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NOTA DI LAVORO 71.2007

JULY 2007

IEM – International Energy Markets

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Summary

Future energy demand will be affected by changes in prices and income, but also by other factors, like temperature levels. This paper draws upon an econometric study, disentangling the contribution of temperature in the determination of the annual regional demand for energy goods. Combining estimates of temperature elasticities with scenarios of future climate change, it is possible to assess variations in energy demand induced (directly) by the global warming. We use this information to simulate a change in the demand structure of households in a CGE model of the world economy, in a set of assessment exercises. The changing demand structure triggers a structural adjustment process, influencing trade flows, regional competitiveness of industries and regions, and welfare. We also consider the possible existence of imperfect competition in the energy markets, analyzing the impact of changes in energy demand with an alternative model version, in which energy industries are modeled as Cournot oligopolies.

Keywords: Climate Change, Energy, Computable General Equilibrium Models, Imperfect Competition

JEL Classification: D58, F12, Q43, Q54

This work is part of a collaborative research on the economic impacts of climate changes, jointly carried out by Fondazione Eni Enrico Mattei, Italy, and the Research unit Sustainability and Global Change of Hamburg University, Germany.

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Francesco Bosello* , Enrica De Cian° and Roberto Roson§

1. Introduction

Climate change is expected to affect energy markets in various ways, both directly and indirectly. Indirect effects will operate through environmental policies, aimed at changing the consumption pattern of energy goods and/or sustaining the development and diffusion of cleaner technologies.
Direct effects are also important. Energy demand will be affected by temperature changes, because higher temperatures imply less energy for heating and more demand for cooling, in addition to variations in the demand for energy as a production factor. We therefore expect a U-shaped relationship between temperature and energy demand. We also expect changes in the composition

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of demand, between alternative energy goods.[1]

This paper analyzes the direct economic impact of climate change on energy demand. From a macroeconomic perspective, the climate impact will not affect primary resources of the various regional economies, but rather the structure of industrial and households demand for goods and services. In other words, we consider a shock that could increase or decrease the demand for energy goods at constant prices and income.

To model the adjustment process, we use a Computable General Equilibrium model of the world economy, based on the GTAP data base and model. In our setting, the change in temperature leads to a forced reallocation of budget for firms and consumers. We therefore compare a baseline general equilibrium for the world economy, with a counter-factual equilibrium, generated by changes in tastes and technology. An analysis of this counter-factual equilibrium highlights the structural adjustment processes and the distributional effects involved.

This exercise relies on a econometric analysis of the relationship between average temperature levels and long run demand for energy goods, by De Cian, Lanzi and Roson (2007). The methodology and the findings of this study are summarized in section 2. Section 3 explains how estimates of temperature elasticities have been used as input parameters for a simulation exercise with a CGE model of the world economy, and illustrates the main results. Section 4 considers whether, and how, results could change if the existence of market power in energy industries is explicitly taken into account in the model. A final section draws some conclusions.

2. Estimating the relationship between energy demand and temperature levels

A number of studies (e.g., Pardo et al., 2002) have investigated the influence of temperature on energy demand, but mainly at the regional/seasonal scale. To our knowledge, the recent paper by Andrea Bigano, Francesco Bosello and Giuseppe Marano (2006) is the first attempt at estimating the (long-run) temperature elasticities of energy demand, in terms of average annual temperatures and national consumption. As far as temperature is concerned, the main empirical finding is that household demand is responsive to changes in temperature, generally through an inverse relationship, and with long time lags. On the other hand, the temperature elasticity of energy demand by the industry and service sectors is, in most cases, small and not statistically significant. The relationship between annual average temperature and annual energy demand is the result of two offsetting effects: higher average summer temperatures increase energy consumption for cooling needs, whereas a milder winter reduces the use of fuels for heating purposes. However, such seasonal heterogeneity may not be captured if the temperature variability is averaged out in one annual temperature. Moreover, the effect of a change in temperature on energy demand is likely to depend on other factors such as income and the climate.

De Cian, Lanzi and Roson (2007) have extended the previous work so as to capture some of the nonlinearities that characterize the relationship between energy demand and temperature. Instead of using only one measure of temperature, the four seasonal average temperatures have been included. Moreover, to capture the dependence of the energy-temperature relationship on the initial climate conditions, countries have been grouped according to their maximum temperature in 2000 into hot

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1 Effects of temperature on energy demand are one type of direct economic impact of climate change. Other impacts include: variations in sea/ocean levels (Bosello et al., 2007), extreme events (Calzadilla et al., 2007), human health (Bosello et al., 2006), touristic flows (Berrittella et al., 2006), water availability (Berrittella et al., 2007), transportation, energy demand, and others.

and cold regions. Countries with a maximum temperature below the threshold have been classified as cold[2], the remaining as hot[3]. Table 1 reports the estimated long run elasticities of energy demand, for different energy vectors, with respect to seasonal temperatures. When geographic heterogeneities are explicitly accounted for, the net effect on annual energy demand depends on the type of fuel considered and on the geographic characteristics, captured by the average annual temperature of the country. The effects of temperature increases on gas and coal are similar between cold and hot countries, whereas electricity demand reacts differently, especially to an increase in summer temperature.

