Macroeconomic costs and benefits for the EU as a first mover in climate change mitigation: a computable general equilibrium analysis

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Policy questions addressed

- What would be the macroeconomic cost for the EU for acting unilaterally (beyond 2020), not only in the medium term, but also in the long term, until 2050
- What would be the macroeconomic cost for the EU if the rest of the world goes later (e.g. 10-15 years after 2020) beyond the current pledges and perform emission reduction as required for reaching the mitigation goals
- In this case, would it be a benefit for the EU stemming from the first move, for example by gaining a competitive position in global trade of clean technologies
- Would it be preferable that the EU waits to synchronize emission reduction actions with the rest of the world (acting 10-15 years after 2020)

Methodology

- The policy issues are addressed by quantifying global scenarios using a version of the GEM-E3 general equilibrium model
- The model has been extended by including endogenous growth induced by technology progress in clean energy technology and by separately representing global trade for these products
- The GEM-E3 model closes the loop between the economy, energy supply/demand and GHG emissions
- GEM-E3 is a comprehensive CGE model, simulating economic growth and activity in multiple sectors and countries for the time period until 2050

Assumptions

- First mover advantage is meant as the possible trade and growth benefits stemming from technological leadership in technologies required to implement transition to a low carbon emitting economy
- It is postulated that the learning (or economies of scale) achieved by the early entrant provides cost advantages which allow maintaining leadership in global markets and that the diffusion of technology worldwide diminishes the first-mover advantages over time
- It is assumed that the European internal market is sufficiently large and unified to allow for achieving a large part of the learning potential of the technologies.
- A two stage process is assumed: in a first stage, the EU adopts policies that induce large-scale commercialization of the new clean technologies in the internal market, while the rest of the world does not follow a similar policy, hence does not use the new technologies; in the second stage, the rest of the world also follows the policy and requires the new technologies.
- Clean energy technologies (photovoltaic, wind, CCS, electric vehicles and heat pumps) have a potential of cost reduction if developed at a large scale. It is a result of R&D and economies of scale in mass production.

Scenario definitions

% indicate GHG emissions change from 2005 levels				
		2020	2025 and 2030	2050
EU27	Reference	-15%	continuation	-35%
	S1: EU acts alone	-25%	Roadmap pathway	-80%
	S2: EU acts first, rest follow later	-25%	Roadmap pathway	-80%
	S3: all act later	-15%	As in Reference	-80% and constant carbon budget despite delay
Rest of the World	Reference	2/3 of the Copenhagen pledges	Constant carbon price as in 2020	Constant carbon price as in 2020
	S1: EU acts alone		Constant carbon price as in 2020	
	S2: EU acts first, rest follow later		Constant carbon price as in 2020	-80% for rest of Annex I +xx% for Non Annex I, so as -50% for World
	S3: all act later			

	Without induced technology				With induced technology			
	2020	2030	2050	Cumulative 2005-2050	2020	2030	2050	Cumulative 2005-2050
GDP in volume (% changes from Reference)								
World	-0.05	-0.10	-0.21	-0.10	-0.04	-0.07	-0.10	-0.06
EU27	-0.07	-0.30	-1.00	-0.33	-0.06	-0.20	-0.52	-0.17
Rest Annex I	-0.06	-0.07	-0.05	-0.05	-0.06	-0.06	-0.03	-0.05
Non Annex I	0.00	-0.02	-0.02	-0.03	0.00	-0.02	0.01	-0.01
Private consumption in volume (% changes from Reference)								
World	-0.12	-0.23	-0.27	-0.20	-0.12	-0.15	-0.02	-0.08
EU27	-0.39	-0.96	-0.97	-0.74	-0.35	-0.55	0.43	-0.16
Rest Annex I	-0.08	-0.09	-0.15	-0.09	-0.08	-0.09	-0.13	-0.08
Non Annex I	-0.03	-0.06	-0.15	-0.08	-0.03	-0.04	-0.08	-0.04
Investment in volume (% changes from Reference)								
World	0.13	0.23	0.07	0.19	0.12	0.22	0.02	0.17
EU27	0.56	1.12	0.88	0.95	0.56	1.08	0.72	0.89
Rest Annex I	-0.04	-0.06	-0.16	-0.06	-0.04	-0.07	-0.20	-0.09
Non Annex I	-0.02	-0.05	-0.16	-0.07	-0.02	-0.04	-0.16	-0.06
Employment (% changes from Reference)								
World	0.01	0.03	0.04		0.01	0.02	0.03	
EU27	0.09	0.27	0.27		0.10	0.26	0.23	
Rest Annex I	-0.03	-0.02	0.01		-0.03	-0.03	-0.01	
Non Annex I	0.01	0.02	0.03		0.01	0.01	0.02	

