow a better representation of subsidy distortionary effect in the market.[3] The baseline scenario assumes constant subsidies (in percent) at the 2005 levels until 2050. The subsidy reform implies a gradual phasing-out over the period 2013 to 2020. The policy causes a world GHG emission reduction of 8 per cent in 2050 relative to the baseline. This number is lower than the 10.2 per cent reported in Burniaux et al. (2009). The main explanations for the difference are that, in line with changes in pricing policies in some non-OECD countries, *price gaps* have tended to decline since 2007, which was the

[3] The method used by the other studies to introduce the subsidies in the database is not transparent.

reference year for subsidy estimates in Burniaux et al. (2009). Moreover the new baseline now considers the world financial and economic crisis and therefore lower global emission levels. Turning to the income effects, the Equivalent Variation (EV) income increases by about 0.3 for the word as a whole in 2050 with respect to the baseline, 0.5 for OECD countries and 0.2 for non-OECD countries.

4. THE ICES EXPERIMENT

In this section we conduct a first experiment of fossil fuel subsidy removal with the CMCC ICES model. Our aim is mainly methodological and functional, to test how the model behaves when estimated subsidies are linked to the model database and then a phasing out policy is simulated.

We use 2008 data on subsidies as in Burniaux and Chateau (2011). In Appendix we report the IEA estimates from 2007 to 2011. To better understand model reaction we replicate as close as possible Burniaux and Chateau (2011), imposing to ICES exactly their geographical/sectoral aggregation, constructing as far as possible the same reference scenario and mimicking the same policy. Nonetheless ICES and Env-Linkages remain different in some basic parameterization, in the calibration year (ENV-Linkages is calibrated in 2005 while the version of ICES currently used in 2001), in the description of the supply side and in the modeling of the evolution of capital stock. These differences are rapidly revised in the next sub section.

4.1 ICES AND ENV-LINKAGES

The production tree of the ICES model is illustrated in Figure 1, while that of ENV-Linkages in Figures 2 and 3.

The production tree of the two models is reasonably similar, when the energy nest is considered.

Basically, in Figure 1 we can observe the same structure of the ENV-Linkages. The technological process for the representative firm in each country and sector is modelled through a capital-energy nest and fossil fuels as primary inputs. However, in the ICES model no possibility is given to capture the substitution between CO2 and non-CO2 gases.