Table 1 – *Estimated temperature elasticities*[4]

	Household energy demand: hot countries / cold countries			
Energy Vector	Spring Temperature	Summer Temperature	Fall Temperature	Winter Temperature
Coal	41.64 /66.19	-42.12 /-66.23	40.41 /64.62	-19.62 /-32.50
Electricity	-7.80 /-2.50	**23.40 /-1.42**	-14.20 /0.85	2.06 /-0.49
Natural Gas	-2.21 /-5.96	-0.62 /1.71	-1.82 /-5.64	-0.18 /-0.61
Oil Products	-2.26 -0.34	-3.82 /1.08	-2.91 /-1.92	0.44 /0.26

Results like those of Table 1 can be usefully combined with scenarios of climate change. For example, we considered the regional change in temperature 2000-2050 estimated by Giorgi and Mearns (2002), to get regional variations in households demand for energy goods at the year 2050, directly induced by the global warming. Results are reported in Table 2.[5]

2 These are Austria, Belgium, Canada, Switzerland, Germany, Denmark, Finland, France, Ireland, Luxembourg, Netherlands, Norway, New Zealand, Sweden and United Kingdom.

3 Hot countries include Australia, Spain, Greece, Hungary, Indonesia, India, Italy, Japan, Korea, Mexico, Portugal, Thailand, United States, Venezuela and South Africa.

4 Elasticities are defined as percentage variations in energy demand, induced by percentage increases in temperature. To correctly assess the results on Table 1, notice that elasticities are sensitive to baseline temperatures. For example, a 1% increase in temperature, when the baseline is 20°C, amounts to two degrees, but when the baseline is 10°C, then the 1% increment corresponds to only one degree. Therefore, hot countries tend to be associated with higher elasticities, in absolute value.

5 Region acronyms as follows: USA – U.S.A., EU – European Union, EEFSU – Eastern Europe and Former Soviet Union, JPN – Japan, RoA1 – Rest of Annex 1 countries in the Kyoto Protocol (developed countries), EEX – Energy exporting countries, CHIND – China and India, RoW – Rest of the World.

Table 2 – *Changes in temperature and household demand for energy goods*

Regions[6]	% Var. in regional average temperature (2000-2050) °C[7]	Ex-ante % increase in household demand for energy commodities			
		Coal	Nat. Gas	Oil Prod.	Electricity
USA	5.329	81.26	-26.65	-2.44	-1.95
EU	5.084	55.16	-13.78	-14.71	-7.04
EEFSU	10.305	76.15	-25.43	-2.35	-0.44
RoA1	5.239	11.19	-17.97	-7.51	-8.49
JPN (HOT)	4.501	76.92	-24.76	-2.10	**0.05**
EEX (HOT)	2.63	0.99	n.a.[8]	-1.57	**4.73**
CHIND (HOT)	4.22	50.03	-17.98	-1.60	**4.63**
RoW (HOT)	2.60	50.13		-1.81	**7.80**

Scenarios of climate change predict an increase in average regional temperatures, bringing about a change in the energy consumption that varies over regions and fuels. The net effect on gas and oil products is homogeneously negative, though on average it tends to be of bigger magnitude in cold regions. The net effect on electricity demand instead differs across countries not only in size, but also in direction.

These results are used in this paper to model the feedback effects of climate into the economic system. Such analysis is an important complement to the literature assessing the costs of climate change. Explicit modeling the effects climate change will have on the economic system is an essential steps toward a more accurate assessment of the climate change damage. Climate change affects energy demand which in turns has a feedback effect into the climate though second order effects brought about by general equilibrium adjustment.

An average temperature increase of 0.93 °C in 2050 is expected to decrease gas and oil products household demand in all regions; electricity demand change is ambiguous, depending on the trade off between heating and cooling needs. The net effect is an increase in electricity demand in the warmer regions: Japan (JPN), China and India (CHIND), the rest of the world (ROW), and in the energy exporting countries (EEx). In the cold or mixed countries instead the heating effect prevails, leading to a reduction in electricity demand. The lower demand for gas and oil products would generate a drop in world prices of these energy goods. Electricity prices instead can go in both direction, with different reallocations effects between different energy sources and countries. Also, changes in household energy expenditure would affect other goods and services spending. Income levels and prices of primary resources would be affected as well. Next section illustrates how a computable general equilibrium model can be used to assess these systemic effects.

3. Simulating the general equilibrium effects of changes in energy demand

Demand for energy goods, like demand for any other good and factor, is a naturally endogenous variable in a general equilibrium model, as it depends on income and relative prices. In order to

6 According to the average temperature of the countries belonging to each region , ROW, CHIND, JPN and EeX classify as hot regions, RoA1 and Eu as mixed regions and EEFSU as cold regions.