"EU acting alone" scenario

Negative but small economic impacts for the EU alleviated under induced technology progress

The small impacts are due to structural changes simulated: decarbonisation of power sector, electrification in transport, strong energy efficiency and renewables

Beneficial for investment and employment in the EU, but detrimental for private consumption and welfare

Impacts on the rest of the world are negligible

	Without induced technology				With induced technology			
	2020	2030	2050	Cumulative 2005-2050	2020	2030	2050	Cumulative 2005-2050
GDP in volume (% changes from Reference)								
World	-0.05	-0.78	-1.86	-0.92	-0.05	-0.75	-0.91	-0.55
EU27	0.00	-0.49	-2.56	-1.02	0.01	-0.45	-1.61	-0.65
Rest Annex I	-0.08	-0.39	-1.47	-0.48	-0.08	-0.38	-0.99	-0.31
Non Annex I	-0.05	-1.43	-1.90	-1.38	-0.05	-1.40	-0.54	-0.79
Private consumption in volume (% changes from Reference)								
World	0.02	-1.35	-1.96	-1.18	0.02	-1.30	-0.48	-0.57
EU27	-0.04	-0.42	-2.10	-0.88	-0.03	-0.37	-0.85	-0.40
Rest Annex I	-0.03	-0.77	-0.98	-0.51	-0.03	-0.73	0.00	-0.12
Non Annex I	0.13	-2.48	-2.81	-2.11	0.13	-2.43	-0.79	-1.18
Investment in volume (% changes from Reference)								
World	-0.28	1.30	-1.20	0.19	-0.28	1.28	-1.06	0.18
EU27	0.08	1.71	-0.21	0.69	0.08	1.70	-0.42	0.59
Rest Annex I	-0.24	1.64	-0.48	0.65	-0.24	1.63	-0.68	0.55
Non Annex I	-0.67	0.61	-2.15	-0.62	-0.67	0.60	-1.61	-0.48
Employment (% changes from Reference)								
World	-0.01	0.26	0.00		-0.01	0.26	-0.05	
EU27	0.20	0.58	0.16		0.20	0.58	0.08	
Rest Annex I	-0.06	0.26	0.03		-0.06	0.26	0.01	
Non Annex I	-0.02	0.24	-0.01		-0.02	0.24	-0.06	

"all regions acting later" scenario

All regions reduce emissions mainly after 2030, at a fast pace to meet the same carbon budget as required for 450ppm

The impacts are negative in all regions and a re larger in the EU compared to the EU acting alone scenario, because of the adverse effects (lower exports, higher prices) stemming from the rest of the World.

Under induced technology progress, impacts are moderate with benefits in all regions.

	Without induced technology				With induced technology			
	2020	2030	2050	Cumulative 2005-2050	2020	2030	2050	Cumulative 2005-2050
GDP in volume (% changes from Reference)								
World	-0.05	-0.80	-1.35	-0.76	-0.05	-0.78	-0.47	-0.47
EU27	-0.06	-0.69	-1.29	-0.55	-0.04	-0.70	-0.34	-0.26
Rest Annex I	-0.07	-0.36	-1.43	-0.46	-0.07	-0.32	-0.99	-0.32
Non Annex I	-0.03	-1.41	-1.30	-1.26	-0.02	-1.40	-0.08	-0.79
Private consumption in volume (% changes from Reference)								
World	-0.03	-1.35	-1.28	-0.97	-0.02	-1.21	0.10	-0.44
EU27	-0.35	-0.40	-0.45	-0.28	-0.31	0.15	0.94	0.37
Rest Annex I	-0.01	-0.73	-0.86	-0.45	-0.01	-0.70	0.02	-0.15
Non Annex I	0.12	-2.53	-1.96	-1.90	0.12	-2.45	-0.12	-1.15
Investment in volume (% changes from Reference)								
World	-0.14	1.19	-0.86	0.30	-0.14	1.15	-0.74	0.29
EU27	0.59	1.41	0.80	1.11	0.59	1.45	0.63	1.08
Rest Annex I	-0.24	1.69	-0.38	0.69	-0.24	1.61	-0.58	0.59
Non Annex I	-0.67	0.47	-1.95	-0.66	-0.67	0.42	-1.49	-0.55
Employment (% changes from Reference)								
World	0.01	0.35	0.24		0.01	0.34	0.19	
EU27	0.10	0.35	0.37		0.10	0.36	0.31	
Rest Annex I	-0.04	0.31	0.05		-0.04	0.29	0.03	
Non Annex I	0.00	0.36	0.25		0.00	0.34	0.20	

