Management and Impacts of Climate Change Programme
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6/99 - From international economic scenarios to the assessment of the sectoral and macroeconomic costs of greenhouse gas emissions reduction

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The ARES project - although essentially methodological in its objectives, i.e. to organize the cross-model consistency of a long-term growth model, an energy model and a general equilibrium model - also allowed the complete economic analysis of the costs of different scenarios of emission rights allocation up to 2030, and of different ways to manage such 'carbon constraints'. On the basis of the economic reference projection, three scenarios were tested:

- A 'Soft-Landing' scenario combining a stabilization of global emissions no later than 2030, a continued reduction of emissions in the states listed in Appendix B of the Kyoto Protocol within an 'extended Kyoto' system including a certain dose of grandfathering, and a progressive slowing down of the increase in developing countries' emissions.
- A 'Contraction and Convergence' scenario, with a long-term convergence of *per capita* emission rights allocations in the name of equity,
- An intermediate 'Global Compromise' scenario combining equal rights and grandfathering in proportions reflecting the structure of preferences at the global level.

The most significant results concerning economic policies come from the study of the difference between the price of carbon and the additional expenses (rate of effort) in the energy sector as derived from a partial equilibrium analysis (POLES) and a general equilibrium effects analysis (IMACLIM).

A scenario of global economic growth to 2030 by region

The development of long-term global growth scenarios was questioned after the failure of predictions, calculated in the 1960s and 1970s, according to which the standard of living in developing countries would come to match that of developed countries within a few decades. The design of consistent growth scenarios spanning several decades remains crucial nonetheless for the study of climate policies, if only because of the inertia of capital in the energy sector. Computable general equilibrium models and rational expectations models are *de facto* based on long-term scenarios, which it would be advisable to examine in detail and to establish on better controlled premises.

We therefore set up regional scenarios with an exogenous growth model that takes into account differences in human capital, whereby differences in growth during the transition period towards long-term equilibrium may be explained. This model, based on Mankiw, Romer and Weil (1992) is simple enough to allow control of the results of the reference projection and its variants. Prediction is carried out using Germain and Guichard's (1998) approach, which assumes a reference country having already reached a long-term equilibrium in the reference year. We made an exception in the case of oil-producing states, whose growth is determined by the realized price of oil and by growth in the rest of the world.

The reference scenario follows the lines of the ‘intermediate’ hypotheses regarding population trends and investment ratios in physical and human capital of all states, in some cases corrected to allow for the past performances of states – exceptional or poor – and for the judgement that can be exercised regarding their future dynamism. It is obviously easily adjustable to fit any theoretical consideration.

The world picture that emerges is one of a 3 % global GDP growth over the 2000-2030 period, associated with a marked decline in population growth and with technical progress continuing the trend of the last 30 years. The weight of long-industrialized states in the global GDP shrinks faster - this decline being mainly to the advantage of Asian regions, as it has been over the last three decades.

Scenarios of emission constraint to 2030 and evaluation on the basis of a sectoral energy model

The initial phase consisted in developing, from the POLES model, an energy reference scenario to match the macroeconomic growth scenario. In the second phase, we assessed, for the energy sector, the costs of three patterns of allocation of the emission rights in question.

One of the main findings is that, in all scenarios, the marginal costs of ‘carbon constraints’ and the effort rates in the energy sector differ widely and reach very high levels in industrialized states when no flexibility mechanism is present: between 450 and 1100 $/tC in the ‘Contraction and Convergence’ scenario, between 250 and 800 $/tC in the ‘Global Compromise’ scenario and between 105 and 365 $/tC in the ‘Soft Landing’ scenario. This confirms the relevance of setting up emission permit markets, which leads to the uniformization of marginal costs around 106 $/tC. Carbon prices then become identical, at a lower level, in all scenarios, suggesting that the corresponding reduction programme is much more efficient in economic terms than in the no-market hypothesis. Initial allocations imply, however, the existence of emission rights transfers from little constrained to highly constrained states – this obviously equating with transfers of wealth. One must note that the ‘Contraction and Convergence’ and ‘Global Compromise’ scenarios involve much greater transfers than the ‘Soft Landing’ scenario (1650 MtC and 1350 MtC, *vs* 750 MtC).

We confirm that the ‘Contraction and Convergence’ scenario is more favourable to developing countries while the ‘Soft Landing’ scenario advantages Appendix B countries. However, we also note a number of exceptions, in particular for the CIS states, which are already constrained by the convergence rule, and for China, which is affected by this same rule and forced to bring down fairly rapidly the current growth rate of its emissions.

These results highlight the difficulties that could arise in the implementation of allocation patterns of the ‘Contraction and Convergence’ type: this principle is attractive in terms of international equity, but the costs it would impose on some of the key actors of future negotiations – United States, Russia and China – appear very high, and one may express doubts as to whether a solution along those lines in the negotiation process would be acceptable to them.

Evaluation of emission rights scenarios in a general equilibrium perspective: working with the IMACLIM model

The analysis of the impact of general equilibrium effects on the economy and energy scenarios developed by CEPII and IEPE respectively focused on the hypothesis of a gradual introduction of a price signal, considered more realistic than the direct introduction of a high level of taxation. The simulations carried out were of three types: free permits with no global market for emission rights, auctioned permits with no global market, and free permits with a global market. The simulations confirmed the sensitivity

of general equilibrium effects to the tested hypotheses regarding permit allocation methods. All in all, free distribution induces a higher rise in energy prices than observed with POLES - due to propagation mechanisms in the inter-industry matrix – as well as significant loss of GDP. With a few exceptions, the general equilibrium analysis and the sectoral analysis lead to the same conclusions regarding the hierarchy of scenarios and of states most affected by the carbon constraints.

Taking into consideration the opportunities given by tax adjustments, however, strongly affects the net economic balance of the scenarios, through a diminution of these taxes due to use of the auction proceeds. It is important to note that, although this flexibility makes it possible to keep GDP losses to below 1% in 2030 for all regions in the 'Global Compromise' scenario and to below 0.5% in the 'Soft Landing' scenario (even with a rise in GDP for some regions), the 'Contraction and Convergence' scenario always leads to significant losses in wealth for the USA, Japan, CIS states and China – a result which confirms the difficulty of adopting this latter option.

Regarding methodological aspects by way of conclusion, we observe that the interfacing between the sectoral energy model POLES and the IMACLIM model seems particularly instructive and promising in terms of future developments. The requirements for close interaction between the sectoral model, growth model and general equilibrium model now appear to be met. Obviously, this first step must be followed by others - in particular the construction, on the same theoretical foundations, of an input-output multisectoral table upstream of POLES and consistent with the long-term scenarios of CEPII.