7 These temperature percentage variations correspond to an increase of 0.93 °C in the regional average temperature level in 2050. Such increase is the 2050 baseline forecast of the CGE model used in this paper.

8 Data for gas demand in this region were missing.

shift demand at constant prices and income, an exogenous variation in some structural parameters of utility or production functions is needed. This has two important consequences. First, in a general equilibrium, the ex-ante variation of demand differs from the ex-post variation, since the latter takes price adjustments into account. Second, in order to meet the budget constraint for every agent, any exogenous shift in the demand for some item has to be compensated by shifts in the demand for other items.

In order to simulate the effects of a changing demand for energy goods, we have introduced and shocked specific shifting factors in the equation describing the demand for goods and factors in a Computable General Equilibrium (CGE) model of the world economy.[9] This model is the popular GTAP model v.6 (Hertel, 1996) in the alternative formulation GTAP-E, originally proposed by Burniaux and Truong (2002).[10]

Structural parameters in the GTAP model are obtained by a standard calibration procedure. This means that parameters are selected such that the model replicates the observed structure of the world economy, as described in a calibration data-set (year 2001). One problem of our application is given by the fact that we are interested in simulating changes occurring in the future, which means that our benchmark should refer to a 2050 scenario, not to a 2001 data-set.
To this end, we derived hypothetical data for 2050, using the methodology described in Dixon and Rimmer (2002). This entails inserting, in the model calibration data, estimated values for some key economic variables: national endowments of labour, capital, land, natural resources, as well as factor and multi-factor productivity.

In this way, we got a reference equilibrium state, that can subsequently be perturbed by exogenous shocks. Therefore, by changing the structure of demand for households and firms, we can run a conventional comparative static exercise, providing information about the systemic, net effect of exogenous changes in "tastes" and "technologies". This information comes in terms of: variations in industrial output, national income, trade flows, foreign debt, welfare and other variables.

Notice that the shock is due to a changing composition of demand, not to variations in endowments of primary resources. This implies that, at the global level, the shock is neither positive nor negative, and the main effects are distributional: differences in relative income, welfare and competitiveness. Table 3 shows percentage variations in some main economic aggregates, generated by the simulation exercise. Tables A1, A2 and A3 in the Appendix show variations in quantities and prices of all goods and factors, including energy commodities. Demanded quantities and industrial output are expected to change in line with the initial shocks: however, the ex post demand and output variation differs from the ex ante one, because of the rebound effect of prices, moving in the opposite direction. For example, although electricity demand in Japan increases, the consequent increase in price leads to substitution toward cheaper imports, causing a fall in domestic output.

9 We modified the equation expressing the demand for energy goods in such a way that, if prices and income would stay constant, the demand would change according to the estimates illustrated in Section 2. We also introduced shifting factors in the demand for all other goods and factors. These factors are endogenously adjusted by the model, such that an explicit budget constraint holds.

10 A CGE model provides an internally consistent and detailed description of an economic system, highlighting trade linkages between industries, regions and markets. CGE models are primarily used to simulate and assess the structural adjustments, undertaken by economic systems as a consequence of shocks, like changes in technology, preferences or economic policy. The mathematical structure of a CGE model can be very complex. The GTAP model is composed of hundreds of equations, defining market-clearing conditions, accounting identities, zero-profit conditions or behavioural relationships, in more than 5000 lines of computer code. The reader interested about the details of the GTAP model should refer to Hertel (ibid.), and to the technical material available on the GTAP site (www.gtap.org).

The most important driving force behind the results is the change in the terms of trade induced by the change in the world demand for energy goods. GDP increases in those regions where changes in energy goods demand bring about gains in terms of trade. For example, in the energy exporting countries EEx, despite the increase in domestic electricity demand, the terms of trade effect is negative, because of the overall fall in the world prices of energy goods.

Second order effects are also at work, through exogenous shifts in demand for non-energy goods and services, so that the overall impact on GDP and utility depends on the comparative advantage characteristics of each region. In Europe and in the United States, for example, there are gains in the terms of trade, but nonetheless GDP and household utility both decline, mainly because of changes in the trade balance.

Real investment is allocated worldwide, in the model, according to expected future returns on capital. Since future returns are linked to current returns, and energy industries are relatively capital-intensive, capital returns are expected to follow the pattern of energy prices. Table A2 highlights a very close relationship between energy prices and capital returns. The drop in capital returns, and investments, is particularly evident in energy exporting countries, contributing to the overall variation in the GDP.

The model also estimates variations in emissions of carbon dioxide, although this is a purely descriptive variable, with no effect on the economic equilibrium of this specific simulation. Comparing the last column of Table 3 and Table A1 it can be seen how variations in CO_2 emissions are related to the change in energy output: they are positive when energy output increases.