EU acting first, rest following later

This scenario delivers the same carbon budget as the previous scenario but the EU emission reduction spans over a longer period of time

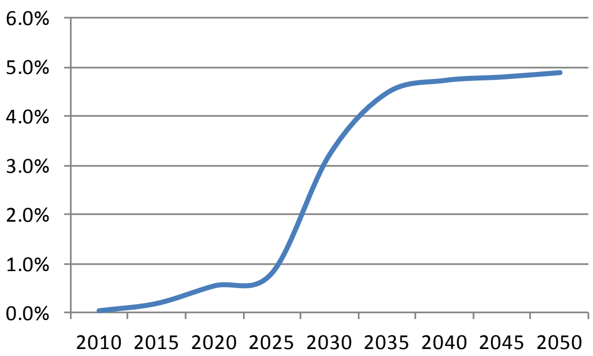
The EU achieves technology progress and restrict diffusion in the early stages of rest of world emission reduction effort

The negative impacts on the EU are smaller than in the "all regions acting later" scenario (trade benefits), whereas the costs for the rest of the world are high in the early stages as technology progress appropriation is delayed

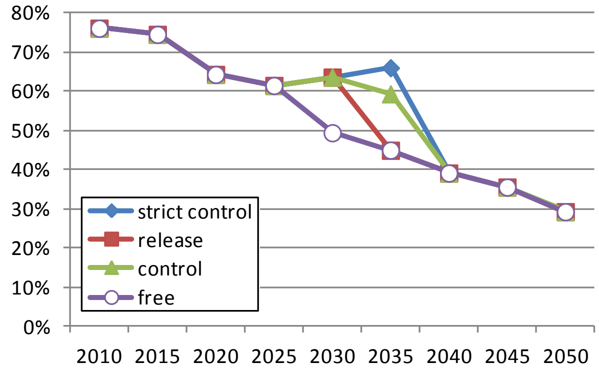
Variants regarding technology diffusion control

- Free: The EU releases the innovation rights already in 2030
- Release: The EU releases the innovation rights from 2035 onwards
- Control: The EU controls innovation rights at a certain extent and the rest of the world get half of innovation cost reductions before 2040 and the entire benefits from 2040 onwards
- Strict control: The EU succeeds to apply stricter controls and the rest of the world get the innovation cost reductions only from 2040 onwards

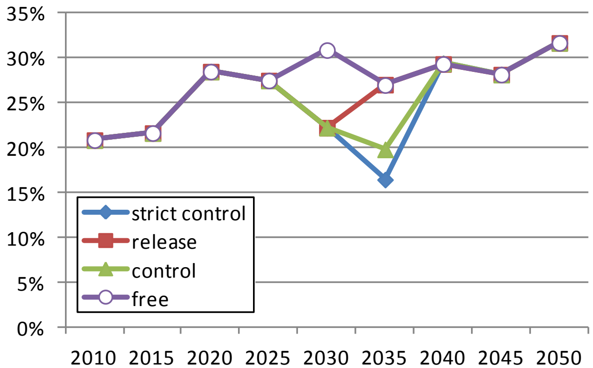
Share of Clean Enery technologies in total value of world exports



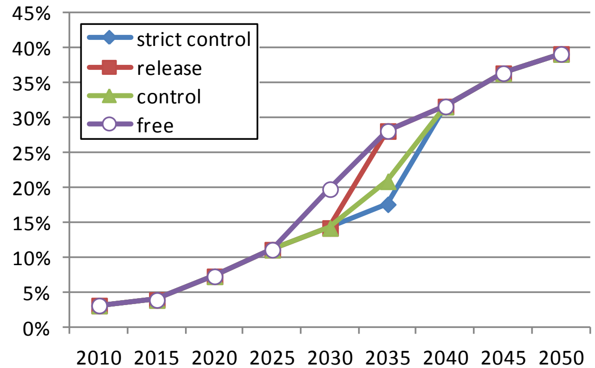
Share of rest of EU27 in total exports of clean energy technologies



Share of rest of Annex I in total exports of clean energy technologies



Share of non Annex I in total exports of clean energy technologies



Global trade of clean energy technologies

In all these cases, the rest of the EU regions meet their emission reduction targets, irrespectively of availability of low cost clean energy technologies, and the EU pursues the ambitious emission reduction pathway (meets the reduced carbon budget).

Global trade of clean energy technologies (wind, solar, CCS, electric vehicles, heat pumps) increase in the decarbonisation scenarios. A basic trend, as simulated in the projections, is the increasing share of developing countries in world trade of clean energy technologies, which is due to their lower production costs.