Figure 1: the production structure in the ICES model

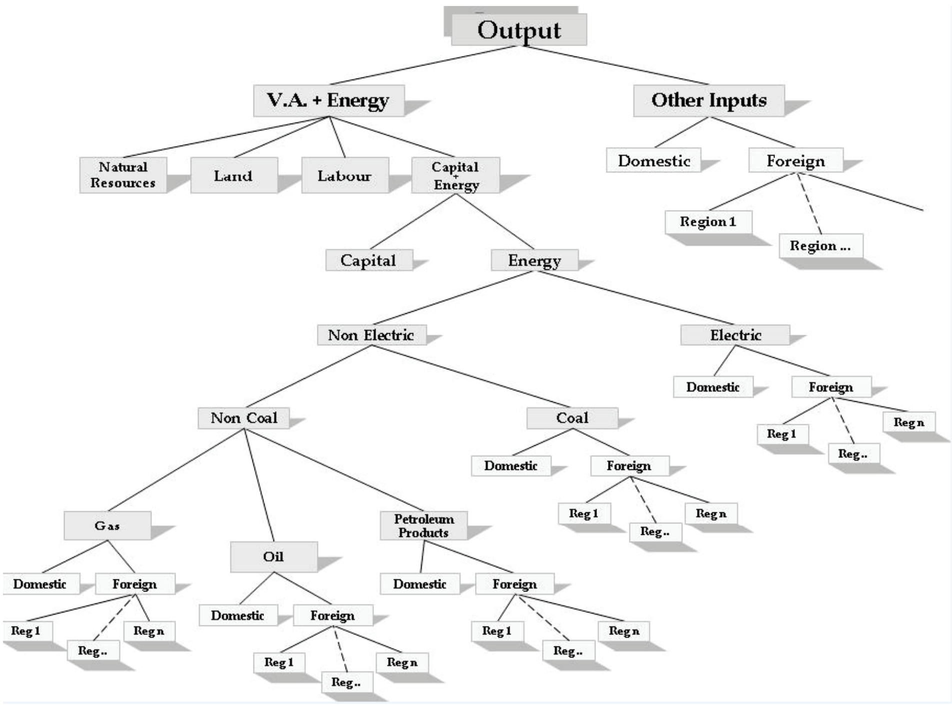


Figure 2: the production structure in the ENV-Linkage model

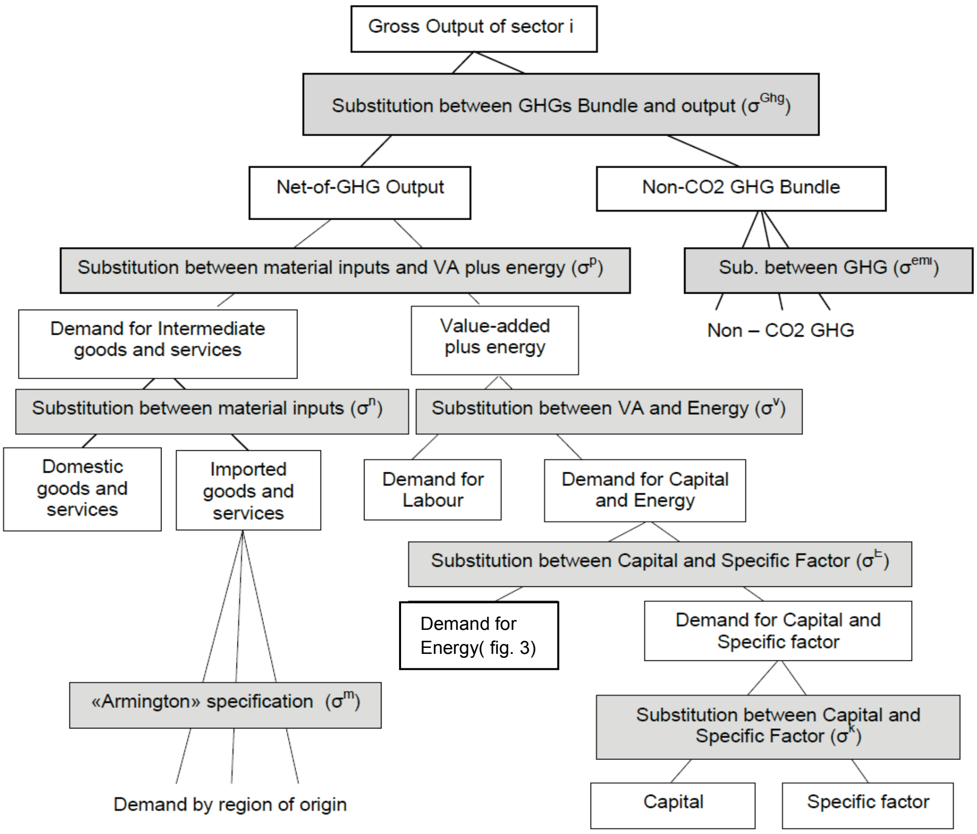
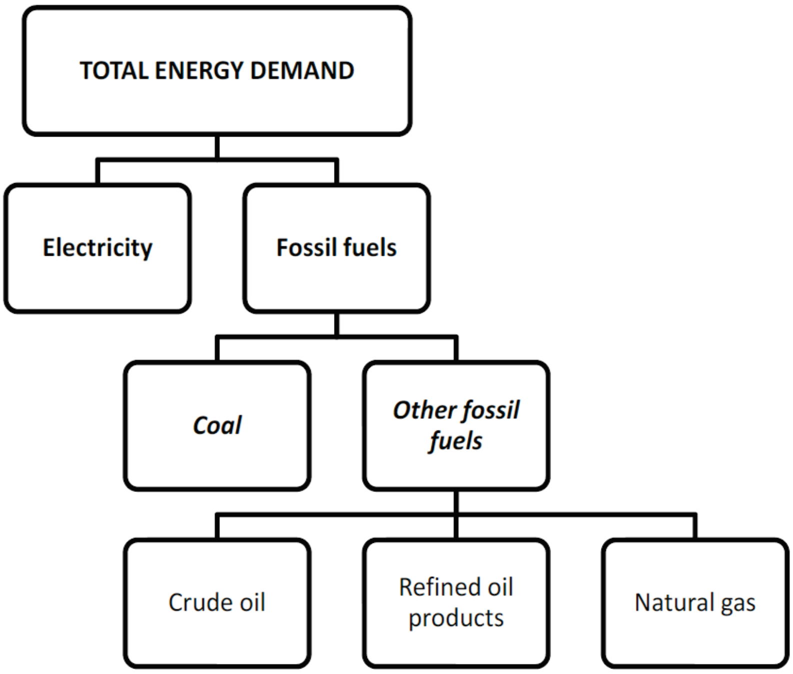