Table 3 – *Results – Main Economic Aggregates (perfect competition, % var.)*

Regions	GDP	Investment	Terms of Trade	Household Utility	CO^2 Em.
USA	-0.004	-0.04	0.073	0.01	-0.831
EU	-0.24	0.034	0.068	-0.261	-4.292
EEFSU	-0.293	-0.386	-0.226	-0.086	0.421
RoA1	-0.138	-0.091	-0.08	-0.093	-2.58
JPN	0.016	-0.001	0.106	-0.002	-0.412
EEx	-0.297	-0.205	-0.377	-0.105	0.301
CHIND	0.004	-0.015	0.097	0.006	2.244
RoW	0.027	0.022	0.09	0.027	0.88

4. Introducing market power in energy industries

Although conventional CGE models are based on the Walrasian paradigm, it is not necessary to assume that all markets are perfectly competitive. Furthermore, almost all CGE models are calibrated on real data sets, which certainly reflect existing market imperfections. Baseline market failures are (to some extent) "embedded", "frozen" into the model, so that the neoclassical paradigm is typically used only as a sort of "theoretical engine", moving the economic structure from one state to another.

Yet, the existence of market power in industries producing energy goods should be carefully assessed. In fact, energy industries are perhaps the farthest away from the competitive paradigm: economies of scale, barriers to entry, regulatory regimes, sunk costs, limited number of competitors, etc., are typical characteristics of these industries throughout the world. So the question is not whether energy industries are competitive, but whether the reaction of the model to any exogenous shock becomes (significantly) different when market power is explicitly taken into account.

The answer to this question relies on how imperfect competition is introduced in the CGE model. This issue is discussed at length in Roson (2006). The key point is that there is no single way of implementing imperfect competition in CGE models, and that alternative solutions could lead to quite different results.

The model which is used here assumes oligopolistic competition à la Cournot (only in energy industries) between symmetric firms, blocked entry and constant returns to scale. We chose this specification because the number of competitors in most energy markets can be assumed as given in the short run, and because economies of scale, although possibly relevant at the plant level, may not play a very important role within broad geographical and sectoral aggregates.

We estimated the initial amount of unitary profits, for energy industries, using a variety of sources (Oliveira-Martins et al. (1996), Maioli (2003), Barbu et al. (2003), OXERA (2003)), combining econometric estimations of profit mark-ups, for some counties and industries, with indexes of market concentration and competitiveness. In official national accounts, profits are typically included inside a broad residual element, which also includes payments on capital services. Correspondingly, we split calibration data for capital inputs in two separate components: "capital" and "profit". Table 4 shows the split parameters used to this purpose.

Table 4 – *Profit shares in the profit-capital aggregates*

Regions	**Coal**	**Oil**	**Gas**	**Oil. Prod.**	**Electricity**
USA	0.560	0.612	0.557	0.900	0.565
EU	0.758	0.207	0.224	0.877	0.458
EEFSU	0.241	0.081	0.105	0.647	0.783
JPN	0.818	0.522	0.731	0.585	0.717
RoA1	0.477	0.900	0.900	0.900	0.900
EEx	0.224	0.285	0.375	0.990	0.841
CHIND	0.617	0.377	0.612	0.900	0.924
RoW	0.415	0.339	0.317	0.675	0.536

In this model, like in any oligopolistic model, profit margins are inversely related to price demand elasticities. Roson (ibid.) shows how industrial and individual demand elasticities can be computed from elasticity of substitution parameters used in the CGE model. When a representative firm sells in a number different regional markets, the demand elasticity can be expressed as a weighted sum of regional elasticities, where the weights are given by market shares. In this simulation exercise, we are simulating exogenous shifts in the households demand for energy goods. Since these shifts are not proportional in all markets, they will directly affect the regional market shares, the aggregate demand elasticities, the unitary profits and ultimately the final market price for energy goods.

In addition, there are important secondary effects at work, related to changes in prices of input factors. The demand shifts induce changes in energy demand. In turn, this generates a reduction/increase of demand for those factors, in which energy industries are relatively intensive, like natural resources and capital. Roson (ibid.) discusses why cost shocks are likely to be amplified in a CGE model with imperfect competition, in comparison with a conventional model formulation, based on perfect competition. This effect is related to the endogenous variation of market shares. However, there is a second mechanism at work here. The model has been recalibrated by assuming unitary profits in the baseline equilibrium, implying reduced cost shares for capital (in comparison with the competitive closure). This means that the induced decrease/increase in the price of capital will be smaller/larger, as well as that any change in the price of this factor will have smaller consequences on energy prices.

Table 5 summarizes how the various model characteristics, discussed above, may affect the results of the simulation exercise, in comparison with the standard, perfect competition setting.

Table 5 – *Key characteristics of the IC model version, amplifying (+) or dampening (-) the impact of variations in energy demand, in comparison with the PC model version*

Key Characteristics	***Effect***
Exogenous variation of market shares	?
Endogenous variation of market shares	+
Lower shares of capital in the price structure	-

Tables A4, A5 and A6 in the Appendix show percentage changes in quantities and prices under imperfect competition, corresponding to Tables A1, A2 and A3. Table 6 shows how industrial demand elasticities changes after the variations in households' demand. Higher elasticities imply less market power and lower profit mark-ups. However, changes in market power play a relatively minor role in influencing price changes under imperfect competition, in a comparison with perfect competition.