GDP and welfare impacts of technology diffusion controls

Differences from "all acting later" scenario (with induced technology progress)

bn.$'2004	cumulative GDP			cumulative Welfare		
	EU	Rest of World	World	EU	Rest of World	World
Free	3413	1254	4667	245	133	379
Release	3231	898	4128	258	83	341
Control	2951	197	3148	274	-6	268
Strict control	2787	-155	2632	283	-51	232

- By increasing controls on technology diffusion the EU succeeds in getting an additional share in trade of clean energy technology during a decade, which coincides with the starting of decarbonisation in the rest of the world; consequently the EU increases production which helps alleviating GDP losses.
- The control on diffusion limits the use of low cost clean energy technologies produced in the EU by the rest of the world; thus decarbonisation is more expensive in non EU regions, where domestic demand decreases and prices increase. Consequently, all exports by the EU addressed to rest of the world decrease and domestic EU prices increase to the extent imports contribute to domestic demand. These changes exert negative impacts on EU's GDP.

Comparison of controlled versus free diffusion of clean energy technology

With induced technology	Control of technology diffusion				Free technology diffusion			
	2020	2030	2050	Cumulative 2005-2050	2020	2030	2050	Cumulative 2005-2050
GDP in volume (% changes from Reference)								
World	-0.05	-0.78	-0.47	-0.47	-0.05	-0.64	-0.47	-0.41
EU27	-0.04	-0.70	-0.34	-0.26	-0.04	-0.43	-0.37	-0.17
Rest Annex I	-0.07	-0.32	-0.99	-0.32	-0.07	-0.26	-0.99	-0.29
Non Annex I	-0.02	-1.40	-0.08	-0.79	-0.02	-1.24	-0.06	-0.70
Private consumption in volume (% changes from Reference)								
World	-0.02	-1.21	0.10	-0.44	-0.02	-1.05	0.10	-0.37
EU27	-0.31	0.15	0.94	0.37	-0.31	-0.06	0.91	0.27
Rest Annex I	-0.01	-0.70	0.02	-0.15	-0.01	-0.50	0.02	-0.08
Non Annex I	0.12	-2.45	-0.12	-1.15	0.12	-2.17	-0.11	-1.01
Investment in volume (% changes from Reference)								
World	-0.14	1.15	-0.74	0.29	-0.14	1.11	-0.74	0.27
EU27	0.59	1.45	0.63	1.08	0.59	1.33	0.60	1.02
Rest Annex I	-0.24	1.61	-0.58	0.59	-0.24	1.59	-0.58	0.58
Non Annex I	-0.67	0.42	-1.49	-0.55	-0.67	0.40	-1.47	-0.55
Employment (% changes from Reference)								
World	0.01	0.34	0.19		0.01	0.33	0.20	
EU27	0.10	0.36	0.31		0.10	0.33	0.30	
Rest Annex I	-0.04	0.29	0.03		-0.04	0.29	0.03	
Non Annex I	0.00	0.34	0.20		0.00	0.33	0.21	

The first-mover advantage of the EU manifested by increasing exports of clean energy technologies and permitted by delaying the diffusion of the reduced cost technologies does not imply gains in the EU GDP, because of adverse effects to the EU and of course to the rest of the world stemming from higher costs of decarbonisation in the rest of the world.

Conclusions

- The scenario results show clear advantages for the EU as a first mover in climate change mitigation compared to a delaying of climate action, provided that in all cases the EU will have to meet a reduced carbon budget (cumulative GHG emissions until 2050 lower than in the Reference).
- The results confirm that irrespectively of whether or not the rest of the world will follow decarbonisation later, the EU has interest to start earlier if the EU will in any case have to meet the reduced carbon budget.
- The induced technology progress plays a considerable role in reducing the decarbonisation costs and in alleviating the negative impacts on the economy. The EU has a sufficiently large internal market to achieve a considerable part of the learning potential of clean energy technologies, such as the solar, wind, CCS, electric vehicles and heat pump technologies, which have been distinctly modelled.
- Getting an advantage in global trade of clean energy technologies will depend on the speed of technology diffusion in the rest of the world after the progress to be achieved in the EU thanks to early climate action. The model simulates increased market shares of the EU as a function of the strictness of control of diffusion, during a decade just after 2030.
- Holding monopoly rents from technology spillover has been found to positively affect households' income and welfare in the EU. The model results, and the sensitivity variants, confirm however that preventing the rest of the world from having the clean energy technology available at reduced cost in the early stage of their decarbonisation efforts has adverse effects on GDP of the EU due to the higher cost of decarbonisation in the rest of the world. The results reveal a trade-off between GDP and welfare effects for the EU; hence, whether or not to seek for first mover trade advantage requires policy consideration by the EU.

Thank you for your attention

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