Figure 3: the energy nest in the ENV-Linkages model



Another structural difference concerns the modeling of capital stock growth. Both ICES and ENV-Linkages are recursive-dynamic models where capital evolves over time following endogenous investment decisions. But while in ICES there is just one kind of capital stock, ENV-Linkages adopts the capital vintage approach. The idea is that the process of capital accumulation progressively brings into existence new "generations" of capital which substitute the old ones. New vintages are then characterized by a different (higher) rate of substitution with other factors of production (typically energy) than older vintages. Table 3 reports these elasticities starting from the upper to the lowest nest of the energy tree in the two models. It can be noted that ENV-Linkages proposes initially lower elasticities than ICES, but then these become larger.

This feature should make emissions in ENV-Linkages in the long term more responsive to the subsidy removal than in ICES.

Table 3: key-differences in elasticity values of ENV-Linkages and ICES

	ENV-Linkages	ICES
Capital / Energy elast.	0.25 - 2 depending on capital vintage	0.5
Electricity / Fossil fuels elast.	0.25 - 2 depending on capital vintage	1
Coal / Other fossil fuels	0.25 - 2 depending on capital vintage	0.5
Remaining fossil fuels	0.25 - 2 depending on capital vintage	1

4.2 EXPERIMENT IMPLEMENTATION

The ICES baseline for the experiment replicates Burniaux and Chateau (2011) as described in Burniaux and Chateau (2010). To be more precise, we do not reproduce all the features of their baseline[4], also because some of them are very difficult to capture in ICES, but just some key variables driving the behavior of our model: population, employment and GDP grow rates. Nonetheless by targeting the GDP pattern we are able to encompass the effects of the majority of exogenous drivers in ENV-Linkages. Moreover, for simplicity, we also compress the ICES dynamic in just one time leap moving the economy from 2001 to 2050. This implies that the phasing out occurs instantaneously.

A final note on how we introduced subsidy removals. The starting assumption is that the whole fiscal component affecting fossil fuel, thus including *taxes and subsidies*, is already incorporated in the energy prices and thus in the value of exchanges recorded by the ICES database. The problem is that it is not explicit. In practice, embedded in prices there is *ad valorem* fiscal component (r), following:

$$P^*(i,c) = [1+ r(i,c)]\, P(i,c) \qquad \text{Eq.1}$$

where P^* is the post-tax / subsidy price, P is the pre-tax / subsidy price, i represents the relevant fossil fuel sector index (coal, oil, gas and electricity), c the country index.

The *ad-valorem* rate is the net result of complex interactions between taxes and subsidies. To be clearer, the rate r is made up of two components, subsidy and tax, according to the following equations:

$$P^*(i,c) = [1+ t(i,c) - s(i,c)]\, P(i,c) \qquad \text{Eq.2}$$

$$r(i,c)= t(i,c) - s(i,c) \qquad \text{Eq.3}$$

where t is the ad valorem tax rate and s is the ad valorem subsidy rate.

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[4] Population and employment; aggregate average and sectoral labor productivity growth; autonomous efficiency gains for capital, land and specific natural resources; autonomous efficiency gains of fertilizers in crops sectors and of the food bundle in livestock rearing; supply of land and natural resources (excepted for fossil fuels sectors); international trade margins; shares of public expenditure in real GDP; public savings and flows of international savings; energy demand for all kind of fuels but crude oil; international prices of fossil fuels; investment to GDP ratios; Non-CO2 fuel GHGs emissions; the share of each type of electricity-producing technology.

Should the tax component prevail the rate *r* is positive, should the subsidy component prevail the rate *r* is negative. Without detailed (and in practice unavailable) information, it is not possible to unequivocally identify whether *r* is positive or negative.

For the moment we by-pass the problem implementing the phasing-out policy in the form of an *ad valorem* tax (i.e. a negative subsidy) over the fossil fuel price *P**. This tax is exactly the (negative) *ad valorem* subsidy reported by Burniaux and Chateau (2011). These values represent the average subsidy rate over the total demand for each type of fuel (coal, oil, gas, electricity) and country (Table 4).