Table 6 – *Percentage changes in industrial demand elasticities*

Industries	**USA**	**EU**	**EEFSU**	**JPN**	**RoA1**	**EEx**	**CHIND**	**RoW**
Coal	1.94	0	-1.66	-0.09	0.44	0.29	-1.63	-0.05
Oil	0.09	-0.08	1.52	0	-0.03	-1.09	1.34	-0.5
Gas	-0.43	0.11	1.22	0	-0.14	-1.07	0.18	-0.01
Oil.Prod.	0.75	0.53	3.22	-0.87	0.34	0	0.63	-1.06
Electricity	-0.6	-0.66	1.42	-2.25	-0.87	1.81	-0.1	-0.98

Figure 1 provides a graphical illustration of the price-quantity movements in the two model versions, for an hypothetical backward shift in the demand for some energy good, lowering both prices and produced quantities. This can be observed in both cases. However, prices fall less under imperfect competition, whereas quantities may fall more or less (in the figure, quantity is assumed to be roughly the same). In the figure, three hypothetical points are considered: a baseline combination of price and quantity, and two price-quantity pairs obtained in the two market regimes (IC and PC). The result obtained under imperfect competition can be interpreted as a the outcome produced by a backward shift in demand, smaller than that observed in perfect competition, and an upward shift in the supply curve of energy goods.

The demand shift is smaller because households' income is relatively higher, as the latter includes profits and capital income (as well as rents on natural resources). The shift in supply is due to relatively higher production “costs”: higher cost of capital and possibly higher unitary profits.

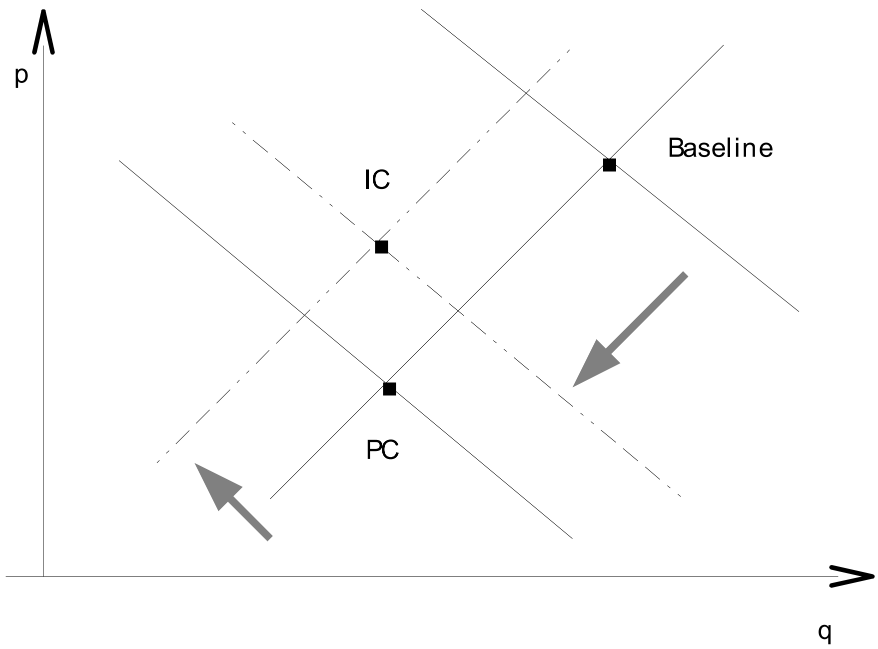

Figure 1 – *An illustrative diagram of relative price-quantity movements in energy industries*

Table 7 shows variations in the main economic aggregates. A comparison with the results under perfect competition highlights the more negative effect on investments that generally emerged under imperfect competition. Also, the gap between gainers and losers is narrower, which is in line with the “dampening” effect of imperfect competition. Table 8 reports the regional Equivalent Variations (EV) computed for two cases. The EV is a money-metric measure of changes in utility for the representative household. It considers which changes in income, at constant prices, would produce the same effects on utility of the simultaneous changes in income and prices, simulated in the two scenarios. We can see that effects are globally worse in imperfect competition. However, the rest of the world (ROW), China and India (CHIND), the energy exporting countries (EEx) and Japan (JPN) appear to get net benefits. These countries are exactly those where climate change increases electricity demand. The final result is due to a complex combination of factors: changes in the terms of trade, structure of preferences, income sources, and other features. For example, in Japan, the welfare loss under perfect competition becomes a welfare gain under imperfect competition.