This is not equivalent to remove exactly the fossil fuel subsidy in the domestic final consumption of households and domestic intermediate consumption of firms, as in the approach of Chateau and Burniaux (2011), because these policy inputs stem from a different source and we have not inserted the subsidy monetary values in the initial year of the GTAP 6 database.

If we shock *r* by imposing a positive change equal to the values in Table 4, we are able at the same time to disentangle and cancel out the subsidy effect if and only if the numbers coming from Burniaux and Chateau (2011) correspond exactly to the *ad valorem* subsidy rate *s*. This is improbable.

Even if this methodology entails some simplifications because we do not include the actual monetary values of subsidies in the database, it represents the most reliable and easy way to implement the policy.

Table 4: % *ad valorem* subsidy rate

	Coal	Oil	Gas	Electricity
China	1.20	1.70	7.10	1.70
India	0.00	20.40	32.20	1.70
Russian Federation	0.00	0.00	21.40	24.80
Oil export. Countries	0.00	34.30	11.40	43.50
Former Soviet Countries	0.00	0.60	15.80	10.90
Rest of the world	0.90	4.10	8.20	5.80

Source: Burniaux and Chateau, (2011)

4.3 RESULTS

The results of the policy in 2050 expressed in percent changes with respect to the baseline, are reported in Table 5 and 6 for CO2 emissions and income Equivalent Variation (EV) respectively.

We find the same qualitative results of Burniaux and Chateau (2011), but much smaller (roughly 1/6th) quantitatively. As said this was somewhat expected as ENV-Linkages, differently from ICES, allows to substitute CO2 emissions with non-CO2 emissions and depicts a higher substitutability of energy sources with other inputs than ICES.

Following subsidy removals, world CO2 emissions reduce by 1.63 per cent. It is also worth noting that emission reduction is stronger in those regions - Russian Federation, Former Soviet Union and Oil Exporting Countries - where the subsidies are higher, whereas, the EU-27 increases its CO2 emissions. Following the abatement of price distortions, energy prices, and thus the prices of all the energy intensive goods, increase more where subsidies were higher. Accordingly, the EU with its low subsidies, gains in competitiveness, its goods experience an increase in demand, in production and this brings about an increase in emissions. Concerning the income EV, the policy is welfare improving in Burniaux and Chateau while in our study this is not the case (-0.13 per cent at the world level). This is not at all surprising as we are imposing a tax over a situation that for the model represents an economic optimum. The next step of the research will consist in introducing explicitly the subsidy in the model database to allow the associated distortion to be accounted for. Anyway, noting that negative effects on welfare are tiny, it is not totally unreasonable to expect that, once all the modification of the case will be implemented, welfare gains will also remain small.

Table 5: CO2 emissions in 2050 (% changes wrt baseline)

	ENV-Linkages	***ICES***
Australia New Zealand	4	0.47
Japan	9	0.15
Canada	6	0.22
USA	6.5	0.22
Europe-27	12	0.48
Brazil	5	0.28
China	-8	-0.06

India	-18	-0.23
Russian Federation	-27	-11.06
Oil export. Countries	-45	-5.35
Former Soviet Union Countries	-23	-4.14
Rest of the world	-8	-0.96
World Total	**-10**	**-1.63**

Table 6: Income equivalent variation in 2050 (% change wrt baseline)

	ENV-Linkages	*ICES*
Australia New Zealand	-0.5	-0.40
Japan	1.1	-0.07
Canada	-2.5	-0.20
USA	0.2	-0.02
Europe-27	0.9	-0.07
Brazil	0.1	0.03
China	0.6	-0.09
India	3	0.15
Russian Federation	-5.8	-0.59
Oil export. Countries	0.05	-0.73
Former Soviet Countries	-9.1	-1.04
Rest of the world	0	-0.04
World Total	**0.3**	**-0.13**

Trade effects are also important. In Table 7 and 8 we report the change in the volume of aggregate imports and exports for each country and energy sector in the ICES model.

The electricity sector shows the most important changes probably because the elasticity of substitution between electricity and fossil fuels is higher than the elasticity substitution between coal and non-coal fossil fuels.

It can be also observed (in bold in Table 7) that Brazil, China, India, EU-27 and USA increase substantively their coal imports. This fossil fuel, poorly subsidized, after the removal increases moderately its price and becomes more competitive. As expected (in bold in Table 8), Russia and the Former Soviet Union Countries decrease their gas exports while Oil Exporting Countries their oil exports.

Table 7: Imports in 2050 (% changes wrt baseline)

ICES model	Coal	Oil	Gas	Oil Products	Electricity
Australia New Zealand	-2.69	-0.68	-1.77	-0.87	-12.47
Japan	1.28	0.23	-0.55	-0.95	-11.60
Canada	0.14	-0.16	-0.77	-0.24	-4.23
USA	**4.68**	-0.36	-0.23	-0.42	-2.04
Europe-27	**3.86**	0.24	-1.17	0.05	-3.33
Brazil	**1.68**	0.72	-1.72	0.17	-5.41
China	**3.53**	0.47	0.92	-0.13	-2.31
India	**4.78**	0.59	12.61	0.52	-10.57
Russian Federation	-9.58	-4.73	-14.55	-4.03	75.28
Oil export. Countries	-23.31	-1.36	-12.59	-0.69	243.72
Former Soviet Countries	-2.30	2.87	-5.04	1.10	5.47
Rest of the world	-0.87	0.02	-2.25	-0.44	1.22

Table 8: Exports in 2050 (% change wrt baseline)

ICES model	Coal	Oil	Gas	Oil Products	Electricity
Australia New Zealand	-0.83	0.66	3.34	0.74	35.32
Japan	-5.69	-0.60	1.70	1.17	24.86
Canada	-2.57	0.20	0.34	0.21	7.85
USA	-7.75	0.75	2.15	0.07	19.07
Europe-27	-6.46	0.02	2.42	0.55	19.92
Brazil	-16.43	-1.66	-2.23	-0.99	20.78
China	-5.19	-0.95	-13.97	0.40	4.47
India	-14.60	-2.66	-32.90	-0.67	12.67
Russian Federation	17.09	2.41	**-4.47**	2.16	-72.13
Oil export. Countries	7.50	**-0.20**	2.13	-1.80	-95.30
Former Soviet Countries	-5.33	-1.45	**-20.12**	1.58	-19.00
Rest of the world	-0.87	-0.19	-6.74	0.21	-12.79

5. CONCLUSIONS

This study details the first experiment conducted to couple the information relative to fossil fuel subsidies with the database and structure of the ICES CGE model developed at the CMCC, and to test the general performance of the model simulating their potential removal.

To date, a consistent global database on fossil fuel subsidies does not exist. Opacity characterizes the data in many developing countries, where governments are not willing to provide easily this type of information. Therefore, data for multi country and multi-fuel analysis derive from a “reconstruction process” based upon the *price gap* method, created by the IEA. In this study we use exactly this information.

The policy exercise consists in an instantaneous phasing out of existing subsidies in 2050. Removals are implemented imposing an *ad valorem* tax exactly equal to subsidies estimated by IEA (2009). We also compare our results with Burniaux and Chateau (2011) which conducted a similar analysis with the OECD ENV-Linkages model.

Both models predict the expected decrease in CO2 emissions which is more pronounced in countries where the subsidy size is larger (Russian Federation, Former Soviet Union Countries and Oil exporting Countries). On the contrary the EU, where subsidies are small, increases its emissions due to a leakage effect. Nevertheless, the magnitudes of these effects are quite smaller in ICES. Its results are in fact closer to Saunders and Schneider (2000), but the two works are hardly comparable.

The differences with ENV-Linkages appear to be crucially dependent upon the capital vintage structure and the associated assumption of a higher substitutability in production of capital with the energy composite. Also the possibility to substitute CO2 with non-CO2 gases plays a role.

Another difference across the ICES and the ENV-Linkages simulations is the welfare effect. While fossil fuel subsidy removal entails a (small) loss in the former, the latter highlights (small) improvements. This is not at all surprising as in ICES the policy is simulated imposing a tax over a situation that for the model represents an economic optimum. In other words a distortion is added instead of being removed. In the next phase of the research fossil fuel subsidies will be introduced explicitly in the price structure of ICES model to accommodate this aspect.