Table 7 – *Results – Main Economic Aggregates (imperfect competition, % var.)*

Regions	GDP	Investment	Terms of Trade	Household Utility	CO^2 Em.
USA	-0.017	-0.062	0.064	0.001	-0.864
EU	-0.256	0.027	0.065	-0.279	-4.334
EEFSU	-0.303	-0.394	-0.219	-0.098	0.391
JPN	0.019	-0.027	0.105	0.009	-0.436
RoA1	-0.181	-0.01	-0.067	-0.171	-2.705
EEx	-0.289	-0.235	-0.345	-0.102	0.281
CHIND	0.003	-0.092	0.084	0.019	2.204
RoW	0.027	-0.034	0.079	0.041	0.869

Table 8 – *Equivalent Variations in the two model versions*[11]

Regions	**IC**	**PC**
USA	139.605	2374.526
EU	-68000.2	-63612.3
EEFSU	-3494.49	-3083.26
JPN	1129.496	-214.999
RoA1	-7947.16	-4311.21
EEx	-10115	-10485.8
CHIND	978.925	331.449
RoW	4991.489	3271.246
WORLD	-82317.3	-75730.3

5. Conclusion

Climate change will have a direct impact on the demand for energy, since the latter is affected by average temperature levels. In this paper, we presented some results obtained by a world CGE model, simulating exogenous changes in the households' demand structure. Our exercise was based on previous findings of an econometric model, suggesting that higher temperatures may bring about lower consumption of most energy goods, but electricity.
Results have been obtained in the CGE model, by imposing an exogenous change in the households' structure of preferences. These results highlight variations in the terms of trade and variations in prices of energy goods, capital services and natural resources.
These findings are robust in terms of market structure specification. We repeated the experiment with an alternative model version, where we assumed that energy industries were Cournot oligopolies, with profits in both the baseline and counter-factual equilibria. Although the model simulates changes in market power for the various regional industries, most of the differences in results between the two model versions can be interpreted as consequences of different cost shares for capital in the model calibration. We found that lower capital shares, under imperfect competition, imply smaller price variations for energy goods, but higher utility losses worldwide.

11 Millions of 2001 US $.

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Appendix – Additional Simulation Results

Table A1 – *Results (Perfect Competition) – Industry production volumes (% change)*

	USA	EU	EEFSU	JPN	RoA1	EEx	CHIND	RoW
Rice	0.008	-0.011	0.260	0.004	0.033	0.163	-0.010	-0.030
Wheat	0.009	-0.015	0.123	0.035	0.009	0.122	-0.008	-0.003
CerCrops	0.012	0.019	0.086	0.039	0.036	0.036	0.034	0.056
VegFruits	0.008	0.081	0.047	0.029	0.051	0.019	-0.002	0.018
Animals	0.022	0.017	0.124	0.010	0.060	0.089	-0.007	-0.003
Forestry	0.004	-0.028	0.265	-0.002	0.071	0.113	0.000	-0.026
Fishing	0.048	0.170	0.294	0.047	0.158	0.072	-0.029	-0.021
Coal	0.133	0.424	3.369	2.362	1.389	1.203	2.544	1.266
Oil	-0.634	-1.860	-0.880	-1.195	-1.197	-0.735	-0.432	-0.728
Gas	-4.207	-6.211	-3.715	-17.823	-2.087	-0.611	-1.003	0.037
Oil_Pcts	-0.249	-4.680	-0.505	-0.399	-1.648	0.128	-0.221	-0.024
Electricity	-0.632	-2.832	0.069	-0.058	-2.944	1.753	0.575	1.887
Water	0.035	0.131	0.128	0.016	0.066	0.001	-0.031	-0.019
En_Int_ind	0.026	-0.013	0.522	-0.013	0.172	0.256	-0.072	-0.069
Oth_ind	0.023	-0.002	0.284	0.004	0.127	0.203	-0.009	-0.035
MServ	0.030	0.135	0.148	0.017	0.121	0.019	-0.016	-0.018
NMserv	0.037	-0.123	0.001	0.006	-0.018	-0.078	-0.023	-0.012

Table A2 – *Results (Perfect Competition) – Prices of primary resources, goods and factors (% change)*

	USA	EU	EEFSU	JPN	RoA1	EEx	CHIND	RoW
Land	0.220	0.262	0.828	0.175	0.404	0.482	0.024	0.138
Labour	-0.004	0.077	-0.199	0.036	0.001	-0.278	0.018	0.007
Capital	-0.012	0.108	-0.460	0.048	-0.083	-0.289	0.022	0.061
Natural Res.	-2.699	-2.744	-1.479	0.021	-3.649	-3.852	0.388	-0.150
Rice	0.147	0.133	0.469	0.094	0.190	0.316	0.023	0.078
Wheat	0.138	0.160	0.317	0.104	0.124	0.079	0.047	0.063
CerCrops	0.153	0.180	0.294	0.087	0.158	0.158	0.048	0.105
VegFruits	0.140	0.201	0.291	0.085	0.148	0.153	0.023	0.085
Animals	0.142	0.177	0.305	0.085	0.179	0.123	0.024	0.072
Forestry	-0.011	0.033	-0.105	-0.012	0.004	-0.168	0.018	0.008
Fishing	-0.040	0.162	-0.210	-0.115	-0.019	-0.262	-0.023	-0.047
Coal	0.093	0.564	4.663	1.288	0.750	1.116	3.200	1.425
Oil	-1.036	-1.915	-1.334	-0.907	-1.575	-1.347	-1.099	-1.004
Gas	-0.112	-0.706	-1.665	-0.184	-0.898	-0.457	-0.337	0.063
Oil_Pcts	-0.896	-1.159	-1.216	-0.573	-1.263	-1.190	-0.869	-0.948
Electricity	-0.025	0.041	-0.302	0.012	-0.046	-0.487	0.465	0.027
Water	-0.014	0.071	-0.318	0.033	-0.047	-0.282	0.083	0.020
En_Int_ind	-0.043	-0.009	-0.265	-0.015	-0.082	-0.231	0.015	-0.012
Oth_ind	0.014	0.072	-0.088	0.027	0.005	-0.098	0.025	0.029
MServ	-0.014	0.058	-0.255	0.030	-0.041	-0.246	0.007	0.010
NMserv	-0.006	0.067	-0.203	0.027	-0.023	-0.221	0.012	0.011