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APPENDIX

Fossil Fuel Consumption Subsidies Database

(Billion Dollars)

		2007	2008	2009	2010	2011
Algeria	Oil	4.08	6.46	3.85	8.46	11.26
	Electricity	1.52	2.37	1.97	2.13	2.13
	Natural Gas	0.00	0.00	0.00	0.00	0.00
	Coal	0.00	0.00	0.00	0.00	0.00
	Total	5.60	8.83	5.83	10.58	13.39
Angola	Oil	0.55	1.05	0.20	0.94	1.06
	Electricity	0.09	0.13	0.11	0.18	0.28
	Natural Gas	0.00	0.00	0.00	0.00	0.00
	Coal	0.00	0.00	0.00	0.00	0.00
	Total	0.64	1.17	0.31	1.13	1.34
Argentina	Oil	3.88	6.63	0.52	0.81	1.70
	Electricity	4.60	5.33	2.65	3.16	4.57
	Natural Gas	3.54	6.14	2.70	2.53	3.76
	Coal	0.00	0.00	0.00	0.00	0.00
	Total	12.02	18.10	5.87	6.49	10.03
Azerbaijan	Oil	0.15	0.34	0.02	0.11	0.65
	Electricity	0.56	0.85	0.58	0.33	0.47
	Natural Gas	0.63	1.25	0.56	0.39	0.83
	Coal	0.00	0.00	0.00	0.00	0.00
	Total	1.34	2.44	1.15	0.83	1.95
Bangladesh	Oil	0.37	0.57	0.03	0.34	0.87
	Electricity	0.75	1.89	2.03	2.79	3.00
	Natural Gas	0.96	1.94	1.54	1.90	1.89
	Coal	0.00	0.00	0.00	0.00	0.00
	Total	2.08	4.41	3.61	5.03	5.77
Brunei	Oil	0.17	0.26	0.11	0.19	0.31
	Electricity	0.04	0.11	0.12	0.15	0.16
	Natural Gas	0.00	0.00	0.00	0.00	0.00
	Coal	0.00	0.00	0.00	0.00	0.00
	Total	0.21	0.37	0.23	0.33	0.47
Chile	Oil	0.00	0.00	0.00	0.00	0.00
	Electricity	0.00	0.00	0.00	0.00	0.00

	Natural Gas	0.00	0.00	0.00	0.00	0.00
	Coal	0.00	0.00	0.00	0.00	0.00
	Total	0.00	0.00	0.00	0.00	0.00

		2007	2008	2009	2010	2011
Chinese Taipei	Oil	0.60	1.30	0.54	0.24	0.45
	Electricity	1.45	3.54	2.25	0.34	1.02
	Natural Gas	0.00	0.02	0.00	0.00	0.00
	Coal	0.06	0.17	0.09	0.00	0.15
	Total	2.12	5.03	2.88	0.58	1.62
Colombia	Oil	0.68	0.88	0.25	0.48	0.65
	Electricity	0.00	0.00	0.00	0.00	0.00
	Natural Gas	0.00	0.13	0.00	0.00	0.00
	Coal	0.00	0.00	0.00	0.00	0.00
	Total	0.68	1.01	0.25	0.48	0.65
Ecuador	Oil	3.08	4.34	1.62	3.73	5.44
	Electricity	0.10	0.24	0.16	0.01	0.12
	Natural Gas	0.00	0.00	0.00	0.00	0.00
	Coal	0.00	0.00	0.00	0.00	0.00
	Total	3.19	4.58	1.78	3.74	5.55
Egypt	Oil	13.99	19.71	9.75	14.07	15.27
	Electricity	3.55	5.21	2.96	3.81	5.42
	Natural Gas	1.85	3.01	2.15	2.40	3.78
	Coal	0.00	0.00	0.00	0.00	0.00
	Total	19.38	27.93	14.86	20.29	24.47
ElSalvador	Oil	0.00	0.00	0.00	0.00	0.00
	Electricity	0.00	0.00	0.00	0.00	0.00
	Natural Gas	0.00	0.00	0.00	0.00	0.00
	Coal	0.00	0.00	0.00	0.00	0.00
	Total	0.00	0.00	0.00	0.00	0.00
India	Oil	17.37	32.12	11.49	16.20	30.86
	Electricity	4.89	7.82	6.21	3.87	5.81
	Natural Gas	2.05	4.16	2.72	2.22	3.03
	Coal	0.00	0.00	0.00	0.00	0.00
	Total	24.32	44.09	20.42	22.28	39.70
Indonesia	Oil	11.30	14.28	8.99	10.15	15.72
	Electricity	1.87	4.74	5.31	5.79	5.56
	Natural Gas	0.00	0.00	0.00	0.00	0.00
	Coal	0.00	0.00	0.00	0.00	0.00