Table A3 – *Results (Perfect Competition) – Ex-post % change in household demand*

	USA	**EU**	**EEFSU**	**JPN**	**RoA1**	**EEx**	**CHIND**	**RoW**
Rice	0.026	0.601	0.205	0.059	0.175	-0.114	-0.042	-0.049
Wheat	0.031	0.648	0.161	0.059	0.355	-0.058	-0.039	-0.049
CerCrops	-0.010	0.565	0.038	0.045	0.302	-0.099	-0.030	-0.053
VegFruits	-0.002	0.545	0.127	0.047	0.310	-0.141	-0.030	-0.050
Animals	0.012	0.615	0.175	0.033	0.321	-0.128	-0.025	-0.045
Forestry	0.059	0.302	0.122	0.073	0.212	-0.154	-0.028	-0.016
Fishing	0.043	0.548	0.242	0.128	0.357	-0.062	-0.024	-0.029
Coal	81.152	54.569	72.301	75.054	10.190	0.653	48.795	49.010
Oil	0.358	2.207	0.267	0.147	1.165	0.247	0.316	-0.280
Gas	-26.603	-13.724	-25.074	-24.794	-17.528	-0.010	-17.891	-0.822
Oil_Pcts	-1.580	-14.097	-2.001	-1.557	-6.569	-1.166	-1.342	-1.289
Electricity	-1.942	-7.341	-0.493	0.047	-8.582	4.744	4.548	7.835
Water	0.063	0.390	0.235	0.038	0.270	-0.079	-0.040	-0.032
En_Int_ind	0.090	0.390	0.294	0.078	0.314	-0.066	-0.026	-0.019
Oth_ind	0.040	0.396	0.264	0.047	0.270	-0.071	-0.030	-0.043
MServ	0.063	0.326	0.206	0.042	0.248	-0.099	-0.021	-0.022
NMserv	0.055	0.311	0.172	0.044	0.228	-0.108	-0.020	-0.020

Table A4 – *Results (Imperfect Competition) – Industry production volumes (% change)*

	USA	EU	EEFSU	JPN	RoA1	EEx	CHIND	RoW
Rice	0.011	-0.003	0.254	-0.010	0.014	0.146	-0.006	-0.024
Wheat	0.009	-0.015	0.117	0.039	0.008	0.114	-0.007	-0.002
CerCrops	0.010	0.016	0.080	0.040	0.028	0.037	0.031	0.052
VegFruits	0.010	0.084	0.048	0.033	0.044	0.021	0.001	0.020
Animals	0.021	0.020	0.120	0.000	0.044	0.080	-0.006	0.001
Forestry	0.002	-0.030	0.257	-0.006	0.042	0.102	0.008	-0.013
Fishing	0.045	0.178	0.288	0.033	0.119	0.064	-0.022	-0.012
Coal	0.130	0.428	3.357	2.352	1.300	1.177	2.518	1.272
Oil	-0.586	-1.765	-0.853	-1.042	-1.152	-0.701	-0.384	-0.639
Gas	-4.200	-6.164	-3.738	-17.796	-2.117	-0.630	-0.985	0.118
Oil_Pcts	-0.309	-4.723	-0.562	-0.411	-1.780	0.046	-0.259	-0.040
Electricity	-0.641	-2.828	0.006	-0.043	-3.077	1.710	0.546	1.926
Water	0.035	0.129	0.117	0.018	-0.017	-0.006	-0.016	-0.006
En_Int_ind	0.026	-0.009	0.502	-0.025	0.085	0.230	-0.055	-0.050
Oth_ind	0.023	0.003	0.278	-0.011	0.084	0.183	-0.001	-0.027
MServ	0.029	0.140	0.147	0.018	0.078	0.007	-0.022	-0.012
NMserv	-0.005	-0.241	-0.086	0.000	-0.192	-0.075	0.005	0.015

Table A5 – *Results (Imperfect Competition) – Prices of primary resources, goods and factors (% change)*