	Total	13.17	19.02	14.30	15.94	21.28
Iraq	Oil	8.67	13.08	5.32	14.43	20.35
	Electricity	1.15	2.03	1.45	1.35	1.59
	Natural Gas	0.35	0.61	0.54	0.28	0.29
	Coal	0.00	0.00	0.00	0.00	0.00
	Total	10.17	15.71	7.31	16.07	22.23

		2007	2008	2009	2010	2011
Iran	Oil	36.56	53.78	29.20	40.92	41.39
	Electricity	9.22	15.19	11.31	14.43	17.40
	Natural Gas	18.78	32.03	24.12	25.49	23.40
	Coal	0.00	0.00	0.00	0.00	0.00
	Total	64.56	101.01	64.63	80.84	82.18
Kazakhstan	Oil	1.29	1.65	0.41	2.03	3.19
	Electricity	0.29	0.77	0.73	1.69	1.75
	Natural Gas	0.17	0.29	0.21	0.22	0.33
	Coal	0.00	0.00	0.47	0.38	0.58
	Total	1.76	2.71	1.81	4.31	5.84
Korea	Oil	0.00	0.00	0.00	0.00	0.00
	Electricity	0.00	0.00	0.00	0.00	0.00
	Natural Gas	0.00	0.00	0.00	0.00	0.00
	Coal	0.00	0.21	0.18	0.18	0.19
	Total	0.00	0.21	0.18	0.18	0.19
Kuwait	Oil	2.79	4.11	1.90	2.81	4.34
	Electricity	2.80	3.89	3.32	3.91	4.68
	Natural Gas	0.85	1.52	0.97	0.90	2.08
	Coal	0.00	0.00	0.00	0.00	0.00
	Total	6.44	9.52	6.19	7.63	11.10
Libya	Oil	2.51	3.18	1.72	3.17	2.26
	Electricity	0.58	0.77	0.41	0.78	0.66
	Natural Gas	0.26	0.37	0.08	0.26	0.21
	Coal	0.00	0.00	0.00	0.00	0.00
	Total	3.35	4.33	2.20	4.21	3.13
Malaysia	Oil	2.69	4.61	1.58	3.89	5.35
	Electricity	0.49	2.20	1.71	0.81	0.94
	Natural Gas	1.42	2.97	1.68	0.97	0.89
	Coal	0.00	0.00	0.00	0.00	0.00
	Total	4.60	9.78	4.97	5.67	7.18

Mexico	Oil	16.49	21.94	3.17	9.34	15.90
	Electricity	1.12	0.57	0.26	0.16	0.00
	Natural Gas	0.00	0.00	0.00	0.00	0.00
	Coal	0.00	0.00	0.00	0.00	0.00
	Total	17.61	22.51	3.43	9.50	15.90
Nigeria	Oil	1.91	2.90	0.00	2.44	3.62
	Electricity	0.46	0.61	0.54	0.47	0.73
	Natural Gas	0.00	0.00	0.00	0.00	0.00
	Coal	0.00	0.00	0.00	0.00	0.00
	Total	2.37	3.51	0.54	2.91	4.35

		2007	2008	2009	2010	2011
Pakistan	Oil	2.66	4.04	0.06	0.14	2.79
	Electricity	1.10	2.15	2.30	2.23	2.75
	Natural Gas	3.86	6.55	3.97	4.93	5.54
	Coal	0.00	0.00	0.00	0.00	0.00
	Total	7.61	12.74	6.34	7.30	11.08
China	Oil	11.75	26.96	5.29	7.77	18.45
	Electricity	4.41	7.25	5.77	11.54	11.21
	Natural Gas	0.00	6.60	0.37	0.00	0.00
	Coal	0.15	3.38	3.99	2.01	1.39
	Total	16.31	44.20	15.43	21.33	31.04
Peru	Oil	0.10	0.24	0.00	0.00	0.32
	Electricity	0.00	0.23	0.03	0.00	0.00
	Natural Gas	0.06	0.15	0.00	0.00	0.00
	Coal	0.00	0.00	0.00	0.00	0.00
	Total	0.15	0.62	0.03	0.00	0.32
Philippines	Oil	0.16	0.12	0.03	1.10	1.46
	Electricity	0.00	0.00	0.00	0.00	0.00
	Natural Gas	0.00	0.00	0.00	0.00	0.00
	Coal	0.00	0.00	0.00	0.00	0.00
	Total	0.16	0.12	0.03	1.10	1.46
Qatar	Oil	0.97	1.51	0.69	1.15	2.03
	Electricity	0.64	1.12	1.05	1.59	2.09
	Natural Gas	0.86	1.53	1.09	1.41	1.86
	Coal	0.00	0.00	0.00	0.00	0.00
	Total	2.47	4.15	2.83	4.16	5.97
Russia	Oil	0.00	0.00	0.00	0.00	0.00

	Electricity	14.95	23.03	14.40	22.26	18.28
	Natural Gas	18.38	28.47	18.57	16.95	21.87
	Coal	0.00	0.00	0.00	0.00	0.00
	Total	33.33	51.50	32.97	39.21	40.15
SaudiArabia	Oil	23.73	36.31	22.06	30.57	46.12
	Electricity	8.58	12.20	10.48	12.95	14.82
	Natural Gas	0.00	0.00	0.00	0.00	0.00
	Coal	0.00	0.00	0.00	0.00	0.00
	Total	32.31	48.50	32.54	43.52	60.94
SouthAfrica	Oil	0.18	0.21	0.12	0.00	0.00
	Electricity	4.98	5.53	2.84	2.12	1.38
	Natural Gas	0.00	0.00	0.00	0.00	0.00
	Coal	0.00	0.00	0.00	0.00	0.00
	Total	5.16	5.75	2.96	2.12	1.38

		2007	2008	2009	2010	2011
Sri Lanka	Oil	0.38	0.65	0.02	0.32	0.82
	Electricity	0.06	0.25	0.17	0.19	0.28
	Natural Gas	0.00	0.00	0.00	0.00	0.00
	Coal	0.00	0.00	0.00	0.00	0.00
	Total	0.44	0.90	0.19	0.51	1.09
Thailand	Oil	1.55	2.08	1.20	2.11	3.29
	Electricity	0.88	4.16	4.23	5.44	5.67
	Natural Gas	0.22	0.58	0.24	0.48	0.48
	Coal	0.17	0.56	0.50	0.44	0.85
	Total	2.82	7.38	6.17	8.48	10.29
Turkmenistan	Oil	0.72	0.71	0.75	0.86	0.83
	Electricity	0.22	0.31	0.25	0.60	0.65
	Natural Gas	2.61	3.80	2.17	3.55	4.36
	Coal	0.00	0.00	0.00	0.00	0.00
	Total	3.55	4.81	3.18	5.02	5.84
Ukraine	Oil	0.00	0.00	0.00	0.00	0.00
	Electricity	1.26	1.51	1.45	2.47	2.66
	Natural Gas	4.83	8.27	5.27	5.20	6.68
	Coal	0.00	0.00	0.00	0.00	0.00
	Total	6.09	9.79	6.72	7.67	9.34
UAE	Oil	1.48	2.03	0.96	2.65	3.93
	Electricity	2.99	5.15	4.42	5.51	6.37

	Natural Gas	3.56	7.84	5.78	9.99	11.52
	Coal	0.00	0.00	0.00	0.00	0.00
	Total	8.02	15.02	11.16	18.15	21.82
Uzbekistan	Oil	0.00	0.00	0.44	0.26	1.06
	Electricity	1.46	2.53	1.77	2.36	2.59
	Natural Gas	6.54	12.68	9.29	9.28	9.09
	Coal	0.00	0.00	0.00	0.00	0.00
	Total	8.00	15.22	11.49	11.90	12.74
Venezuela	Oil	13.14	16.26	10.40	15.70	21.97
	Electricity	2.65	4.34	2.61	2.85	3.22
	Natural Gas	2.23	3.61	1.07	1.42	1.89
	Coal	0.00	0.00	0.00	0.00	0.00
	Total	18.02	24.22	14.09	19.97	27.08
Vietnam	Oil	0.32	1.09	0.00	0.00	1.02
	Electricity	1.68	2.25	2.10	2.69	2.92
	Natural Gas	0.09	0.21	0.13	0.23	0.16
	Coal	0.01	0.01	0.01	0.01	0.02
	Total	2.10	3.57	2.23	2.93	4.12

Source: IEA estimates on fossil fuel consumption subsidies available at: http://www.iea.org/publications/worldenergyoutlook/resources/energysubsidies/