	USA	EU	EEFSU	JPN	RoA1	EEx	CHIND	RoW
Land	0.211	0.266	0.810	0.121	0.336	0.453	0.044	0.154
Labour	-0.017	0.055	-0.213	0.042	-0.034	-0.268	0.002	0.009
Capital	0.000	0.133	-0.435	0.060	0.036	-0.270	-0.022	0.033
Natural Res.	-2.502	-2.608	-1.426	-0.013	-3.585	-3.639	0.518	-0.024
Rice	0.144	0.141	0.460	0.068	0.163	0.292	0.034	0.090
Wheat	0.132	0.162	0.313	0.086	0.116	0.075	0.054	0.064
CerCrops	0.146	0.180	0.291	0.072	0.144	0.151	0.056	0.106
VegFruits	0.136	0.204	0.290	0.072	0.138	0.145	0.033	0.088
Animals	0.136	0.180	0.301	0.071	0.160	0.115	0.033	0.074
Forestry	-0.010	0.046	-0.095	-0.006	-0.012	-0.162	0.009	0.002
Fishing	-0.034	0.178	-0.191	-0.108	-0.005	-0.246	-0.029	-0.052
Coal	0.087	0.547	4.649	1.279	0.751	1.125	3.129	1.418
Oil	-0.959	-1.823	-1.264	-0.797	-1.486	-1.237	-1.000	-0.903
Gas	-0.112	-0.708	-1.636	-0.175	-0.876	-0.399	-0.344	0.058
Oil_Pcts	-0.828	-1.089	-1.141	-0.528	-1.181	-1.075	-0.796	-0.875
Electricity	-0.021	0.026	-0.244	0.004	-0.002	-0.383	0.449	0.018
Water	-0.019	0.077	-0.309	0.041	0.000	-0.261	0.062	0.011
En_Int_ind	-0.043	-0.007	-0.254	-0.006	-0.058	-0.215	0.005	-0.017
Oth_ind	0.011	0.070	-0.087	0.032	0.011	-0.093	0.018	0.025
MServ	-0.016	0.058	-0.252	0.037	-0.025	-0.232	-0.007	0.002
NMserv	-0.013	0.057	-0.208	0.034	-0.021	-0.209	-0.003	0.008

Table A6 – *Results (Imperfect Competition) – Ex-post % change in household demand*

	USA	EU	EEFSU	JPN	RoA1	EEx	CHIND	RoW
Rice	0.041	0.643	0.229	0.068	0.255	-0.108	-0.043	-0.051
Wheat	0.046	0.685	0.185	0.065	0.383	-0.057	-0.040	-0.052
CerCrops	0.008	0.601	0.061	0.059	0.335	-0.095	-0.031	-0.052
VegFruits	0.013	0.581	0.148	0.062	0.345	-0.135	-0.028	-0.050
Animals	0.026	0.652	0.197	0.052	0.355	-0.123	-0.023	-0.045
Forestry	0.063	0.313	0.130	0.091	0.187	-0.149	-0.015	-0.002
Fishing	0.053	0.582	0.258	0.133	0.381	-0.061	-0.018	-0.025
Coal	81.144	54.581	72.292	75.096	10.119	0.657	48.837	49.019
Oil	0.327	2.133	0.236	0.058	1.032	0.219	0.299	-0.296
Gas	-26.610	-13.701	-25.088	-24.766	-17.593	-0.025	-17.881	-0.737
Oil_Pcts	-1.657	-14.161	-2.047	-1.580	-6.705	-1.222	-1.350	-1.310
Electricity	-1.953	-7.340	-0.524	0.070	-8.673	4.710	4.560	7.853
Water	0.074	0.417	0.247	0.053	0.207	-0.080	-0.027	-0.020
En_Int_ind	0.095	0.419	0.299	0.090	0.238	-0.069	-0.015	-0.003
Oth_ind	0.051	0.430	0.278	0.059	0.235	-0.070	-0.023	-0.034
MServ	0.070	0.354	0.218	0.058	0.195	-0.097	-0.009	-0.006
NMserv	-0.012	-0.420	-0.125	-0.004	-0.218	-0.095	0.039	0.055

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(lxxxi) This paper was presented at the EAERE-FEEM-VIU Summer School on "Computable General Equilibrium Modeling in Environmental and Resource Economics", held in Venice from June 25th to July 1st, 2006 and supported by the Marie Curie Series of Conferences "European Summer School in Resource and Environmental Economics".
(lxxxii) This paper was presented at the Workshop on "Climate Mitigation Measures in the Agro-Forestry Sector and Biodiversity Futures", Trieste, 16-17 October 2006 and jointly organised by The Ecological and Environmental Economics - EEE Programme, The Abdus Salam International Centre for Theoretical Physics - ICTP, UNESCO Man and the Biosphere Programme - MAB, and The International Institute for Applied Systems Analysis - IIASA.
(lxxxiii) This paper was presented at the 12th Coalition Theory Network Workshop organised by the Center for Operation Research and Econometrics (CORE) of the Université Catholique de Louvain, held in Louvain-la-Neuve, Belgium on 18-20 January 2007.

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